The Information Content of Net Buying Pressure: Evidence from TAIEX Options

ABSTRACT

This paper examines whether price changes in an option market result from informed trading, by looking at the effect of net buying pressure on the implied volatilities of option, using data of TAIEX options. I document that there is no exist of informed trade in TAIEX options. However, I find that TAIEX options follow the limit of arbitrage hypothesis, supply curve of option has a positive slope. There are negative relationship between the change in average implied volatility and the lagged change in average implied volatility and positive relationship between the change in average implied volatility and net buying pressure. Moreover, I also find that there are positive (negative) relationships between net buying pressures of call (put) options and TAIEX return for all moneyness categories which mean investor obviously buy call (put) options if the underlying asset is raised (fallen). However, there is no the prediction power of net buying pressure of the TAIEX options over the future TAIEX returns.

I. INTRODUCTION

With my job experience in OTC market especially the concept of implied volatility smile curve, I try to relate the concept of the implied volatility to the option market and also investigate the relationship between stock market and option market. Additionally, with the initiation stage of SET 50 index option as same as Taiwan option market (January 2002 – May 2004), this study may create some contribution that can apply to stock market of Thailand.

This study extends the information content of net buying pressure by Kang and Park (2007) to measure in the TAIEX options. By the way, from illiquidity of emerging market which bid-ask spread contained a lot of information and the study of Bollen and Whaley (2004) which examines the relationship between net buying pressure and the shape of the implied volatility functions (IVFs), I use daily data instead of intraday data that against the study of Kang and Park.

This study examines whether option market price changes result from informed trading, by looking at the effect of net buying pressure on implied volatilities of options, there is the relationship between options market and stock market, and there is the prediction power of net buying pressure of the index options over the future index returns.

To investigates the effect of informed trades in the TAIEX options, I apply three alternative hypotheses, the limit of arbitrage and the volatility-learning and direction-learning hypotheses, from Kang and Park (2007) and test which hypothesis is the most suitable to explain TAIEX options. The limit of arbitrage hypothesis assumes that supply curve of an option has a positive slope. With upward slope supply curve, an excess liquidated demand will cause price and implied volatility to increase, and an excess liquidated supply will cause price and implied volatility to decrease. Under this hypothesis, differently shaped of IVFs can be expected due to option prices allow to be affected by supply and demand, and diverged from model values. In the contrast, the learning hypothesis assumes that the slope of the supply curve of an option is flat. The market makers decision depends on the information flows into the market or the trading activity of investors provide information to the market makers. There are two types of news that can move option prices which are the volatility and the direction of the future underlying asset price movements. The learning hypothesis of Bollen and

Whaley's is separated into the volatility-learning hypothesis and the direction-learning hypothesis as categorized by the news effect.

Assessing the impact of net buying pressure on the implied volatilities, the change in average implied volatility of options is regressed with contemporaneous measures of the index return, index trading volume, net buying pressure, and a lagged change in average implied volatility in a particular moneyness categories and sub-periods. Examining the relationship between options market and stock market, and the prediction power of net buying pressure of the index options over the future index returns, net buying pressure is regressed with the lagged term of index returns and net buying pressure itself in a particular moneyness categories and sub-periods.

Applying the methodology of Kang and Park to the daily data option demand and the implied volatility belong to the emerging option market, I find that there is no exist of informed trade in TAIEX options, disregards both the volatility-learning hypothesis and the direction-learning hypothesis. However, I find that TAIEX options follow the limit of arbitrage hypothesis, the IVFs reflect a series of supply and demand equilibrium, and supply curve of option has a positive slope. There are the differently shaped of IVFs among sub-periods. There are a negative relationship between the change in average implied volatility and the lagged change in average implied volatility and positive relationship between the change in average implied volatility and net buying pressure. Moreover, I also find that there are positive (negative) relationships between net buying pressures of call (put) options and TAIEX return for all moneyness categories which mean investor obviously buy call (put) options if the underlying asset is raised (fallen). However, there is no the prediction power of net buying pressure of the TAIEX options over the future TAIEX returns, no relationship between net buying pressure and the lagged term of TAIEX returns.

The paper is organized as follows. Section II describes the result of the previous study. Section III introduces the concept of net buying pressure, implied volatility and hypotheses. Section IV explains the empirical methodology. Section V presents the data used in the paper. Section VI provides the empirical results, and Section VII contains the summarized conclusion.

II. LITERATURE REVIEW

The Implied Volatility Term Structure

Under the benchmark Black-Scholes model, the term structure of implied volatility shouldn't exist, or more precisely, it should be a flat, uninteresting line. Mixon (2007) uses the simple rational economic explanation, the expectations hypothesis, for the explanation of the implied volatility term structure of at-the-money stock index options. The intuition and tests are the same as the expectations hypothesis of the term structure of interest rates. The central question is whether the slope of the term structure predicts future changes in implied volatility. The results indicate that even the predictions do not match which the expectations hypothesis, the slope of the term structure is a significant predictor of future short term implied volatility.

There are many study try to explain the shape of IVF focus on the relaxation of Black-Scholes assumption about the constant volatility by allowing the volatility of underlying security to develop either deterministically or stochastically through time. Emanuel and MacBeth (1982) examine the power of the deterministic Cox and Ross (1976) constant elasticity of variance (CEV) model to explain the cross-sectional distribution of stock option prices. Together with the implied binomial tree framework of Dupire (1994), Derman and Kani (1994), and Rubinstein (1994) on the cross-section of option prices[1]. They conclude that deterministic volatility models cannot explain the time-series variation in option price or in the shape of IVFs.

Bates (2000) models stochastic process on volatility with jumps for valuing index options and finds that the inclusion of a jump process can improve the model's ability to generate IVFs, but parameters must be set under unreasonable basis[2].

Hentschel (2003) study the errors in implied volatility estimation and find that even the assumptions of Black-Scholes hold, the estimated implied volatility contains a lot of noise and bias due to the measurement errors especially in the option price and underlying asset price. These can imply that there is a relationship among implied volatility, option price and underlying asset price.

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[1] Deterministic volatility models assume that the volatility rate is a general function of security price and time. The CEV model is a special case of the deterministic volatility model and the Black-Scholes model is the special case of CEV model.

[2] Stochastic volatility with jump process is one type of Markov chain process.

Net Buying Pressure Hypothesis

This concept plays the major role in my study. Bollen and Whaley (2004) examine the relation between net buying pressure and the shape of the implied volatility function for index and individual stock options and find that changes in implied volatility are directly related to net buying pressure and consist with the limit of arbitrage hypothesis.

Under the Black-Scholes (1973) assumption of frictionless markets, option market liquidity suppliers can perfectly hedge their portfolios, so supply curves will be flat. Either time variation in the demands to buy or sell options or public order imbalances for particular option series will have no effect on option price and, also implied volatility, so Bollen and Whaley set their hypotheses upon this concept. However, they are not involved in the information content on the underlying asset's volatility. Kang and Park (2007) extend Bollen and Whaley hypotheses to find whether price changes in an option market result from informed trading and they find that there is the information content on net buying pressure.

Limit of arbitrage

Shleifer and Vishny (1997) describe about the limit to the professional arbitragers that as the market makers or the liquidity suppliers who tried to liquidate their position upon their risk aversion, when the risks increase, option price and implied volatility increase as well. They set the research question as "how effective is professional arbitrage is extreme circumstances, when prices are far away from fundamental values?" Their paper shows that the professional arbitrage may not bring the security prices to the fundamental values and the professional arbitragers also avoid take high volatile arbitrage position due to their risk aversion.

Liu and Longstaff (2000) study the limit of arbitrage by using the quantitative method. They examine the optimal trading strategy of risk-averse investor where arbitrage opportunities are exist. They find that the optimal strategy is far away from arbitrage strategy.

Information Trading

Easley, O'Hara and Srinivas (1998) and Chan, Chang and P. Lung (2008) use option market and stock market to test the informed trading concept. They examine the information role of options across exercise, option type and different market condition.

The first researchers suggest that transactions in derivative market may be an important predictor of future security price movements. By the way, the second researchers suggest that the stock market leads the options market and the informed trading exists in the option market.

In addition, Copeland and Galai (1983) also link the relationship between the information effects and the bid-ask spread by setting the assumption that a market-maker is assumed to optimize his position by setting a bid-ask spread that maximizes his benefits by expected revenues received from liquidity motivated traders and expected losses to information motivated traders. Kang and Park (2007) distinguish their study by extend the informed trading or learning hypothesis into volatility-learning and direction-learning hypotheses.

III. THERORETICAL FRAMEWORK

There are many theoretical concepts applied in this study. The net buying pressure, implied volatility, and hypotheses will be described deeply in this section.

Implied Volatility

The implied volatility approach calculates volatility implied by the current market value of options. This is undertaken by specifying the option price and calculating the volatility that would be needed in a mathematical option pricing formula such as Black-Scholes to derive the specified market price as a fair value of the option. With the Black-Scholes assumption, the implied volatility surface should flat or options of the same stock should get the same implied volatility but in the real world this is not true due to many reasons such as measurement errors, unrealistic of Black-Scholes assumptions, imprecise of bid-ask spread, and etc. Even the relaxing of the Black-Scholes assumption of constant volatility, both deterministic and stochastic processes still do not explain IVFs better than Black-Scholes model.

There is a better way to explain IVFs, if I assumed that the IVF is as a series of market clearing option prices quoted in terms of Black-Scholes implied volatilities. It means that there is a relationship between the demands to buy and sell options and the option price, also implied volatility.

Net Buying Pressure Hypothesis

Net buying pressure is defined as the difference between the number of buyer-motivated and the number of seller-motivated contracts traded each day. The buyer-motivated (seller motivated) is the transaction that executed above (below) the prevailing bid/ask midpoint. The difference is computed series-by-series basis, and is multiplied by the absolute value of the option's delta. The option's delta is the numbers of stocks need to hold when the option is exercised in order to make risk-free portfolio, so net buying pressure can be interpreted as the demand in that option.

