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

Thakolsri, Supachock and Sethapramote, Yuthana and Jiranyakul, Komain

National Institute of Development Administration

June 2016

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

Supachok Thakolsri
Public Enterprise Policy Office
Ministry of Finance
Bangkok, Thailand
Email: choky1456@hotmail.com

Yuthana Sethapramote
School of Development Economics
National Institute of Development Administration
Bangkok, Thailand
Email: yuthanas@gmail.com

Komain Jiranyakul
School of Development Economics
National Institute of Development Administration
Bangkok, Thailand
Email: komain_j@hotmail.com
(Corresponding author)

Abstract

In this study, we examine the relationship between the change in implied volatility index and the underlying stock index return in the Thai stock market. The data used are daily data during November 2010 to December 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 underlying stock index return and the change in implied volatility. The finding in this study gives implication for risk management.

Keywords: Equity index return, option prices, 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 has been recently well-documented.[1] The implied volatility index can measure investors' sentiment or fear. Investors' fear is defined in the sense that a decline in the equity index or negative index 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). Specifically, 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 positive return does. Bollerslev and Zhou (2006) find that the leverage effect is always stronger for implied volatility than realized volatility in the US stock market. Dennis et al. (2006) examine the dynamic relation between daily stock return and daily innovations in option-derived implied volatility. They find that the asymmetric relation between return and implied volatility primarily stems from systematic market-wide risk factors rather than aggregate firm-level effects. In other words, the return-implied volatility relation should be a market phenomenon. Hibbert et al. (2008) examine the short-term dynamic relation between the S&P500 and Nasdaq 100 index returns and changes in implied volatility in both daily and intraday level. There findings reveal that neither the leverage nor volatility feedback effects adequately explained their results. Instead, a strong daily and intraday negative return-implied volatility relation stems from the representativeness from behavior of traders and the extrapolation bias concepts. Fernandes et al. (2014) find the results that confirm the evidence that there is a negative relationship between implied volatility index and the S&P500 index return. Badshah (2013) uses quintile regression to examine the short-term relation between stock index returns and changes in implied volatility indexes in the US and some European stock markets. One of the main findings from this research reveals that there exists strongly negative and asymmetric relation between each volatility index and its corresponding stock market index. The asymmetry increases monotonically from the median quantile to the uppermost quantile.

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. Shaikh and Padhi (2014) investigate the contemporaneous inter-temporal relationship between the change in implied volatility index and stock return in India. They find the negative and asymmetric effect in the Indian stock market. Lee and Ryu (2013) reexamine the

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

relationship between return and implied volatility to make a comparison between the US and Korean stock markets using a new vector auto-regression framework. They find the existence of asymmetric volatility phenomenon in both markets even though the impulse response dynamics in the Korean stock market are quite different from those of the US stock market.

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. Furthermore, the majority of past studies use weekly and monthly data on realized volatility to analyze this relationship (Hibbert, et al., 2008). In the present paper, we investigate the relationship between daily changes in the Thai implied volatility index (Thai VIX) and the returns of the SET50 index. We use the Thai stock market as a case study for an emerging stock market in Southeast Asia. The results from our regression analysis suggest that there exists an asymmetric and negative short-run relationship of the change in implied volatility index with the underlying stock index return in the Thai stock market. We add to the literature in that the existence of this relationship is consistent with the phenomenon found in many advanced stock markets. Our paper is organized as follows. 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

We use our computed daily Thai volatility index instead of realized volatility index because the option-derived volatility index does not cause problems in estimations, especially sampling and specification errors.[2] Therefore, our analysis will focus on the relation between the change in implied volatility and its underlying index return.

2.1 Data

The data in this study are obtained from SET Market Analysis and Reporting Tools (SETSMART) and Thompson Financial DadaStream. The dataset consists of daily closing prices of the SET50 index and the prices of stock options, which can be used to construct the implied volatility index for Thailand.[3] The period in the analysis covers the November 2010-December 2013 period 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).

We use the option pricing formula of Black and Scholes (1973) to compute the Thai implied volatility index. This formula is expressed as:

---

[2] Bollerslev and Zhou (2006) give discussions regarding various methodological issues of using volatility.

