Relationship of the change in implied volatility with the underlying equity index return in Thailand

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Abstract

The main purpose of this study is to examine the relationship between the change in implied volatility index and the underlying stock index return. The dataset used in this study is from 11/19/2010 to 12/27/2013. The regression analysis is performed on stationary series. The empirical results reveal that there is evidence of a significantly negative and asymmetric relationship between the return and the change in implied volatility in the Thai stock market. The finding in this study gives implication for risk management.

Keywords: Equity index return, implied volatility, asymmetric effect
JEL classification: G15, C22

1. Introduction

The leverage effect posits that stock return shocks lead to asymmetric changes of expected volatilities in stock markets (see details in Black, 1976, and Christie, 1982). For the implied volatility literature, the evidence on the asymmetric impacts of the underlying index returns on implied volatility indices is recently well-documented.[1] Since the implied volatility index can measure investors' sentiment or fear, investors' fear that is defined in the sense that a decline in the equity index or negative index

[1] Implied volatility index is also known as the investors fear guage index (Whaley, 2000).

return and if negative return is associated with an asymmetrically larger rise in the implied volatility index, investors will take this phenomenon into account when they make decision. The asymmetric relationship between index return and the change in implied volatility index is well documented (see for example, Flemming et al., 1995, Whaley, 2000, and Giot, 2005). Giot (2005) finds that the S&P100 index exhibits the statistically negative relationship with its implied volatility. The relationship exhibits asymmetry and thus indicates that negative stock return yields bigger change in the corresponding implied volatility than does positive return. Bollerslev and Zhou (2006) find that the leverage effect is always stronger for implied volatility than realized volatility in the US stock market.

For other stock markets, Tang (2007) finds a negative correlation between the index return and the implied volatility in the Korean stock market. Frijns et al. (2010) finds that the relationship between implied volatility and the underlying index return is significantly negative and asymmetric in the Australian stock market. Siriopoulos and Fassas (2012) find that there is a significant negative and asymmetric relationship between the change in implied volatility index and the underlying equity index return in the Greek stock market, which is contradictory to the previous finding of Skiadopoulos (2004) that the relationship does not exist.

Even though there is a growing literature on the relationship between the implied volatility indices and their underlying stock index returns in advanced stock markets, few research works have been conducted regarding emerging stock markets. The present study uses the Thai stock market as a case study to examine the relationship between the Thai implied volatility index and it underlying index return. The results of regression analysis suggest that there exists the asymmetrically negative relationship of the change in implied volatility index with the underlying stock index return. The next section describes the data and empirical models used in the regression analysis. Section 3 presents empirical results and the last section concludes.

2. Analytical framework

2.1 Data

The dataset in the present study obtained from Dadastream consists of daily closing prices of the SET50 index and the implied volatility index.[2] The period in the analysis covers 11/19/2010 to 12/27/2013 with 634 observations. The change in the SET50 index, comprising 50 companies with large market capitalization from various equity sectors, is used as a proxy of the stock market return because the index is constructed to accommodate the issuing of options in the Stock Exchange of Thailand (SET). The descriptive statistics and unit root test statistics of the return and the change in implied volatility index are shown in Table 1. The mean of daily return is small and close to zero. The return series is positively skewed and leptokurtic. The Jarque-Bera statistic indicates that the return series is not normally distributed. For the change in implied volatility index, the mean is negative but close to zero while the series is positively

[2] The implied volatility index is constructed by using Black and Sholes formula as explained in Thakolsri et al. (2015).

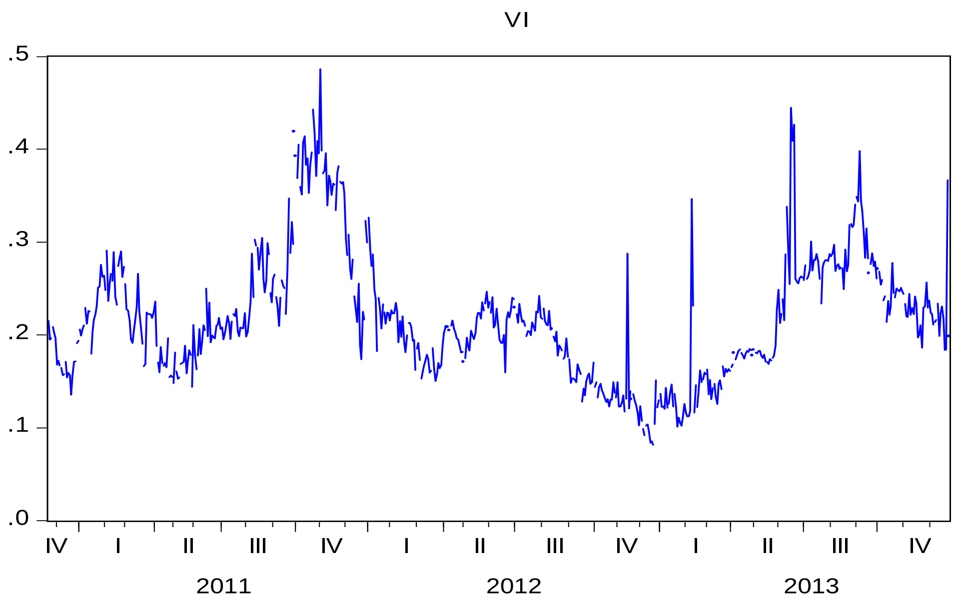
skewed and leptokurtic. This series is also not normally distributed. Both series exhibit negatively serially correlated as shown by the first-order autocorrelation coefficients, which suggest that there are mean reversion processes. In addition, the ADF statistics indicate that both series are stationary. Therefore, OLS estimates should be suitable.