This concept comes from Bollen and Whaley (2004) which described that there is a relationship between net buying pressure and implied volatility of the option but that it is not involved in the information content on the underlying asset's volatility. Kang and Park (2007) extend their hypotheses to find whether price changes in an option market result from informed trading and I extend the concept of Kang and Park to the emerging option market. They suggest three alternative hypotheses, the limit of arbitrage and the volatility-learning and direction-learning hypotheses.

The limit of arbitrage hypothesis assumes that supply curve of an option has a positive slope which X-axis is price and Y-axis is quantity of the option. This comes from Shleifer and Vishny (1997) which describe about the limit to the professional arbitragers. As the market makers or the liquidity suppliers who tried to liquidate their position upon their risk aversion, when the risks increase, option price and implied volatility increase as well. With upward slope supply curve, an excess liquidated demand will cause price and implied volatility to increase, and an excess liquidated supply will cause price and implied volatility to decrease which means that the IVFs reflect a series of supply and demand equilibrium, and the differently shaped of IVFs can be expected due to option prices allow to be affected by supply and demand, and diverged from model values.

In the opposite way, the learning hypothesis assumes that the slope of the supply curve of an option is flat. This hypothesis based on the view that the option's underlying asset returns is totally complex and vary over times. In this sense, a relationship between options demand and implied volatility would be observed only the information flows into the market which shifting the supply curve. In other word, the market makers decision depends on the information flows into the market or the trading activity of investors provide information to the market makers. There are two types of news that can move option prices which are the volatility and the direction of the future underlying asset price movements. The learning hypothesis of Bollen and Whaley's is separated into the volatility-learning hypothesis and the direction-learning hypothesis as categorized by the news effect.

Limit of arbitrage Hypothesis

H1: There is positive relationship between the changes in average implied volatility and net buying pressure.

Under the limit of arbitrage hypothesis, each implied volatility is determined depending on the demand of each option series. Therefore, I will observe a positive relationship between the changes in average implied volatility and net buying pressure. By the way, the implied volatility of different option series does not have to move together. So, net buying pressure of ATM options does not affect the implied volatility of OTM or ITM options.

H2: There is negative relationship between the change in average implied volatility and the lagged changes in average implied volatility.

Under the limit of arbitrage hypothesis, the changes in average implied volatility and the lagged term relationship is reversed because market makers who are taking a risk by supplying liquidity want to rebalance their portfolio.

Volatility-learning Hypothesis

H1: There is positive relationship between the changes in average implied volatility and net buying pressure.

If the volatility occurs and signaling imbalance shock to investors, the imbalance will change the investors' expectation about the future volatility, so the implied volatility will change accordingly. I will observe a positive relationship between the changes in average implied volatility and net buying pressure. However, totally different from the limit of arbitrage hypothesis, net buying pressure of ATM options will drive the changes in implied volatilities of all options in the same direction and also be reacted more rapidly from the investor due to the highest vega or volatility of ATM options, which imply that they are the most informative about the future volatility of the stock market.

H2: There is no relationship between the change in average implied volatility and the lagged changes in average implied volatility.

I expect no relationship between the change in average implied volatility and the lagged changes in average implied volatility because the information is already reflected in the price and the implied volatility by the trading activities of the investors. Moreover, the new information about the market volatility drives the changes in the implied volatility are unpredictable.

Direction-learning Hypothesis

H1: There is relationship between the changes in average implied volatility and net buying pressure.

As the information regarding the price movement of the underlying asset signal to informed trader at time t and given that informed traders trade in the option market to use that information, the implied volatility of call (put) will be positive (negative) function of net buying pressure of call options and negative (positive) function of net buying pressure of put options, ignoring of moneyness.

H2: There is negative relationship between the change in average implied volatility and the lagged changes in average implied volatility.

When the positive (negative) signal information about the future underlying asset price movements arrives in the option market before it arrives in the underlying asset market, the price and implied volatility of calls calculated with the underlying asset price will move up (down) and the price and implied volatility of puts will move down (up) at time t. Then, whenever, the positive (negative) signal information is contributed to the underlying asset market at time $t+1$, the index price will rise (drop) at time $t+1$, the price and implied volatility of calls will go down (up), and the price and implied volatilities of puts will go up (down).

H3: Net buying pressure of the index option market will have any prediction power for the future index returns.

If the direction-learning hypothesis is true, the informed traders will trade in the index option market first and the information content of trades is contributed to the underlying asset market. So, there should have some prediction power for future index returns.

IV. DATA

I obtain the data from many sources which are Taiwan Economic Journal (TEJ) database, Google Finance website, DataStream, Taiwan Futures Exchange website and the Central Bank of the Republic of China (Taiwan) website. The study focus on daily data of TAIEX options consist of closing price, strike price, expiration date, options type, open interest and trading volume records. The underlying asset is the Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX). TAIEX options trading began on 24th December 2001. Both call and put options are European style. The multiplier is 50 New Taiwan dollars per index point and the expiration date is the third Thursday of the delivery month. The intraday transactions data include trading time are used to find net demand on each option series. For the daily data of TAIEX, I include closing price, dividend yields and volume records which are contemporaneous with the data of TAIEX options. The sample period is unique because it consists of a downtrend market 2nd January 2002 – 30th April 2003, an uptrend market 1st May 2003 – 19th March 2004 and a political tension 20th March 2004 – 25th May 2004. Figure 1 shows the TAIEX level and return during the period January 2002 through May 2004 and its statistical stationary.

[Figure 1 is here]

I calculate the implied volatility and moneyness or option deltas from Black-Scholes option pricing model under Newton Raphson method[3]. The reference for the standard deviation is estimated as the historical volatility of the return of the TAIEX over the most recent sixty trading days. The risk-free rate of interest plotted from overnight interbank rate, 10 days, 30 days, 60 days, 90 days, 120 days, 150 days, 180 days and 360 days money market rate by interpolated Cubic B-Spline method[4]. I categorize the level of moneyness upon the definition of Bollen and Whaley. Options with absolute deltas below 0.02 and above 0.98 are excluded due to price discreteness[5].

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[3] The procedures of calculation are followed. First, I estimate the option price $P_j(\sigma_0)$ based on an initial guess for implied volatility, σ_0. Second, I estimate the regression, $P_j(\sigma_0) - P_j + \sigma_0(\partial P_j(\sigma_0) / \partial\sigma) = \sigma(\partial P_j(\sigma_0) / \partial\sigma) + e_j$, where is P_j the option market price. Third, I calculate the value of $\partial\sigma = P_j(\sigma_0) - P_j / vega$. Fourth, I calculate the value of $\sigma_1 = \sigma_0 - \partial\sigma$. If the absolute value of $\partial\sigma$ is greater than 0.0001, I repeat the three steps using σ_1 as the new guess for implied volatility. If the absolute value of $\partial\sigma$ is less than 0.0001, then σ_1 is the estimated volatility.

[4] I use Cubic B-Spline method because this method is used in Taiwan bond market.

[5] To describe the level of price discreteness, consider the option with an exercise price of 67 and time to maturity of 30 days. If risk-free rate is 4 percent and the underlying stock price is 54.7, with a volatility rate of 33 percent, and pays no dividends, the value of the option under Black-Scholes model is 0.036 and its delta is 0.02. Under the quotation, its price is rounded up 0.10, the option implied volatility is 45 percent, 1,200 basis points higher than its actual value.

[Table I is here]

Table I shows the moneyness level category by the range of delta. Table II illustrates the average implied volatility categorized by the moneyness level, sub-periods and option types. There are a different shape of IVFs among option types and sub-periods such as smile, smirk, and etc., followed limit of arbitrage hypothesis. The greatest level of IVFs occur during political tension period, as same as the difference between the implied and realized volatility. The lowest level of IVFs happen during uptrend period. Almost all sub-periods, the implied volatility is greater than realized volatility except downtrend period. The exception comes from call options, their difference between the implied and realized volatility increase from -2.21 percent under ITM category to -1.67 percent under ATM category and then increase again to -0.20 percent under OTM category. The greater of the implied volatility over realized volatility follow the previous study of both Bollen and Whaley and Kang and Park.

[Table II is here]

Figure 2, figure 3 and figure 4 show the average IVFs, the average difference between implied volatility and realized volatility of call and put options categorized by the moneyness level and sub-periods and level of TAIEX options IVF, its trendline and realized volatility, respectively.

[Figure 2 is here]

[Figure 3 is here]

[Figure 4 is here]

Table III illustrates the number of TAIEX options categorized by the moneyness level, sub-periods and option types. Panel A and panel B show the trading volume and open interests of TAIEX options, respectively. They show that call options have be higher liquidity and held long term position than put options for all sub-periods. The greatest portion of the trading volume and open interests is under the uptrend period call options. They are 42.46 percent of the entire period for the trading volume and 41.60 percent of the entire period for the open interests. If I focus on the moneyness level, OTM categories both call and put options have the greatest portion of entire period. Panel C shows the net buying pressure in call and put options categorized by the moneyness level, sub-periods. The negative net buying position in call options and the positive net buying position in put options, followed with the average implied volatility of put options are higher than that of call options as illustrated in table II, can be found by limit of arbitrage hypothesis. These occur under downtrend and political tension periods, vice versa for uptrend period. By the way, it doesn't imply that the other hypotheses cannot explain the table III, consistently.

[Table III is here]

Vega is the rate of change in the option price with volatility. Volatility-learning hypothesis can be explained by monitoring the shape of vega. Net buying pressure of ATM options will drive the changes in implied volatilities of all options in the same direction and also be reacted more rapidly from the investor due to the highest vega, which imply that they are the most informative about the future volatility of the stock market. Figure 5 shows the average vega categorized by the moneyness level and sub-periods. All of the average vega shapes follow the expectation of volatility learning hypothesis.

[Figure 5 is here]

V. METHODOLOGY

To assess the impact of net buying pressure on the implied volatilities, the change in average implied volatility of options is regressed with contemporaneous measures of the index return, index trading volume, net buying pressure, and a lagged change in average implied volatility in a particular moneyness. Trading volume and index returns are used as control variables. Trading volume is expected to be correlated with volatility because both variables represent information flow in the market. Index returns are expected to be negatively correlated with changes in implied volatility.

