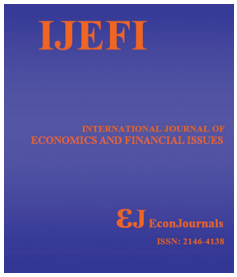

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A Box Spread Test of the SET50 Index Options Market Efficiency: Evidence from the Thailand Futures Exchange

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ABSTRACT

This paper provides the box spread test of the SET50 index options market efficiency using daily data from October 29, 2012, through March 30, 2016. The results show that the market frictions imposed by the bid-ask spread, along with brokerage commissions, exchange fees, and interest on initial margin deposit, appear to have a significant effect on arbitrageurs' abilities to take advantage of the mispricing of the box spreads. When using bid-ask prices rather than closing prices, the box spread arbitrage opportunities drop to <1%, and none of them is persisted on the following trading day. Considering transaction costs, the results therefore confirm the internal options market efficiency in the SET50 index options market. However, the results do not provide support for the argument that the SET50 index options market efficiency improved over time.

Keywords: Market Efficiency, Index Options, Box Spreads
JEL Classifications: G13, G14

1. INTRODUCTION

A SET50 index options contract is the second product on Thailand Futures Exchange and was launched on October 29, 2007. Currently SET50 index is still the only underlying asset traded in Thailand's options market. Investors and entrepreneurs can use it to protect their portfolio from unanticipated events and to speculate on the market movement. However, options market must be efficient in order to do the best possible job at these important functions. The purpose of this paper is therefore to empirically test the efficiency of the SET50 index options market using a box spread arbitrage pricing relationship.

Despite the importance of the testing of the options market efficiency, the research in testing the efficiency of a relatively new but growing market, namely the SET50 index options market, has been rather limited. Lertburapa (2015) examines the riskless arbitrage opportunity under put-call parity condition which underlying asset is SET50 index futures. She uses bid-ask prices of the SET50 index options as a part of transaction costs. The results show some riskless arbitrage opportunities under a violation of put-call parity; however, the percentage of violations reduces significantly to 1% after including all transaction costs. Although the put-call parity test provides a model-free method to examine the efficiency of the SET50 index options market, it is a test of cross-market efficiency of futures and options markets. Testing results could be biased due to possible futures mispricing. The box spread arbitrage strategy, on the other hand, involves two pairs of SET50 index call and put options having the same expiration date and the risk free asset. It is appropriate for testing the efficiency of the SET50 index options market when SET50 index is not traded.

One of the earliest researches in the box spread arbitrage strategy is Ronn and Ronn (1989). They use Chicago Board Options Exchange bid-ask prices on listed options. Their sample consists of eight trading days, one day per year, between 1977 and 1984. They find some small gain opportunities for the agents having low transaction costs and quick execution ability as well as some improvement in market efficiency over the sample time period. Ackert and Tian (2000; 2001) examine the efficiency of the S&P 500 index option market. Ackert and Tian (2000) use daily

data for the S&P 500 index and index options from January 1, 1986, through December 31, 1996. They include bid-ask spreads and commissions to analyze the effect of transaction costs on pricing efficiency. They find frequent and substantial violations of the box spread relationship. There is no evidence that options market efficiency improved over time. Ackert and Tian (2001) examine the effect of Standard and Poor's Depository Receipts (SPDRs), traded on January 29, 1993, on the link between index and options markets. They use daily data from February 1, 1992, through January 31. 1994, and find some improvement in market efficiency over time. However, there is little evidence that the introduction of SPDRs improved the link between stock and index options markets. Capelle-Blancard and Chaudhury (2001) examine the efficiency of the French options market using daily data on CAC 40 index options from January 2, 1997, through December 30, 1999. Their results support market efficiency as the frequency of arbitrage condition violation is low. With the shift to the Euro, they do not find any clear evidence of enhanced efficiency. Fung et al. (2004) use 20 months of time-stamped records of both bid-ask quotes and transaction data of Hang Seng Index options to examine the pricing efficiency of options market in Hong Kong. The results provide support for market efficiency. Arbitrage opportunities are not possible to both members and nonmembers of the Exchange. Benzion et al. (2005) use bid-ask prices of index options traded on the Tel-Aviv 25 Stock Index (TA25) in June-July 2000 to detect box spread arbitrage opportunities. They find that arbitrage gain is relatively small, shrinks substantially with transaction fees, and disappears quickly with time; therefore, the TA25 options market is highly efficient. Vipul (2009) examines the market efficiency for the European style Nifty Index options using daily data from January 1, 2002, through December 31, 2003. The results show some arbitrage opportunities after accounting for the transaction costs. However, the mispricing persists for <2 min. Its magnitude is also higher for the options that are farther from the money and also during the periods of higher volatility.