[3] Option prices of the underlying stocks included in computing the SET50 index are available from November 11, 2010 to December 27, 2013. Therefore, the number of observations of our study is dictated by the availability of the data.

$$C(S,t) = SN(d_1) - Xe^{-r(t-T)}N(d_2) \quad (1)$$

where C is the call option price, S is the current stock price, X is the option striking price or exercise price, r is the risk-free rate, T is the expiration date of the option. The cumulative normal density functions, $N(d_1)$ and $N(d_2)$, are normally distributed with a mean of zero and a standard deviation of one. These variables are specified as:

$$d_1 = [\ln(S/X) + (r + \frac{1}{2}v_S^2)^{(T-t)}]/v_S\sqrt{(T-t)} \quad (2)$$

and

$$d_2 = d_1 - v_S\sqrt{(T-t)} \quad (3)$$

where v_S is the volatility of the underlying stock price measured by its standard deviation. The expression $SN(d_1)e^{-r(T-t)}$ is the expected value that is equal to S_T if $S_T > X$ and zero otherwise. The function $N(d_2)$ is the probability that the option will be exercised so that $XN(d_2)$ is the striking price multiplied by the probability that the striking price will be paid. One parameter in the Black and Sholes pricing formula that cannot be directly observed is the volatility of the underlying stock price. Nevertheless, it is possible to compute such a volatility value that causes the option value to be consistent with the market price of an option. According to Watsham and Parramore (1997), we can calculate the implied volatility in the Thai stock market by plugging in the values of all parameters for the option pricing formula expressed in Eq. (1), including the option price from the Thai options market. Then we use the iterative procedure to calculate the Thai VIX such that the option price obtained from the formula is equal to the actual option price observed in the option market. Since the established volatility is the implied volatility for each individual option at each exercise price, the implied volatility index are computed as an average of all individual implied volatilities from the at-the-money or near-the-money options. Such calculation is consistent with the fact that the price of at-the-money option is far more sensitive to volatility than the price of deep-out-of-the-money option. The results found by Christensen and Prabala (1998) provide an empirical justification for the common practice of interpreting the Black-Scholes implied volatility as a volatility forecast, not just a convenient means of quoting option prices. In addition, Dennis et al. (2006) find evidence indicating that implied volatilities are good proxies of expected stock volatilities. Hibbert et al. (2008) also indicate that it is advantageous to use the VIX to examine the return-volatility relationship compared to the use of realized volatility.

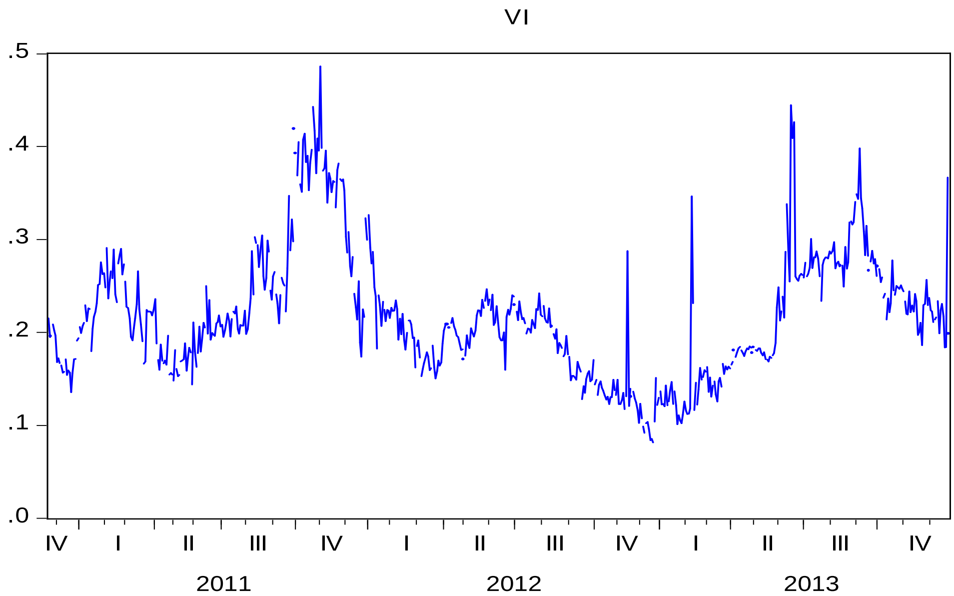
The descriptive statistics and unit root test statistics of the return and the change in implied volatility index are reported in Table 1. The mean of daily SET50 index return is small and very close to zero. The return series is positively skewed and leptokurtic. The Jarque-Bera statistic indicates that the return series is not normally distributed. For the change in implied volatility index, the mean is negative but very close to zero while the series is positively skewed and leptokurtic. This series is also not normally distributed. Both series exhibit negatively serially correlation as shown by the first-order autocorrelation coefficients, which suggest that there are mean reversion processes. In addition, the ADF tests for the test with a constant only and with a constant and a linear trend are used to test for unit root. The test statistics reject the null hypothesis of unit root in both daily SET50 index return and the change in the Thai implied volatility index. Therefore, the test results indicate that both series are stationary. As a result, OLS estimates should be applicable to investigate the return-implied volatility relationship, which will be described in the next sub-section.