Regressions are run for ATM calls, ATM puts, OTM calls and OTM puts. In summary, these regressions are specified as follow:

$$\Delta ATM\_\sigma_t = \alpha_0 + \alpha_1 RS_t + \alpha_2 VS_t + \alpha_3 ATM\_D_{1,t} + \alpha_4 ATM\_D_{2,t} + \alpha_5 \Delta\sigma_{t-1} + \varepsilon_t \quad (1)$$

$$\Delta OTM\_\sigma_t = \alpha_0 + \alpha_1 RS_t + \alpha_2 VS_t + \alpha_3 OTM\_D_{1,t} + \alpha_4 ATM\_D_{2,t} + \alpha_5 \Delta\sigma_{t-1} + \varepsilon_t \quad (2)$$

where ΔATM_σ_t is the change in the average ATM calls (or puts) option implied volatility and ΔOTM_σ_t is the change in the average OTM calls (or puts) option implied volatility from the close on day $t-1$ to the close on day t. RS_t is the index returns from the close on day $t-1$ to the close on day t, and VS_t is the stock volume on day t expressed in millions New Taiwan dollars. ATM_D_t and OTM_D_t is the summed net buying of ATM calls or puts and OTM calls or puts, respectively, on the close day t.

I can differentiate the three alternative hypotheses by comparing the sign and size of the coefficients of net buying pressures, α_3's and α_4's, in equation (1) and (2). It will be questionable that why I use OTM options only to test the effect among cross moneyness. The answer is the higher volume of them over ITM options.

To investigate the impacts of net buying pressure on the changes in implied volatility among different periods, the equation (1) and (2) are regress for entire period, downtrend, uptrend and political tension.

To examine the relationship between options market and stock market, and the prediction power of net buying pressure of the index options over the future index returns, net buying pressure is regressed with the lagged term of index returns and net buying pressure itself in a particular moneyness.

Regressions are run for calls and puts. In summary, these regressions are specified as follow:

$$NBP_t = \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 r_t + \alpha_3 r_{t+1} + \alpha_4 NBP_{t-1} + \varepsilon_t \quad (3)$$

where NBP_t is the net buying pressure on the close day t. r_t is the return of the TAIEX on the close day t.

To investigate the prediction power of net buying pressure over the future index returns among different periods, the equation (3) regress for entire period, downtrend, uptrend and political tension.

Limit of arbitrage Hypothesis

H1: There is positive relationship between the changes in average implied volatility and net buying pressure.

H2: There is negative relationship between the change in average implied volatility and the lagged changes in average implied volatility.

To examine the limit of arbitrage hypothesis, I regression the equation (1) and (2). I will observe a positive relationship between the changes in average implied volatility and net buying pressure. By the way, the implied volatility of different option series do not have to move together. So, net buying pressure of ATM options does not affect the implied volatility of OTM options. I also expect the changes in average implied volatility and the lagged term relationship is reversed.

Volatility-learning Hypothesis

H1: There is positive relationship between the changes in average implied volatility and net buying pressure.

H2: There is no relationship between the change in average implied volatility and the lagged changes in average implied volatility.

To examine the volatility-learning hypothesis, I regression the equation (1) and (2). I will observe a positive relationship between the changes in average implied volatility and net buying pressure. However, totally different from the limit of arbitrage hypothesis, I expect net buying pressure of ATM options will positively relate to the implied volatilities of OTM options. I expect no relationship between the change in average implied volatility and the lagged changes in average implied volatility.

Direction-learning Hypothesis

H1: There is relationship between the changes in average implied volatility and net buying pressure.

H2: There is negative relationship between the change in average implied volatility and the lagged changes in average implied volatility.

H3: There is relationship between net buying pressure and future index return.

To examine the direction-learning hypothesis, I regression the equation (1), (2) and (3). I expect that the coefficients of net buying pressure of call (put) options will be positive and the coefficients of net buying pressure of put (call) options will be negative respect to change in the implied volatility of call (put), ignoring of moneyness. I also expect the changes in average implied volatility and the lagged term relationship is reversed. If there have some prediction power of the index option market to future index returns, it should have some relationship between future index return and net buying pressure which sign depend on option series.

VI. EMPIRICAL RESULT

Table IV summarizes the regression results for the impact of net buying pressure on the changes of implied volatility or results of equation (1) and (2). Panel A and panel B report the estimation result of change in the implied volatility of ATM calls and puts, while panel C and panel D report for OTM calls and puts, respectively. There is no any sub-periods that has a significance at 95% confidence level of the coefficient of index return, α_1 's for both equation (1) and (2). For the sign of coefficient, uptrend and downtrend have negative sign for ATM and OTM calls in panel A and panel C and positive sign for ATM and OTM puts in panel B and panel D, which followed the direction-learning hypothesis of the previous study of Kang and Park that $\Delta\sigma_t$ should be negatively related to RS_t for calls and positively related to RS_t for puts. The exploitation of information, about the future movement of the underlying stock price will flow into the option market before stock market. Under sub-periods of political tension, the sign of coefficients are negative all of equation (1) and (2).

Repeatedly, there is no enough statistically significant at 95% confidence level of the coefficient of trading volume, α_2 's of equation (1) and (2) for any sub-periods. The sign is positive for equation (1) and (2) under uptrend sub-period, which means that when the trading volume of the underlying asset increase the option price will be increased. Differently to the downtrend and political tension sub-periods, the sign is positive for calls and negative for puts. Totally far away from previous study of Kang and Park, which find that the price of an option is going to decrease if underlying assets are more actively traded.

Consistent with the direction-learning hypothesis and limit of arbitrage hypothesis, $\Delta\sigma_t$ is negatively correlated with $\Delta\sigma_{t-1}$ (α_5 's) and significant at 95% confidence level, followed the previous study of Kang and Park and Bollen and Whaley, respectively.

The main test of this study focus on the coefficient of net buying pressure, α_3 s and α_4 s, which use as the tombstone for the hypothesis under this study, will follow among limit of arbitrage, volatility-learning and direction-learning hypotheses. There is no enough significant of the coefficient to support any hypothesis under sub-periods. However, under the entire period the coefficients are statistically significant at 95% confidence level and the results support limit of arbitrage hypothesis, that there is a positive relationship between the change in implied volatility and net buying pressure with no affect across option series or moneyness level. Panel A, α_3 s and α_4 s stand for net buying pressure of ATM calls and ATM puts and their coefficient are 0.05344 and 0.04507, respectively. In line with the result of panel B, α_3 s and α_4 s stand for net buying pressure of ATM puts and ATM calls and their coefficient are 0.01569 and 0.00041, respectively. Panel C and Panel D have two regressions under each sub-period. α_3 s stand for net buying pressure of OTM calls under panel C and net buying pressure of OTM puts under panel D for both regressions. α_4 s stand for net buying pressure of ATM calls for the first regression and ATM puts for the second regression under both panel C and panel D. Followed the limit of arbitrage hypothesis, α_3 s are often statistically significant at 95% confidence level.

[Table IV is here]

Table V shows the estimation regression results for the relationship between the net buying pressure and the TAIEX return of equation (3). I add the equation (3) to test whether there is the relationship between options market and stock market, and the prediction power of net buying pressure of the index options over the future index returns, followed direction-learning hypothesis. The result shows obviously that there is no the prediction power of net buying pressure of the index options over the future index returns. There is no statistically significant of coefficient of future index return, α_3's. By the way, this regression shows the relationship between net buying pressure and current index return, which have positive relationship for calls and negative relationship for puts regardless of the moneyness level and sub-periods category by the result of the statistically significant of coefficient of current index return, α_2's. They implies that net position of the call options will increase when underlying index return increase, and net position of put options will increase when underlying index return decrease.

[Table V is here]

VII. CONCLUSION

This study extends the information content of net buying pressure by Kang and Park (2007) to measure in the TAIEX options, the emerging option market. The empirical evidence in this study shows result against the study of Kang and Park that TAIEX options follow the limit of arbitrage hypothesis, supply curve of option has a positive slope and there is no exist of informed trade in TAIEX options. I find that there are a negative relationship between the change in average implied volatility and the lagged change in average implied volatility and positive relationship between the change in average implied volatility and net buying pressure for the entire period sample. Moreover, I also find that there are positive (negative) relationships between net buying pressures of call (put) options and TAIEX return regardless moneyness categories and sub-periods which mean investor obviously buy call (put) options if the underlying asset is raised (fallen). However, there is no the prediction power of net buying pressure of the TAIEX options over the future TAIEX returns. This study steps backward to follow the hypothesis of Bollen and Whaley (2004), the main methodology that Kang and Park used for their study. The reasons come from the emerging stage of Taiwan option market (January 2002 – May 2004) which the market does not learn about the information traded and the demand and supply of the option price make its price go far away from fundamental value (mispricing). The other reason is daily data using, followed Bollen and Whaley instead of intraday data as Kang and Park.

This study provides some useful implication that during the emerging stage of option market, the option price will be totally different from the model price, influenced by the law of demand and supply under limit of arbitrage hypothesis. For the further study, I recommend to use intraday data and apply the concept under this study to stock market of Thailand, if the available of data is possible in stock market of Thailand. I also recommend using the other method of option pricing e.g. Cox Square Root (CSR) model which better estimate warrants listed in Thailand than Black-Scholes model followed the study of Shastri and Sirodom (1995).

REFERENCES

Bate, D., 2000. Post-'87 crash fears in the S&P 500 futures options market. *Journal of Econometrics 94*, 181-238.

Black, F., 1975. Fact and fantasy in the use of options. *Financial Analysts Journal 31*, 36–72.

Black, F., 1976. Studies of stock price volatility changes. Proceedings of the 1976 Meetings of the Business and Economics Section. *American Statistical Association*, 177–181.

Bollen, N.P.B., Whaley, R., 2004. Does net buying pressure affect the shape of implied volatility functions? *Journal of Finance 59*, 711–753.

Chan, K., Chang, Y., Lung, P., 2008. Informed trading under different market conditions and moneyness: Evidence from TXO options. *Pacific-Basin Finance Journal xxx*, xxx–xxx.