The remainder of this paper is organized as follows. The structure of box spreads is detailed in Section 2. Section 3 describes data and methodology. The empirical results of the box spread test are presented in Section 4, and Section 5 concludes the paper.

2. STRUCTURE OF BOX SPREADS

A box spread is often used to test the efficiency of options market. It is model independent and is based on the simple assumption that investors prefer more to less. Throughout the paper we will use the following notation:
C = Price of a European call option;
P = Price of a European put option;
K = Exercise price;
S = Price of underlying asset;
t = Time to maturity of the option;
r = Interest rate.

The box spread is constructed with two European calls and two European puts, all having the same underlying asset and the same expiration date. One pair of call and put has a lower exercise price (K_L), and the other has a higher exercise price (K_H).

A long box spread combines a bull call spread and a bear put spread. The bull call spread involves purchasing a call with exercise price K_L and simultaneously selling a call with exercise price K_H, while the bear put spread involves selling a put with exercise price K_L and simultaneously purchasing a put with exercise price K_H. The long box spread always requires a positive initial investment of $C_L-C_H+P_H-P_L$ due to a negative relationship between call premium and exercise price and a positive relationship between put premium and exercise price. The future payoff for each of the three possible price ranges of the underlying asset at expiration equals K_H-K_L, which is always positive (Figure 1). Thus, the long box spread strategy mimics a riskless investment of $(K_H-K_L)\exp(-rt)$.

A short box spread, on the other hand, is the inverse of the long box spread strategy. It therefore gives an initial inflow of $C_L-C_H+P_H-P_L$ and requires a payment of K_H-K_L for each of the three possible price ranges of the underlying asset at the time of expiration as shown in Figure 2. Thus, the short box spread strategy mimics a riskless borrowing of $(K_H-K_L)\exp(-rt)$.