Table 1. Descriptive and unit root test statistics of the return and the change in implied volatility (11/19/2010-12/27/2013)

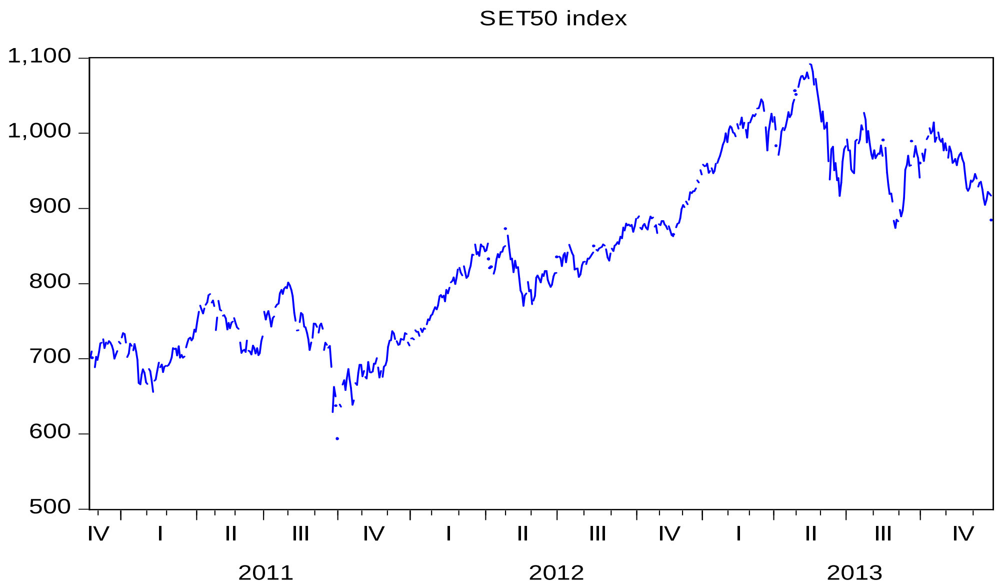
	r_t	Δv_t
Mean	0.0004	-2.70E05
Median	0.0015	-0.0004
Maximum	0.0758	0.2280
Minimum	-0.0910	-0.1686
Standard deviation	0.0144	0.0295
Skewness	-0.0144	0.9373
Kurtosis	7.7442	19.5125
Jarque-Bera statistic	612.890	7,284.159
First-order autocorrelation	-0.051	-0.334
ADF statistic (constant only)	-26.283 [0]	-16.752 [3]
	(0.000)	(0.000)
ADF statistic (constant and trend)	-26.272 [0]	-16.738 [3]
	(0.000)	(0.000)

Note: The series r and Δv are the return and the change in implied volatility index, respectively. The number in bracket is the optimal lag length determined by Akaike information criterion. The number in parenthesis is the probability of accepting the null hypothesis of unit root.

The evolutions of the implied volatility index and the equity index series are shown in Figure 1.



(a) Implied volatility index series



(b) SET50 index series

Figure 1. Daily prices of implied volatility and SET50 (11/19/2010-12/27/2013)

The stock index seems to exhibit a rising trend while the implied volatility index shows no trend. The stock index is highest at the beginning of the third quarter of 2013 and lowest during the third and fourth quarter of 2011. The implied volatility index exhibits at least two peaks during the period of investigation.