Copeland, T., Galai, D., 1983. Information effects on the bid-ask spread. *Journal of Finance 38*, 1457–1469.

Cox, J., Ross, S., 1976. The valuation of options for alternative stochastic processes. *Journal of Financial and Quantitative Analysis 37*, 471-493.

Das, S., 2004. Implied Volatility. *Swaps/ Financial Derivatives Product, Pricing, Applications and Risk Management 3rd Edition*, 461.

Derman, E., Kani, I., 1994. Riding on the smile. *Risk 7*, 32-39.

Dupire, B., 1994. Pricing with a smile. *Risk 7*, 18-20.

Easley, D., O'Hara, M., Srinivas, P., 1998. Option volume and stock prices: evidence on where informed traders trade. *Journal of Finance 53*, 431–465.

Emanuel, D., MacBeth, J., 1982. Further results on the constant elasticity of variance call option pricing model. *Journal of Financial and Quantitative Analysis 4*, 533–554.

Hentschel, L., 2003. Errors in implied volatility estimation. *Journal of Financial and Quantitative Analysis 38*, 779–810.

Liu, J., Longstaff, F., 2004. Losing money on arbitrage: optimal dynamic portfolio choice in markets with arbitrage opportunities. *Review of Financial Studies 17*, 611–641.

Mixon, S., 2007. The implied volatility term structure of stock index options. *Journal of Empirical Finance 14*, 333-354.

Rubinstein, M., 1994. Implied binomial trees. *Journal of Finance 49*, 771–818.

Shastri, K., Sirodom, K., 1995. An empirical test of the BS and CSR valuation models for warrants listed in Thailand. *Pacific-Basin Finance Journal 3*, 465-483.

Shleifer, A., Vishny, R., 1997. The limits of arbitrage. *Journal of Finance 52*, 35–55.

Table I

Moneyness Category Definitions

This table provides the definition of each moneyness category used by Bollen and Whaley (2004). Bollen and Whaley measure the moneyness of an option by using the option's delta, which can be interpreted as the likelihood of being exercise at maturity. Options with absolute deltas below 0.02 and above 0.98 are excluded due to price discreteness. The sample period is from January 2002 to May 2004.

Call Category		Delta range	Put Category		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	$-0.98 < \Delta_P \leq -0.875$

Note: DITM stands for deep in-the-money, ITM for in-the-money, ATM for at-the-money, OTM for out-the-money, and DOTM for deep out-the-money.

Table II

Average Implied Volatilities by Option Delta for TAIEX Options during the Period January 2002 through May 2004

The Black and Scholes (1973) formula is used to compute implied volatilities for TAIEX options by using Newton Raphson method. The delta value of each option series is computed using the closing price of TAIEX, the risk-free rate of interest plotted from overnight interbank rate, 10 days, 30 days, 60 days, 90 days, 120 days, 150 days, 180 days and 360 days money market rate by interpolated Cubic B-Spline method matching the option's time to maturity, and the realized volatility over the most recent 60 trading days. All volatilities are annualized. The sample period is from January 2002 to May 2004 which divided into three sub-periods. Downtrend market is from January 2, 2002 to April 30, 2003, uptrend market is from May 1, 2003 to March 19, 2004, and political tension is from March 20, 2004 to May 25, 2004.

Period	Type	Average implied volatility					Average difference between implied and realized volatility				
		1	2	3	4	5	1	2	3	4	5
Entire Period	Calls	0.2505357	0.2504933	0.2543104	0.2550683	0.2632283	0.0135448	0.0068069	0.0082946	0.0109204	0.0155860
Downtrend		0.2622524	0.2616902	0.2684482	0.2721483	0.2794476	-0.0220861	-0.0225235	-0.0166642	-0.0123169	-0.0020488
Uptrend		0.2258584	0.2255573	0.2246848	0.2230365	0.2223499	0.0378896	0.0368675	0.0356646	0.0326135	0.0341723
Political tension		0.3109380	0.3001970	0.2976139	0.3010195	0.3099040	0.0437138	0.0268801	0.0235702	0.0252655	0.0301830
Entire Period	Puts	0.2639753	0.2699019	0.2747172	0.2738141	0.2867827	0.0260733	0.0253729	0.0255009	0.0268809	0.0401483
Downtrend		0.2998157	0.3016821	0.3011370	0.3019467	0.3204402	0.0167382	0.0170670	0.0166730	0.0184353	0.0388296
Uptrend		0.2147691	0.2109897	0.2081318	0.2085122	0.2067968	0.0261456	0.0220590	0.0201592	0.0192449	0.0199240
Political tension		0.3319317	0.3466514	0.3597083	0.3611377	0.3834039	0.0587521	0.0745694	0.0824520	0.0880465	0.1053636
Entire Period	All options	0.2588342	0.2613085	0.2641200	0.2627814	0.2720753	0.0212807	0.0171525	0.0165658	0.0174875	0.0248116
Downtrend		0.2854346	0.2838986	0.2846357	0.2850756	0.2951238	0.0018743	-0.0005380	-0.0001556	0.0010241	0.0135837
Uptrend		0.2190421	0.2175153	0.2171431	0.2174340	0.2164631	0.0306709	0.0286924	0.0286002	0.0274567	0.0287793
Political tension		0.3241624	0.3274478	0.3285888	0.3255121	0.3350791	0.0531868	0.0548553	0.0529425	0.0508430	0.0559338

Table III

The Number of TAIEX Options during the Period January 2002 through May 2004

This table presents the number of contracts traded, open interests in the TAIEX options market and the net buying across three sub-periods. The delta value of each option series is computed using the closing price of TAIEX, the risk-free rate of interest plotted from overnight interbank rate, 10 days, 30 days, 60 days, 90 days, 120 days, 150 days, 180 days and 360 days money market rate by interpolated Cubic B-Spline method matching the option's time to maturity, and the realized volatility over the most recent 60 trading days. All volatilities are annualized. The sample period is from January 2002 to May 2004 which divided into three sub-periods. Downtrend market is from January 2, 2002 to April 30, 2003, uptrend market is from May 1, 2003 to March 19, 2004, and political tension is from March 20, 2004 to May 25, 2004. In panel C, the net buying of contracts across three sub-periods is defined as the number of contracts traded above the prevailing bid/ask midpoint less the number of contracts traded below the prevailing midpoint times the absolute value of the option's delta.

Delta value categorization	Entire Period				Downtrend			
	Calls		Puts		Calls		Puts	
	No. of contract	Prop. of total	No. of contract	Prop. of total	No. of contract	Prop. of entire period	No. of contract	Prop. of entire period
Panel A: Number of contracts traded								
1	1,108,782	0.0403	3,996,301	0.1454	91,602	0.0033	487,689	0.0177
2	2,299,828	0.0837	3,689,707	0.1343	229,243	0.0083	465,371	0.0169
3	2,668,755	0.0971	1,759,682	0.0640	311,669	0.0113	206,713	0.0075
4	4,919,439	0.1790	1,421,776	0.0517	543,465	0.0198	183,948	0.0067
5	5,048,996	0.1837	568,668	0.0207	562,104	0.0205	86,753	0.0032
Totals	16,045,800	0.5839	11,436,134	0.4161	1,738,083	0.0632	1,430,474	0.0521
Panel B: Open interests								
1	2,734,182	0.0436	10,846,542	0.1728	233,655	0.0037	1,205,357	0.0192
2	4,945,940	0.0788	8,155,239	0.1299	484,307	0.0077	1,050,143	0.0167
3	5,321,410	0.0848	3,660,014	0.0583	605,612	0.0096	524,938	0.0084
4	10,052,719	0.1602	3,202,477	0.0510	1,152,063	0.0184	517,865	0.0083
5	12,089,509	0.1926	1,750,494	0.0279	1,461,897	0.0233	291,562	0.0046
Totals	35,143,760	0.5600	27,614,766	0.4400	3,937,534	0.0627	3,589,865	0.0572
Panel C: Net buying of contracts								
1	2,352		-9,462		1,074		-2,883	
2	5,494		47		730		1,090	
3	5,169		1,185		153		1,258	
4	3,430		1,356		-1,702		3,059	
5	2,922		-604		-3,983		1,128	
Totals	19,367		-7,478		-3,728		3,652	

Table III *(continued)*

Delta value categorization	Uptrend				Political tension			
	Calls		Puts		Calls		Puts	
	No. of contract	Prop. of entire period	No. of contract	Prop. of entire period	No. of contract	Prop. of entire period	No. of contract	Prop. of entire period
Panel A: Number of contracts traded								
1	867,904	0.0316	2,789,383	0.1015	149,276	0.0054	719,229	0.0262
2	1,808,602	0.0658	2,607,648	0.0949	261,983	0.0095	616,688	0.0224
3	1,813,396	0.0660	1,165,257	0.0424	543,690	0.0198	387,712	0.0141
4	3,610,846	0.1314	1,016,019	0.0370	765,128	0.0278	221,809	0.0081
5	3,567,310	0.1298	315,271	0.0115	919,582	0.0335	166,644	0.0061
Totals	11,668,058	0.4246	7,893,578	0.2872	2,639,659	0.0961	2,112,082	0.0769
Panel B: Open interests								
1	2,122,418	0.0338	7,934,054	0.1264	378,109	0.0060	1,707,131	0.0272
2	3,880,273	0.0618	5,692,836	0.0907	581,360	0.0093	1,412,260	0.0225
3	3,846,807	0.0613	2,270,409	0.0362	868,991	0.0138	864,667	0.0138
4	7,571,291	0.1206	1,881,286	0.0300	1,329,365	0.0212	803,326	0.0128
5	8,685,001	0.1384	797,548	0.0127	1,942,611	0.0310	661,384	0.0105
Totals	26,105,790	0.4160	18,576,133	0.2960	5,100,436	0.0813	5,448,768	0.0868
Panel C: Net buying of contracts								
1	1,670		-8,003		-392		1,424	
2	5,717		-3,197		-953		2,154	
3	5,146		-1,221		-130		1,148	
4	6,269		-2,929		-1,137		1,226	
5	7,994		-1,871		-1,089		139	
Totals	26,796		-17,221		-3,701		6,091	