Figure 1: Long box spread payoff at expiration

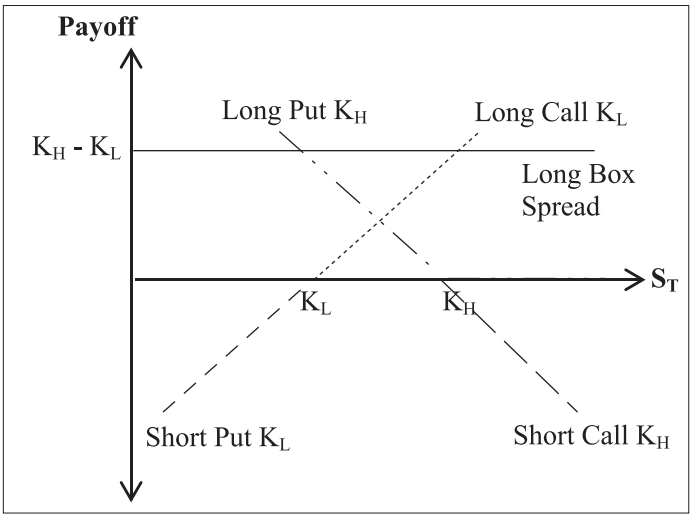

Figure 2: Short box spread payoff at expiration

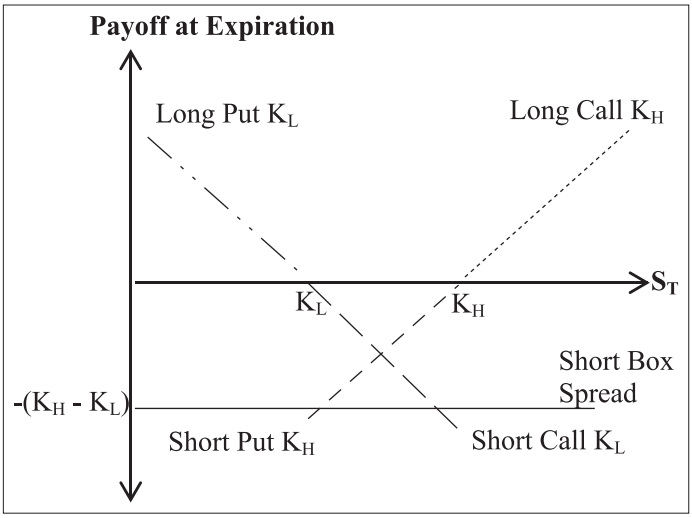

Table 1: Cash flows of the long box spread and borrowing strategies

Actions	Initial cash flows	Cash flows at the time of expiration		
		$S_T \leq K_L < K_H$	$K_L < S_T \leq K_H$	$K_L < K_H < S_T$
Buy call with K_L	$-C_L$	-	$S_T - K_L$	$S_T - K_L$
Sell call with K_H	C_H	-	-	$-(S_T - K_H)$
Sell put with K_L	P_L	$-(K_L - S_T)$	-	-
Buy put with K_H	$-P_H$	$K_H - S_T$	$K_H - S_T$	-
Borrowing	$(K_H - K_L)\exp(-rt)$	$-(K_H - K_L)$	$-(K_H - K_L)$	$-(K_H - K_L)$
Total	$C_H - C_L - P_H + P_L + (K_H - K_L)\exp(-rt)$	0	0	0

Table 2: Cash flows of the short box spread and investment strategies

Actions	Initial cash flows	Cash flows at the time of expiration		
		$S_T \leq K_L < K_H$	$K_L < S_T \leq K_H$	$K_L < K_H < S_T$
Sell call with K_L	C_L	-	$-(S_T - K_L)$	$-(S_T - K_L)$
Buy call with K_H	$-C_H$	-	-	$S_T - K_H$
But put with K_L	$-P_L$	$K_L - S_T$	-	-
Sell put with K_H	P_H	$-(K_H - S_T)$	$-(K_H - S_T)$	-
Investment	$-(K_H - K_L)\exp(-rt)$	$K_H - K_L$	$K_H - K_L$	$K_H - K_L$
Total	$C_L - C_H + P_H - P_L - (K_H - K_L)\exp(-rt)$	0	0	0

When two strategies have identical future cash flows, they should have the same initial value. This gives rise to a box spread parity for European options as follows:

$$C_L - C_H + P_H - P_L = (K_H - K_L)\exp(-rt) \quad (1)$$

If the box spread parity is violated, one can make risk-free arbitrage profit by pursuing the long or the short box spread strategy.

When the left-hand side of Equation 1 is lower than the right-hand side of equation, $C_H - C_L - P_H + P_L + (K_H - K_L)\exp(-rt) > 0$, an arbitrageur can earn riskless profit by buying the bull call spread and the bear put spread and borrowing the amount $(K_H - K_L)\exp(-rt)$. The future payoff from options equals $K_H - K_L$ and is exactly the amount needed to payoff the loan as shown in Table 1.