2.2 Empirical Models

The simplest way of investigating the relationship between the change in implied volatility index and the underlying equity index return is a simple regression of stationary series expressed as:

$$\Delta v_t = a_0 + a_1 r_t + e_t \tag{1}$$

where Δv is the change in implied volatility index, and r is the equity index return. Theoretically, the coefficient a_0 should be insignificant and the coefficient a_1 should be significantly negative. However, there are both positive and negative return shocks in the stock market that can be separated. Thus the equation that can be used to test for the asymmetric effect of positive and negative return can be expressed as:

$$\Delta v_t = \alpha_0 + \alpha_1 r(+)_t + \alpha_2 r(-)_t + \alpha_3 \Delta v_{t-1} + e_t \tag{2}$$

where r(+) denotes positive return and r(-1) denotes negative return. The inclusion of lagged change in implied volatility gives a room to test for the possibility of mean reversion in implied volatility. If the model in equation (2) is correct, the intercept term should not be significantly different from zero. Moreover, the two coefficients in the model should be significantly different from zero with different sizes. The model in equation (2) is used by Siriopoulos and Fassas (2012) who do not include the lagged change in implied volatility in the equation.

Other models that are used by Ederington and Guan (2010) to test for the relationship of the change in implied volatility with equity index return can be expressed as:

$$\Delta v_t = \alpha_0 + \alpha_1 r_t + \alpha_2 r(-)_t + \alpha_3 r_{t-1} + \alpha_4 \Delta v_{t-1} + e_t \quad (3)$$

and

$$\Delta v_t = \alpha_0 + \alpha_1 r_t + \alpha_2 r(-)_t + \alpha_3 r_{t-1} + \alpha_4 \Delta v_{t-1} + \alpha_5 r_t^2 + e_t \quad (4)$$

In equations (3) and (4), r(-1) is equal to r if r is less than zero and zero otherwise. The negative coefficient of r(-1) indicates the asymmetric impacts of negative and positive return shocks, i. e., the implied volatility tends to increase more following a negative return than it falls following a positive return. The lagged return is included to test for the possibility of lags or reversals in the relationship. If the coefficient of the squared return (r^2) is significantly negative, the relationship is non-linear.

3. Empirical Results

In the present study, the Thai implied volatility index is considered to be a proxy for expected risk while the SET50 index is a proxy of the Thai stock market. In an attempt to examine the relationship between the change in implied volatility and stock index return are plotted as shown in Figure 2.

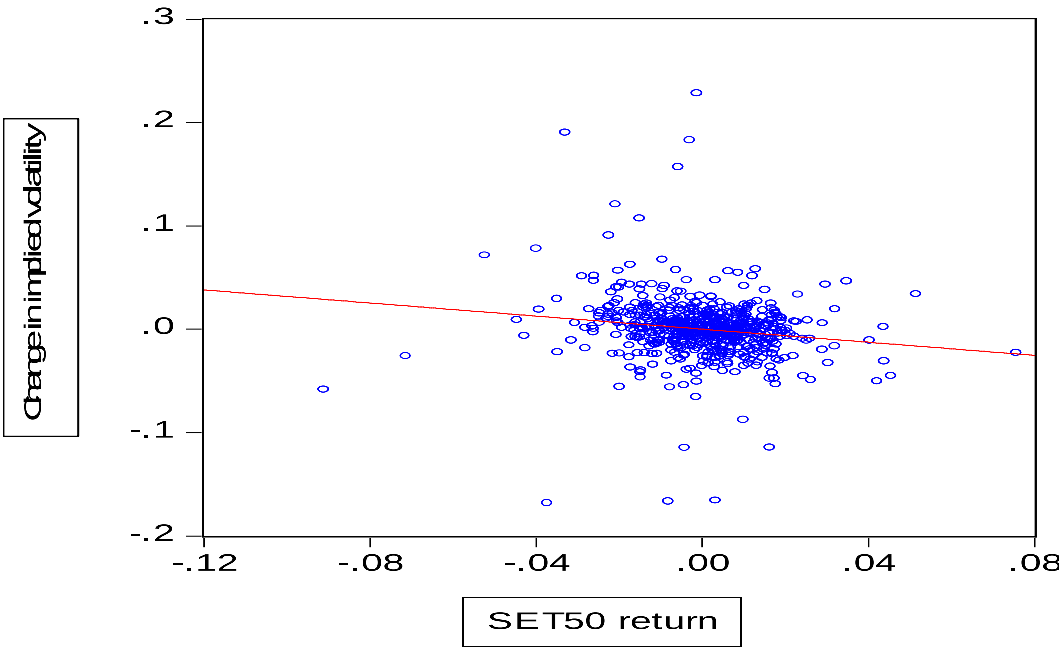


Figure 2. Daily return of SET50 index and changes in implied volatility: 2011-2013.