Table IV

Summary of Regression Results for the Impact of the Net Buying Pressure on the Changes of Implied Volatility for TAIEX Options during the Period January 2002 through May 2004

The regression underlying the results reported in this table is

$$\Delta\sigma_t = \alpha_0 + \alpha_1 RS_t + \alpha_2 VS_t + \alpha_3 D_{1,t} + \alpha_4 D_{2,t} + \alpha_5 \Delta\sigma_{t-1} + \varepsilon_t$$

where $\Delta\sigma_t$ is the change in the option's implied volatility in moneyness category from the close on day $t-1$ to the close on day t, RS_t is the index return from the close on day $t-1$ to the close on day t, VS_t is the stock volume on day t expressed in millions of New Taiwan dollars, and $D_{1,t}$ and $D_{2,t}$ are summed net buying pressures over day t. Panel A contains the results for the change in the implied volatility of ATM call options, Panel B contains the results for the change in the implied volatility of ATM put options, Panel C contains the results for the change in the implied volatility of OTM call options, and Panel D contains the results for the change in the implied volatility of OTM put options. An asterisk * is attached when the coefficient is significant at the 5% significance level. The sample period is from January 2002 to May 2004 which divided into three sub-periods. Downtrend market is from January 2, 2002 to April 30, 2003, uptrend market is from May 1, 2003 to March 19, 2004, and political tension is from March 20, 2004 to May 25, 2004.

D_1	D_2	Parameter estimates												
		Adj. R^2	α_0	*(p-Value)*	α_1	*(p-Value)*	α_2	*(p-Value)*	α_3	*(p-Value)*	α_4	*(p-Value)*	α_5	*(p-Value)*
Panel A: Changes in ATM call volatility as function of D_1 and D_2														
ENBP_ATMC	ENBP_ATMP	0.22772	-0.00658*	(0.03265)	-0.40403*	(0.00000)	0.00007*	(0.01398)	0.05344*	(0.03876)	0.04507*	(0.04458)	-0.41527*	(0.00000)
DNBP_ATMC	DNBP_ATMP	0.22894	-0.00245	(0.61079)	-0.50090*	(0.00004)	0.00003	(0.52280)	0.08013*	(0.02469)	0.05157	(0.07826)	-0.40468*	(0.00000)
UNBP_ATMC	UNBP_ATMP	0.14275	-0.00852*	(0.01923)	-0.28181*	(0.04060)	0.00009*	(0.00868)	-0.01307	(0.69457)	-0.01091	(0.73349)	-0.33207*	(0.00000)
PNBP_ATMC	PNBP_ATMP	0.36993	-0.04507*	(0.02092)	-0.10335	(0.72002)	0.00037*	(0.01632)	0.22282	(0.80036)	0.28909	(0.71462)	-0.52825*	(0.00009)
Panel B: Changes in ATM put volatility as function of D_1 and D_2														
ENBP_ATMP	ENBP_ATMC	0.14954	-0.00217	(0.55803)	-0.15934	(0.10982)	0.00002	(0.51579)	0.01569*	(0.00562)	0.00041*	(0.00989)	-0.39800*	(0.00000)
DNBP_ATMP	DNBP_ATMC	0.17107	0.00294	(0.61240)	0.16702	(0.24779)	-0.00004	(0.54361)	-0.01772	(0.61719)	-0.02497	(0.56174)	-0.42749*	(0.00000)
UNBP_ATMP	UNBP_ATMC	0.18642	-0.00682	(0.05678)	0.30045*	(0.02811)	0.00006	(0.08365)	0.04122	(0.19202)	-0.01390	(0.67063)	-0.39313*	(0.00000)
PNBP_ATMP	PNBP_ATMC	0.44541	0.01716	(0.41826)	-1.49068*	(0.00004)	-0.00010	(0.56308)	1.04074	(0.24291)	1.36080	(0.16987)	-0.46594*	(0.00030)
Panel C: Changes in OTM call volatility as function of D_1 and D														
ENBP_OTMC	ENBP_ATMC	0.21075	-0.00536*	(0.00556)	-0.32187*	(0.00000)	0.00006*	(0.00281)	0.00742*	(0.00785)	0.01024	(0.52316)	-0.37661*	(0.00000)
ENBP_OTMC	ENBP_ATMP	0.21216	-0.00525*	(0.00664)	-0.29678*	(0.00000)	0.00006*	(0.00357)	0.00911*	(0.00737)	0.01672	(0.22932)	-0.38054*	(0.00000)
DNBP_OTMC	DNBP_ATMC	0.24468	-0.00085	(0.78049)	-0.31129*	(0.00003)	0.00000	(0.88434)	0.00893	(0.77118)	0.01169	(0.60448)	-0.44129*	(0.00000)
DNBP_OTMC	DNBP_ATMP	0.24759	-0.00063	(0.83566)	-0.27287*	(0.00021)	0.00000	(0.95864)	0.01070	(0.72602)	0.02261	(0.22292)	-0.44845*	(0.00000)

Table IV *(continued)*

D_1	D_2	Parameter estimates											
		Adj. R^2	α_0	*(p-Value)*	α_1	*(p-Value)*	α_2	*(p-Value)*	α_3	*(p-Value)*	α_4	*(p-Value)*	α_5	*(p-Value)*
UNBP_OTMC	UNBP_ATMC	0.07556	-0.00698*	(0.00333)	-0.17587	(0.05815)	0.00007*	(0.00060)	0.90777	(0.30044)	-0.00409	(0.83208)	-0.20571*	(0.00226)
UNBP_OTMC	UNBP_ATMP	0.07797	-0.00684*	(0.00415)	-0.16439	(0.07552)	0.00007*	(0.00075)	0.91265	(0.29838)	0.01474	(0.42943)	-0.20263*	(0.00275)
PNBP_OTMC	PNBP_ATMC	0.31061	-0.02798*	(0.01517)	-0.52724*	(0.00930)	0.00022*	(0.01208)	0.17930	(0.96961)	0.24329	(0.58702)	-0.17573*	(0.02060)
PNBP_OTMC	PNBP_ATMP	0.30558	-0.02632*	(0.02131)	-0.49797*	(0.01925)	0.00021*	(0.01421)	0.13125	(0.97784)	0.01074	(0.97870)	-0.18534*	(0.01836)
Panel D: Changes in OTM put volatility as function of D_1 and D_2														
ENBP_OTMP	ENBP_ATMC	0.09577	0.00132	(0.66553)	-0.27855*	(0.00157)	-0.00001	(0.63176)	0.18106*	(0.00400)	-0.00860	(0.73650)	-0.28977*	(0.00000)
ENBP_OTMP	ENBP_ATMP	0.09797	0.00116	(0.70258)	-0.30218*	(0.00061)	-0.00001	(0.68490)	0.12711*	(0.00554)	-0.02746	(0.21621)	-0.29244*	(0.00000)
DNBP_OTMP	DNBP_ATMC	0.12086	0.00424	(0.31239)	0.21717	(0.06228)	-0.00005	(0.24895)	0.22879	(0.32191)	-0.04198	(0.18180)	-0.36097*	(0.00000)
DNBP_OTMP	DNBP_ATMP	0.11859	0.00367	(0.38076)	0.16958	(0.14397)	-0.00004	(0.34721)	0.31923	(0.16676)	-0.02547	(0.32429)	-0.36445*	(0.00000)
UNBP_OTMP	UNBP_ATMC	0.07233	-0.00518*	(0.00725)	0.08319	(0.23909)	0.00004*	(0.00874)	0.06254	(0.91513)	-0.01873	(0.23913)	-0.23329*	(0.00050)
UNBP_OTMP	UNBP_ATMP	0.06779	-0.00506*	(0.00902)	0.07456	(0.29336)	0.00005*	(0.00854)	0.12431	(0.83183)	0.00728	(0.63419)	-0.23339*	(0.00052)
PNBP_OTMP	PNBP_ATMC	0.59904	0.07024*	(0.00385)	-1.34067*	(0.00035)	-0.00043*	(0.01870)	28.48480*	(0.00099)	1.15762	(0.20928)	-0.27865*	(0.00799)
PNBP_OTMP	PNBP_ATMP	0.58684	0.07613*	(0.00169)	-1.29924*	(0.00077)	-0.00049*	(0.00595)	30.99184*	(0.00148)	-0.56212	(0.54726)	-0.26680*	(0.01239)

Note: ENBP_ATMC stands for entire period's net buying pressure on at-the-money call options, DNBP_ATMC for downtrend's net buying pressure on at-the-money call options, UNBP_ATMC for uptrend's net buying pressure on at-the-money call options, and PNBP_ATMC for downtrend's net buying pressure on at-the-money call options. In the same way, ENBP_ATMP, ENBP_OTMC, ENBP_OTMP stand for entire period's net buying pressure on at-the-money put options, out-the-money call options, and out-the-money put options, respectively.