Table 1. Descriptive and unit root test statistics of the return and the change in implied volatility (November 19,2010-December 27, 2013)

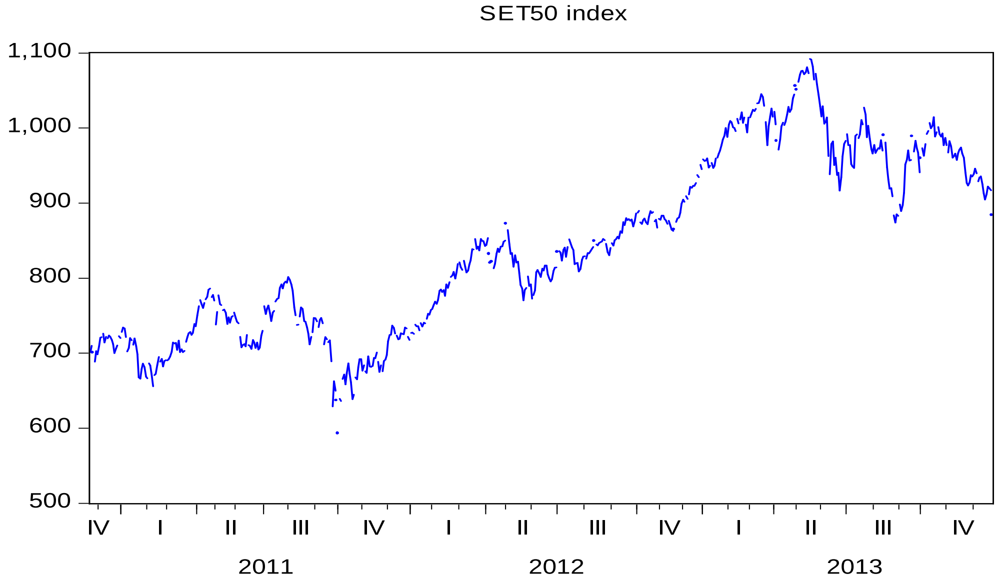
	r_t	Δv_t
Mean	0.0004	-2.70E05
Median	0.0015	-0.0004
Maximum	0.0758	0.2280
Minimum	-0.0910	-0.1686
Standard deviation	0.0144	0.0295
Skewness	-0.0144	0.9373
Kurtosis	7.7442	19.5125
Jarque-Bera statistic	612.890	7,284.159
First-order autocorrelation	-0.051	-0.334
ADF statistic (constant only)	-26.283 [0]	-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 (November 19,2010-December 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:

$$\Delta v_t = a_0 + a_1 r_t + e_t \qquad (4)$$

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:

$$\Delta v_t = \alpha_0 + \alpha_1 r(+)_t + \alpha_2 r(-)_t + \alpha_3 \Delta v_{t-1} + e_t \qquad (5)$$

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 Eq. (5) 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 Eq. (5) 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:

$$\Delta v_t = \alpha_0 + \alpha_1 r_t + \alpha_2 r(-)_t + \alpha_3 r_{t-1} + \alpha_4 \Delta v_{t-1} + e_t \qquad (6)$$

and

$$\Delta v_t = \alpha_0 + \alpha_1 r_t + \alpha_2 r(-)_t + \alpha_3 r_{t-1} + \alpha_4 \Delta v_{t-1} + \alpha_5 r_t^2 + e_t \qquad (7)$$

In Eqs. (6) and (7), *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 and the size effect is present.