In Figure 2, the scattered diagram of daily SET50 return and the change in implied volatility suggests a negative relationship. The simple regression analysis of equation

(1) gives the coefficient of negative slope of -0.678 and is highly significant. However, the Durbin-Watson statistic is 2.639, which is substantially above 2 and indicates that there can be a negative serial correlation in the estimated equation. In other words, the estimated equation might not be valid.

Further regression analysis of the daily change in implied volatility index with the separated positive and negative returns expressed in equation (2) gives the results as shown in Table 2.

Table 2 Results of the least sqaure estimate of the change in implied volatility and separated positive and negative index returns

Dependent variable: Δv_t				
	Intercept	$r(+)_t$	$r(-1)_t$	Δv_{t-1}
Coefficient	-0.001	-0.275	-0.469	-0.364
	(0.617)	(0.050)	(0.000)	(0.000)
Adjusted $R^2 = 0.143$, F = 36.198, D-W = 2.142				

Note: The number in parenthesis is the probability. Δv denotes the change in implied volatility index. r(+) denotes positive return while r(-) denotes negative return.

The results in Table 2 show that the estimated intercept in the OLS estimate is statistically insignificant or is zero, which indicates that if the equity index does not change over the day, the change in respective implied volatility index should be very small. The estimated coefficient of the negative return is significant at the 1 percent level and larger than that of the positive return, which is significant at the 5 percent level. Specifically, if the SET50 index exhibits a negative return of 100 basis points or +1 percent, the implied volatility will rise by 0.469 percent. However, a positive return of the same size will cause smaller drop in implied volatility, i.e. the index exhibits a positive return of -1 percent, implied volatility index will drop by 0.275 percent. The Wald coefficient restriction test shows that the null hypothesis that the absolute value of the coefficient of the negative return is 1.5 times of that of the positive return cannot be rejected. Therefore, the negative return shocks impose a larger impact than the negative return shocks on implied volatility.[3] In addition, the highly significance of the negative coefficient of the one-day lag of the change in implied volatility index suggests the possibility that implied volatility index exhibits mean reversion.

The reaction of implied volatility to the market return shocks can also be shown by the OLS estimations results as shown in Table 3. Model 1 of equation (3) without the squared return is estimated first. The results show that the intercept is insignificant. The estimated coefficient of the current return is significant at the 5 percent level while the negative coefficient of the one-day lagged return is insignificant. The highly significant and negative coefficient of lagged change in implied volatility suggests the possibility that the implied volatility is mean reverting.

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[3] This evidence is in line with Siriopoulos and Fassas (2012) who use the new method of computing the Greek implied volatility index.

Table 3 The implied volatility reaction to market return shocks.

Dependent variable: Δv_t							
	Intercept	r_t	$r(-1)_t$	r_{t-1}	Δv_{t-1}	r^2_t	Adj. R^2
Model 1	-4.36E-05	-0.355	-0.065	-0.170	-0.378		0.148
	(0.979)	(0.015)	(0.779)	(0.033)	(0.000)		
Model 2	-0.003	-0.110	-1.049	-0.191	-0.372	-10.591	0.156
	(0.128)	(0.630)	(0.018)	(0.017)	(0.000)	(0.009)	

Note: r denotes equity index return, r(-1) denote negative return.

However, the coefficient of current return is insignificant when the current squared return is included in Model 2 of equation (4). Moreover, the coefficient of lagged negative return is negative and significant at the 5 percent level. The significantly negative coefficient of r(-1) indicates that negative shocks impose a stronger impact on implied volatility than negative shocks, which confirm the results in Table 2. Nonetheless, the significantly coefficient of current squared return indicates that there is evidence of non-linear relationship between the index return and implied volatility. The negative coefficient suggests that the relationship is convex. The quadratic term or squared return introduced by Giot (2005) is included in the regression of Model 2 in Table 3 in order to assess the size effect of the return. The significant coefficient of the quadratic term indicates that small and large returns can affect the changes in implied volatility index differently.

4. Conclusion

This paper attempts to examine the relationship between the Thai implied volatility changes and the underlying stock index return using daily data. The period of investigation is during 11/19/2010 and 12/27/2013. The ordinary least square method is used. The regression results from stationary variables of the change in implied volatility index and the underlying stock index return reveal that the asymmetric relationship is found, which is consistent with the existing literature. In other words, negative return imposes a larger impact on implied volatility than does the negative return. Furthermore, the size effect is also observed. This size effect suggests that the size of the return does matter for the change in the Thai implied volatility index.

The overall results give some implication for risk management. If negative return is associated with an asymmetrically larger rise in the implied volatility index, risk-averse investors who take the increased risk will require more compensation in terms of higher risk premium than those who do not want to take associated risk at all. Thus the finding also suggests that portfolio managers of investment companies should take into account of investors" reaction when they form their portfolios.

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