Table V

Summary of Regression Results for the Relationship between the Net Buying Pressure and the TAIEX Return during the Period January 2002 through May 2004

The regression underlying the results reported in this table is

$$NBP_t = \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 r_t + \alpha_3 r_{t+1} + \alpha_4 NBP_{t-1} + \varepsilon_t$$

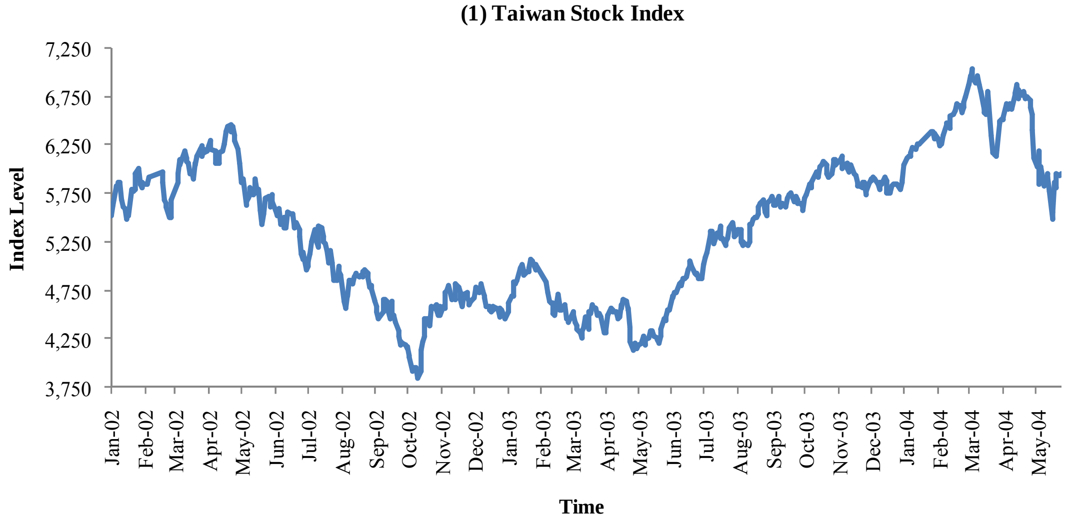
where NBP_t is the summed net buying pressure over day t, and r_t is the return of TAIEX over day t. An asterisk * is attached when the coefficient is significant at the 5% significance level. The sample period is from January 2002 to May 2004 which divided into three sub-periods. Downtrend market is from January 2, 2002 to April 30, 2003, uptrend market is from May 1, 2003 to March 19, 2004, and political tension is from March 20, 2004 to May 25, 2004.

Category	Period	Parameter estimates										
		Adj. R^2	α_0	*(p-Value)*	α_1	*(p-Value)*	α_2	*(p-Value)*	α_3	*(p-Value)*	α_4	*(p-Value)*
Panel A: Relations between call option's net buying pressure and returns of TAIEX												
ITM	Total	0.21880	-8.06881*	(0.00026)	-601.66313*	(0.00006)	1671.54063*	(0.00000)	-161.79144	(0.22512)	0.11743*	(0.00409)
	Downtrend	0.37920	5.48176*	(0.00331)	-225.90358	(0.08519)	1451.02626*	(0.00000)	-23.25351	(0.82139)	0.06809	(0.22352)
	Uptrend	0.29998	-29.92226*	(0.00000)	-1141.17804*	(0.00986)	3596.67332*	(0.00000)	-51.48641	(0.88086)	0.07603	(0.25641)
	Political tension	0.15867	-27.42885*	(0.01248)	-507.66089	(0.25896)	781.26659	(0.07291)	-497.21454	(0.29637)	-0.24931	(0.10452)
ATM	Total	0.11057	-3.84135*	(0.00074)	-63.27971	(0.38767)	600.41195*	(0.00000)	-92.69136	(0.17973)	0.05924	(0.15262)
	Downtrend	0.27753	0.93137	(0.28225)	-42.54443	(0.46005)	549.92942*	(0.00000)	-49.61058	(0.30944)	0.05381	(0.33718)
	Uptrend	0.08212	-13.06782*	(0.00000)	-79.13207	(0.72929)	1056.70421*	(0.00000)	-162.27731	(0.42024)	0.00573	(0.93293)
	Political tension	0.04531	0.24408	(0.96501)	187.61787	(0.45422)	535.72233*	(0.02391)	53.32313	(0.83869)	-0.07261	(0.65891)
OTM	Total	0.20362	-4.20475*	(0.00000)	-177.90188*	(0.00148)	607.98573*	(0.00000)	-103.19309*	(0.04055)	0.12656*	(0.00206)
	Downtrend	0.38285	-1.51335*	(0.01167)	-85.26996*	(0.04552)	473.89076*	(0.00000)	-35.25182	(0.29223)	0.07234	(0.19689)
	Uptrend	0.18119	-8.02950*	(0.00011)	-520.26052*	(0.00460)	1144.56815*	(0.00000)	-287.78208	(0.06397)	0.14703*	(0.02824)
	Political tension	0.40878	-4.95816	(0.09840)	-17.66134	(0.91236)	688.04432*	(0.00000)	-114.15829	(0.37938)	0.05395	(0.73286)

Table V *(continued)*

Category	Period	Adj. R^2	α_0	*(p-Value)*	α_1	*(p-Value)*	α_2	*(p-Value)*	α_3	*(p-Value)*	α_4	*(p-Value)*
Panel B: Relations between put option's net buying pressure and returns of TAIEX												
ITM	Total	0.24213	-2.23448	(0.27456)	483.11652*	(0.00081)	-1708.50434*	(0.00000)	66.78327	(0.59588)	0.09498*	(0.02072)
	Downtrend	0.36837	9.34208*	(0.00000)	-57.20472	(0.58013)	-1124.33172*	(0.00000)	59.75602	(0.46539)	0.02677	(0.63307)
	Uptrend	0.28213	-14.72986*	(0.00022)	1747.30512*	(0.00001)	-2879.51870*	(0.00000)	328.65111	(0.28971)	0.07040	(0.27911)
	Political tension	0.32418	-22.00519	(0.12468)	1317.07303	(0.05684)	-2614.67185*	(0.00003)	308.97535	(0.61935)	0.14822	(0.33538)
ATM	Total	0.14232	-0.52030	(0.58783)	159.13900*	(0.01241)	-578.41940*	(0.00000)	93.06775	(0.11612)	0.10009*	(0.01504)
	Downtrend	0.25482	1.86327*	(0.00610)	-31.33579	(0.47490)	-394.86462*	(0.00000)	70.57649	(0.06196)	-0.00739	(0.89553)
	Uptrend	0.13746	-2.39162	(0.24197)	749.24770*	(0.00006)	-833.29532*	(0.00000)	290.15530	(0.07786)	0.17595*	(0.00764)
	Political tension	0.25402	-15.15445*	(0.01950)	-3.64044	(0.99003)	-1034.25002*	(0.00010)	70.62888	(0.79014)	-0.07974	(0.61054)
OTM	Total	0.15547	-2.20210*	(0.01030)	221.03763*	(0.00009)	-503.80722*	(0.00000)	55.01744	(0.29354)	0.17073*	(0.00003)
	Downtrend	0.31084	0.43237	(0.49399)	58.23339	(0.17646)	-430.77521*	(0.00000)	45.69523	(0.20116)	0.13601*	(0.01855)
	Uptrend	0.12907	-5.30965*	(0.00739)	749.98434*	(0.00002)	-698.39265*	(0.00006)	258.55941	(0.09863)	0.19056*	(0.00338)
	Political tension	0.23713	-14.60716*	(0.00160)	155.00412	(0.39413)	-617.17790*	(0.00025)	-50.88184	(0.76352)	-0.06820	(0.65945)

Figure 1



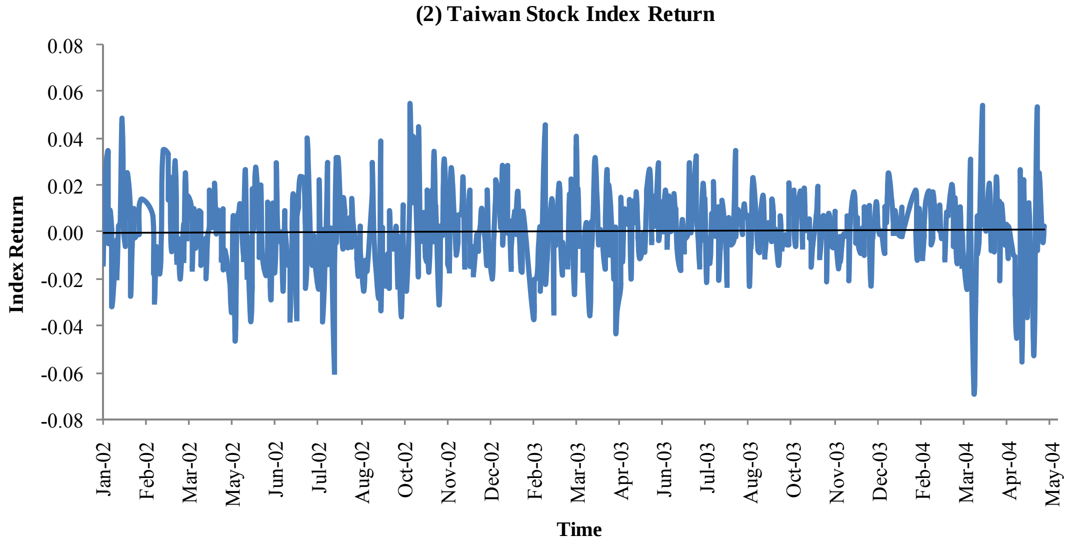


Figure 1. Taiwan Stock Index during the Period January 2002 through May 2004. This figure explains TAIEX spot levels and returns from January 2002 through May 2004.