Some hypotheses can be tested using our specified empirical models mentioned above. The first hypothesis is that contemporaneous return on the SET50 index is the change in the current Thai VIX as specified in Eq. (4). If this hypothesis does not hold, then the leverage or volatility feedback effects can explain the return-volatility relation. The second hypothesis that negative return imposes a larger impact on the change in the current Thai VIX than positive return does. This hypothesis can be tested using Eqs. (5)-(7). The third hypothesis posits that lagged return on the SET50 index is an important determinant used by the stock market to determine the change in the current implied volatility. If the coefficient of lagged return is insignificant, then the leverage effect might not hold in daily data. This hypothesis can be tested using Eqs. (6) and (7). The last hypothesis is that the size effect in Eq. (7) might exist. The insignificant coefficient of the squared return indicates the absence of the size effect and vice versa.

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 return-implied volatility relationship, we estimate Eq. (1) using the least squares method. However, the estimated equation is not convincing.

The relationship between the change in implied volatility and stock index return are plotted as shown in Figure 2.

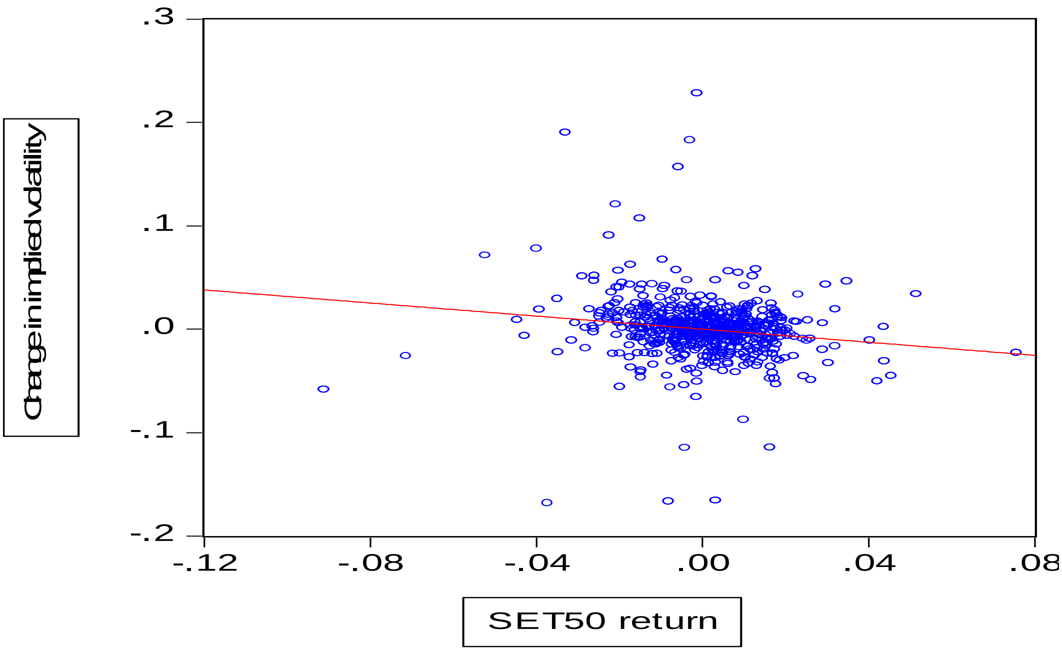


Figure 2. Daily return of SET50 index and changes in implied volatility: November 19, 2011-December 27, 2013.

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 -0.378 and is highly significant at the 1 percent level. 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. Therefore, the leverage effect cannot be disproved.

Further regression analysis of the daily change in implied volatility index with the separated positive and negative returns expressed in Eq. (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. The mean of the change in Thai VIX of zero indicates that if the SET50 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 and the positive returns are zero can be rejected at the 1 percent level (Wald F = 12.87 with p-value = 0.00). Therefore, it can be argued that the negative return shocks impose a larger impact than the negative return shocks on implied volatility.[4] 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 estimated results as shown in Table 3. Model 1 of Eq. (3) without the squared return is estimated first. The results show that the intercept is insignificant, which implies that the mean is zero and is consistent with the descriptive statistics reported in Table 1. 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.

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 Eq. (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 a negative shock imposes a stronger impact on the change in implied volatility than a positive shocks. The results confirm the results in Table 2. Nonetheless, the significantly negative 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] This evidence is in line with Siriopoulos and Fassas (2012) who use the new method of computing the Greek implied volatility index.