Figure 2

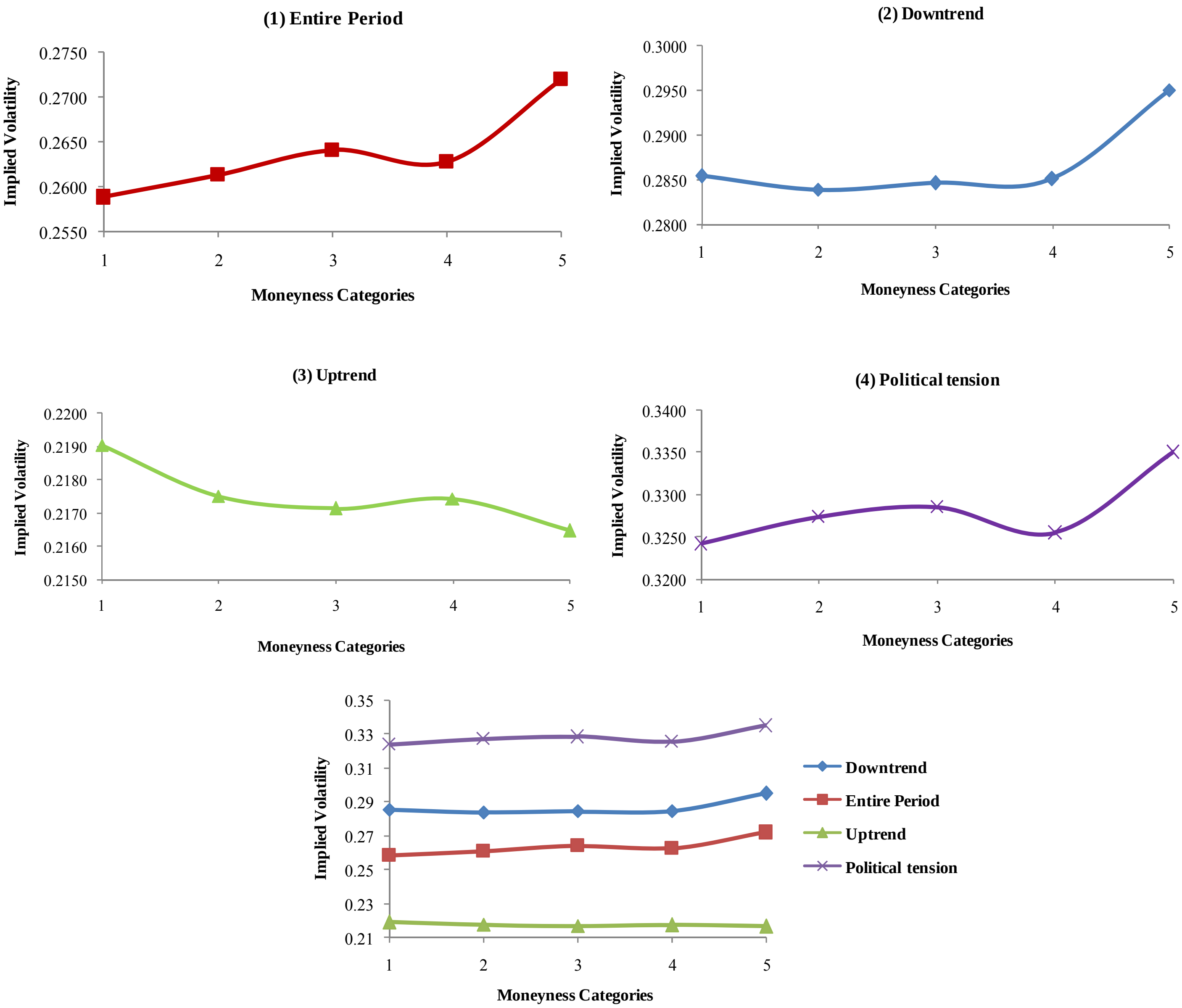


Figure 2. Estimated Implied Volatility Functions (IVFs) of TAIEX Options during the Period January 2002 through May 2004. The IVF is the average implied volatility of options in five moneyness categories based option's delta, which can be interpreted as the likelihood of being exercise at maturity. For calls, the five delta (Δ) categories are $0.875 \leq \Delta \leq 0.98$, $0.625 \leq \Delta < 0.875$, $0.375 \leq \Delta < 0.625$, $0.125 \leq \Delta < 0.375$, and $0.02 \leq \Delta < 0.125$. The corresponding put categories are $-0.02 \geq \Delta > -0.125$, $-0.125 \geq \Delta > -0.375$, $-0.375 \geq \Delta > -0.625$, $-0.625 \geq \Delta > -0.875$, and $-0.875 \geq \Delta \geq -0.98$. The Black and Scholes (1973) formula is used to compute implied volatilities for TAIEX options by using Newton Raphson method. The delta value of each option series is computed using the closing price of TAIEX, the risk-free rate of interest plotted from overnight interbank rate, 10 days, 30 days, 60 days, 90 days, 120 days, 150 days, 180 days and 360 days money market rate by interpolated Cubic B-Spline method matching the option's time to maturity, and the realized volatility over the most recent 60 trading days. All volatilities are annualized. The sample period is divided into three sub-periods. Downtrend market is from January 2, 2002 to April 30, 2003, uptrend market is from May 1, 2003 to March 19, 2004, and political tension is from March 20, 2004 to May 25, 2004.

Figure 3

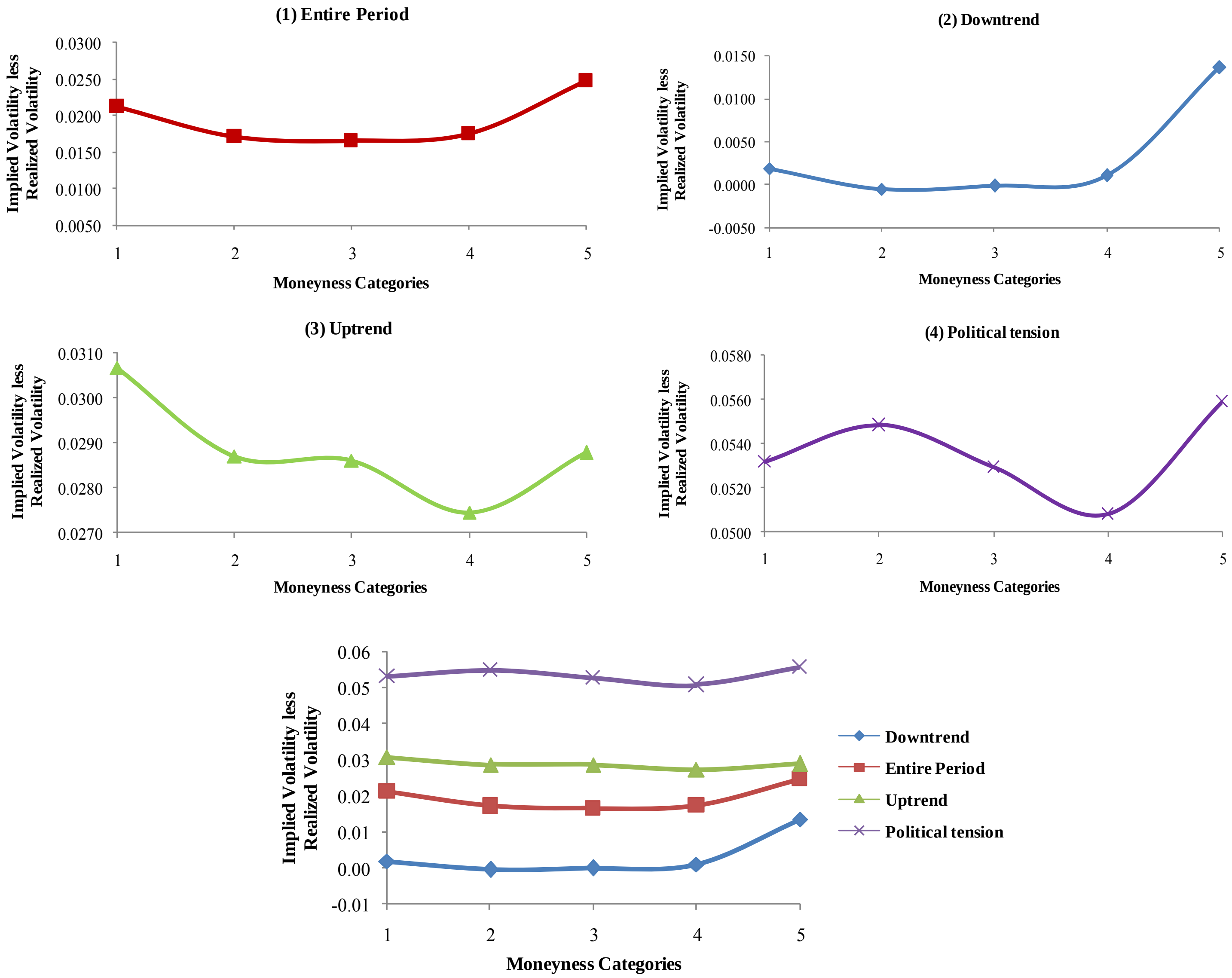
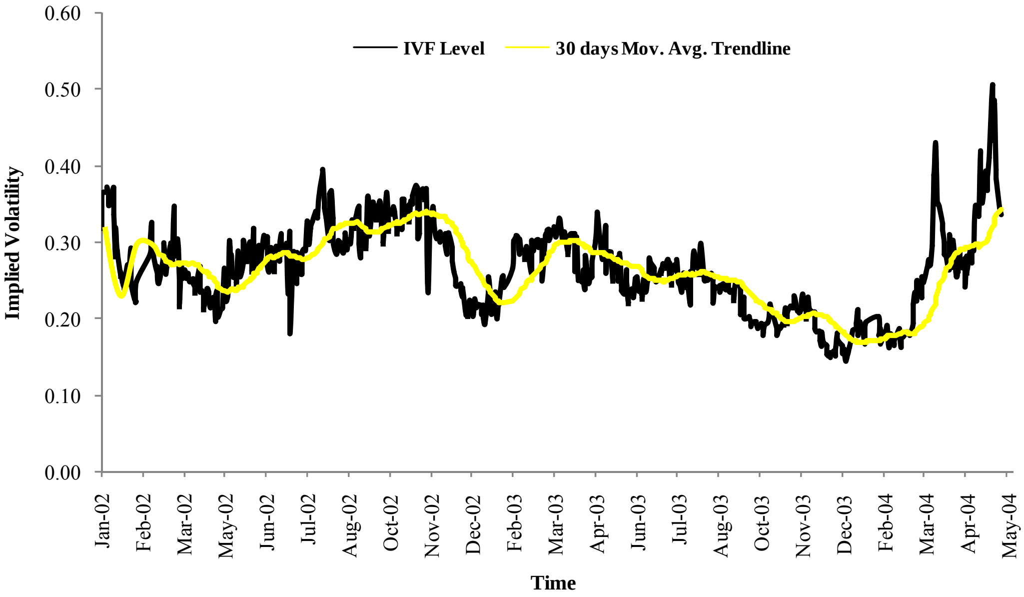


Figure 3. Average Difference between Implied Volatility and Realized Volatility for TAIEX Options during the Period January 2002 through May 2004. The IVF is the average implied volatility of options in five moneyness categories based option's delta, which can be interpreted as the likelihood of being exercise at maturity. For calls, the five delta (Δ) categories are $0.875 \leq \Delta \leq 0.98$, $0.625 \leq \Delta < 0.875$, $0.375 \leq \Delta < 0.625$, $0.125 \leq \Delta < 0.375$, and $0.02 \leq \Delta < 0.125$. The corresponding put categories are $-0.02 \geq \Delta > -0.125$, $-0.125 \geq \Delta > -0.375$, $-0.375 \geq \Delta > -0.625$, $-0.625 \geq \Delta > -0.875$, and $-0.875 \geq \Delta \geq -0.98$. The Black and Scholes (1973) formula is used to compute implied volatilities for TAIEX options by using Newton Raphson method. The realized volatility is computed from TAIEX daily return over the most recent 60 trading days. The delta value of each option series is computed using the closing price of TAIEX, the risk-free rate of interest plotted from overnight interbank rate, 10 days, 30 days, 60 days, 90 days, 120 days, 150 days, 180 days and 360 days money market rate by interpolated Cubic B-Spline method matching the option's time to maturity, and the realized volatility over the most recent 60 trading days. All volatilities are annualized. The sample period is divided into three sub-periods. Downtrend market is from January 2, 2002 to April 30, 2003, uptrend market is from May 1, 2003 to March 19, 2004, and political tension is from March 20, 2004 to May 25, 2004.

Figure 4

(1) TAIEX Options Implied Volatilities



(2) TAIEX Options
Implied Volatilities and Realized Volatilities

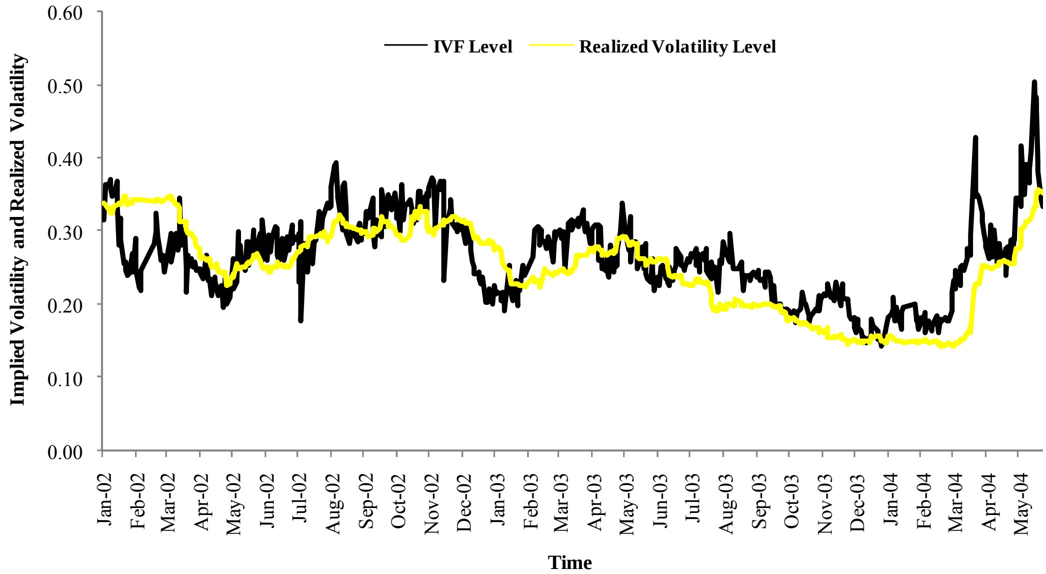


Figure 4. Level of TAIEX Options Implied Volatility Function (IVF) and Realized Volatility during the Period January 2002 through May 2004. The IVF is the average implied volatility of options in five moneyness categories based option's delta, which can be interpreted as the likelihood of being exercise at maturity. For calls, the five delta (Δ) categories are $0.875 \leq \Delta \leq 0.98$, $0.625 \leq \Delta < 0.875$, $0.375 \leq \Delta < 0.625$, $0.125 \leq \Delta < 0.375$, and $0.02 \leq \Delta < 0.125$. The corresponding put categories are $-0.02 \geq \Delta > -0.125$, $-0.125 \geq \Delta > -0.375$, $-0.375 \geq \Delta > -0.625$, $-0.625 \geq \Delta > -0.875$, and $-0.875 \geq \Delta \geq -0.98$. The Black and Scholes (1973) formula is used to compute implied volatilities for TAIEX options by using Newton Raphson method. The realized volatility is computed from TAIEX daily return over the most recent 60 trading days. The delta value of each option series is computed using the closing price of TAIEX, the risk-free rate of interest plotted from overnight interbank rate, 10 days, 30 days, 60 days, 90 days, 120 days, 150 days, 180 days and 360 days money market rate by interpolated Cubic B-Spline method matching the option's time to maturity, and the realized volatility over the most recent 60 trading days. All volatilities are annualized. "Level" under IVF is the average implied volatility of category three options.

Figure 5

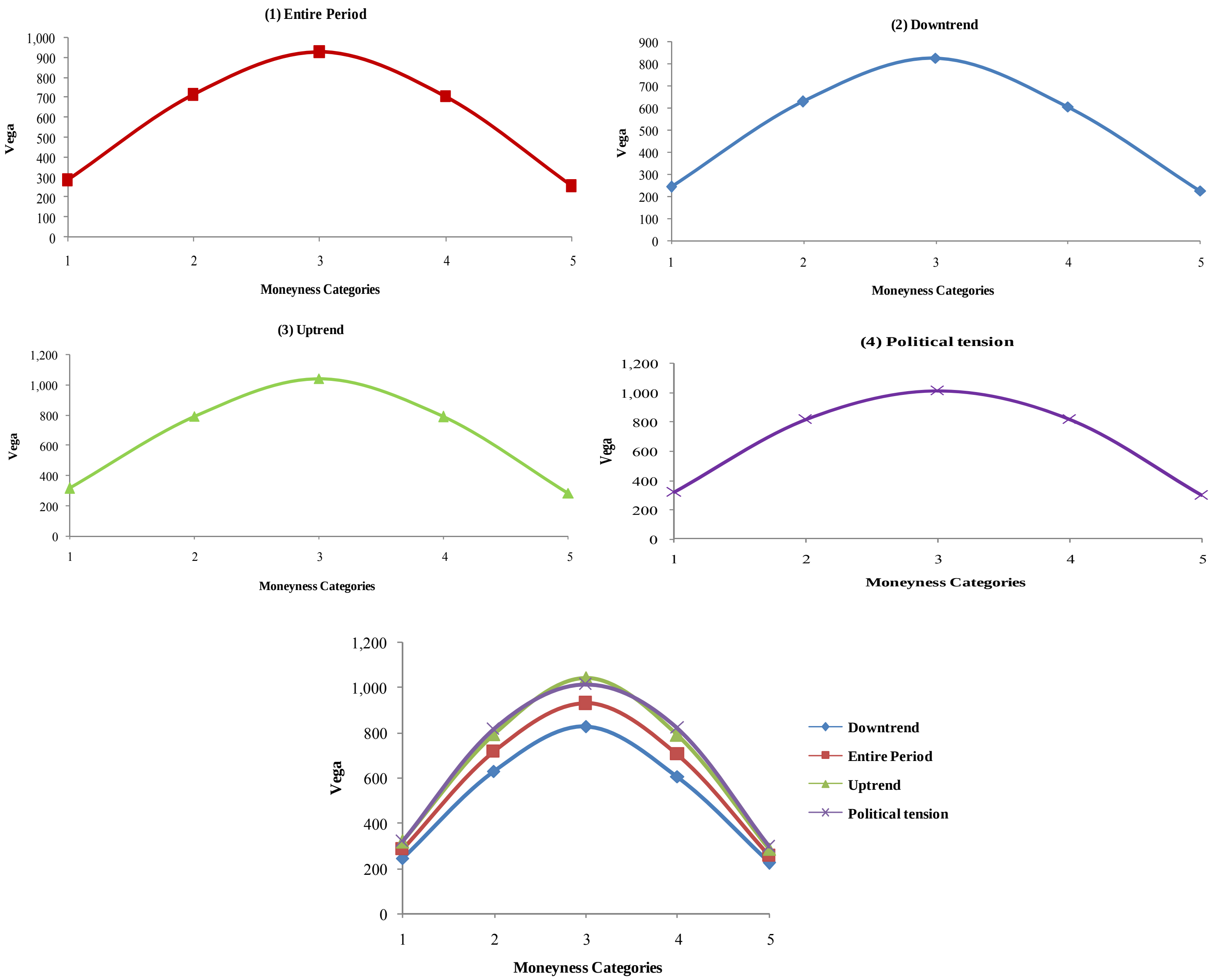


Figure 5. Estimated Vega of TAIEX Options during the Period January 2002 through May 2004. The estimated vega is the average vega of options in five moneyness categories based option's delta, which can be interpreted as the likelihood of being exercise at maturity. For calls, the five delta (Δ) categories are $0.875 \leq \Delta \leq 0.98$, $0.625 \leq \Delta < 0.875$, $0.375 \leq \Delta < 0.625$, $0.125 \leq \Delta < 0.375$, and $0.02 \leq \Delta < 0.125$. The corresponding put categories are $-0.02 \geq \Delta > -0.125$, $-0.125 \geq \Delta > -0.375$, $-0.375 \geq \Delta > -0.625$, $-0.625 \geq \Delta > -0.875$, and $-0.875 \geq \Delta \geq -0.98$. The delta value of each option series is computed using the closing price of TAIEX, the risk-free rate of interest plotted from overnight interbank rate, 10 days, 30 days, 60 days, 90 days, 120 days, 150 days, 180 days and 360 days money market rate by interpolated Cubic B-Spline method matching the option's time to maturity, and the realized volatility over the most recent 60 trading days. The realized volatility is annualized. The sample period is divided into three sub-periods. Downtrend market is from January 2, 2002 to April 30, 2003, uptrend market is from May 1, 2003 to March 19, 2004, and political tension is from March 20, 2004 to May 25, 2004.