It should be noted that Model 2 is superior to Model 1 because Model 1 does not take into account of the size effect that can affect the change in the Thai VIX.

Our results show that the asymmetry of the return-implied volatility relation is observed in the Thai stock market. This evidence is in line with the findings by Giot (2005), Fernandes et al. (2014), Hibbert et al. (2008) and Badshah (2013) for advanced stock markets. Furthermore, our finding is also consistent with the findings by Tang (2007) and Lee and Ryu (2013) for the Korean stock market and Shaiks and Padhi (2014) for the Indian stock market and Siriopoulos and Fassas (2012) for the Greek stock market. Even though our data span is short due to the availability of the data, but our results are quite convincing.

4. Conclusion

This paper attempts to examine the risk-return relation using the constructed Thai implied volatility changes as a measure of risk daily data. The period of investigation is during November 19, 2010 and December 27, 2013. The ordinary least squares 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 changes than does the negative return. Furthermore, the mean reversion and the size effect are also observed. This size effect suggests that the size of the return does matter for the change in the Thai implied volatility index. The mean reversion indicates that the fluctuations in implied volatility index will return to the mean of zero. Our results might indicate the validity of the leverage effect or/and the volatility feedback effect.

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.

References

Badshah, I. U., 2013. "Quantile regression analysis of the asymmetric return-volatility relation," Journal of Futures Markets, 33(3), 235-265.

Black, F., 1976. "The pricing of commodity contracts," Journal of Financial Economics, 3(2), 167-179.

Black, F. and Sholes, M., 1973. "The pricing of options and corporate liabilities," Journal of Political Economy, 81(3), 637-654.

Bollerslev, T., and Zhou, H., 2006. "Volatility puzzle: a unified framework for gauging return-volatility regressions," Journal of Econometrics, 131(1-2), 123-150.

Christensen, B. J., & Prabhala, N. R. (1998), The relation between implied and realized volatility. Journal of Financial Economics, 50(2), 125-150.

Christie, A., 1982. "The stochastic behavior of common stock variances: value, leverage and interest rate effects," Journal of Financial Economics, 10(4), 407-432.

Dennis, P., Mayhew, S. and Stivers, C., 2006. "Stock returns, implied volatility innovations, and the asymmetric volatility phenomenon," Journal of Financial and Quantitative Analysis, 41(2), 381-406.

Ederington, L. H. and Guan, W., 2010. "How asymmetric is the US stock market volatility?," Journal of Financial Markets, 13(2), 225-248.

Fernandes, M., Medeiros, M. C. and Scharth, M., 2014. "Modeling and predicting the CBOE market volatility index," Journal of Banking and Finance, 40(C), 235-265.

Fleming, J., Ostdiek, B. and Whaley, R., 1995. "Predicting stock market volatility: a new measure," Journal of Futures Markets, 15(2), 265-302.

Frijns, B., Tallau, C., and Tourani-Rad, A., 2010. "The information content of implied volatility: evidence from Australia," Journal of Futures Markets, 30(2), 134-155.

Giot, P., 2005. "Relationships between implied volatility indexes and stock index returns," Journal of Portfolio Management," 31(3), 92-100.

Hibbert, A. M., Daigler, R. T. and Dupoyet, B., 2008. "A behavioral explanation for the negative asymmetric return-volatility relation," Journal of Banking and Finance, 32(10), 2254-2266.

Lee, B. S. and Ryu, D., 2013. "Stock returns and implied volatility: a new VAR approach," Economics, 7(0), 1-20.

Siriopoulos, C. and Fassas, A., 2012. "An investor sentiment barometer-Greek implied volailtiy index (GRIV), Global Finance Journal, 23(2), 77-93.

Shaikh, I. and Padhi, P., 2014. "Inter-temporal relationship between India VIX and Nifty equity index," Decision, 41(4), 439-448.

Skiadopoulos, G., 2004. "The Greek implied volatility index: construction and properties," Applied Financial Economics, 14(16), 1187-1196.

Tang, C., 2007. "Fear in the Korea market," Review of Futures Markets, 16(1), 106-140.

Whaley, R., 2000. "The investor fear gauge," Journal of Portfolio Management, 26(1), 12-17.

Watsham, T. J., & Parramore, R. (1997), Quantitative methods in finance. London, International Thompson Business Press.