When the left-hand side of Equation 1 is higher than the right-hand side of equation, $C_H - C_L - P_H + P_L + (K_H - K_L)\exp(-rt) < 0$, an arbitrageur can earn riskless profit by selling the bull call spread and the bear put spread and investing the amount $(K_H - K_L)\exp(-rt)$. The future payment of $K_H - K_L$ from options is offset by the amount of investment return as shown in Table 2.

3. DATA AND METHODOLOGY

This study investigates the efficiency of the SET50 index options market using daily data downloaded from the websites of SETSMART and Bank of Thailand. The data set consists of closing prices (CL), bid prices (B), ask prices (A), and time to maturity of SET50 index options and interest rate from October 29, 2012, through March 30, 2016. SET50 index options are European. The contract multipliers of the SET50 index options are 200 Baht per index point. Starting in October 29, 2012, SET50 index options are available for the three nearest consecutive months, and the next quarterly month. The consecutives strike prices are now separated by 25 index points. There are at least five strike prices available (two in-the-money strikes, two out-of-the-money strikes, and one at-the-money strike). Therefore, the data set covers SET50 index options maturing in November 2012 to those due in March 2016 with 962 different strike prices. However, all transactions with zero values in closing price, bid price, ask price, or volume fields are excluded in the data set. This paper uses Krung Thai's minimum retail rate (r_B) and savings interest rate (r_S) for borrowing and investment, respectively. It is also important to take transaction costs (brokerage commissions, exchange fees, interest on initial margin deposit, and bid-ask spread) into account (Table 3).

Table 3: Details of transaction costs

Types of transaction costs	Value
Brokerage commissions[a]	80 baht/contract
Exchange fees[b]	5 baht/contract
Interest on initial margin deposit[c]	
Long box spread	No initial margin requirement
Short box spread	$(\exp(r_S t)-1)(K_H - K_L)400$
Bid-ask spread[d]	An option can be purchased at the ask price and sold at the bid price

[a]This paper uses Capital Nomura Securities PLC's brokerage commissions. It costs individual investors 80 baht per contract to trade the 1st-25th contract via market officer during our sample period. Individual investors are also subject to 7% value-added tax. [b]Exchange fees cover trading fee of 3.50 baht per contact and clearing fee of 1.50 baht per contract. These fees are constant during our sample period. Individual investors are also subject to 7% value-added tax. [c]Investors are usually required to deposit initial margin with their respective broker before trading SET50 index options. The interest that could be earned during the holding period on this money is an opportunity cost for the arbitrageur. [d]When the bid-ask spread is not considered as a part of transaction costs, closing price is used for buying and selling options

Therefore, this study considers four scenarios differing in terms of assumptions about the transaction costs as shown in Table 4. Define TC for transaction costs other than those arising from the bid-ask spread. In this paper, TC includes brokerage commissions, exchange fees, and interest on initial margin deposit and can be calculated as follows:

Long box spread: $TC = 4(80+5)(1+0.07) = 363.8$

Short box spread: $TC = 4(80+5)(1+0.07) + (\exp(r_S t) - 1)(K_H - K_L)400$

$$TC=363.8+(\exp(r_S t)-1)(K_H-K_L)400$$

There are four scenarios differing in terms of assumptions about the transaction costs. Scenario 1 ignores all transaction costs. Scenario 2 considers brokerage commissions, exchange fees, and interest on initial margin deposit as transaction costs. Scenario 3 uses the bid-ask spread as the transaction cost of trading. The bid-ask spread, along with brokerage commissions, exchange fees, and interest on initial margin deposit, represents transaction costs in Scenario 4.

Table 5 shows the conditions for the mispricing of the long and the short box spreads under each of four scenarios. If the mispricing is identified, the absolute value of the left hand side of that box spread inequality is used as the arbitrage profit when pursuing the appropriate strategies. It is identified as Ex Post test. Moreover, this paper investigates the persistence of the mispricing by identifying the arbitrage opportunities on each trading day and tracking whether the arbitrage opportunities for the same set of call and put options are available on the following trading day. It is identified as Ex Ante test. Both Ex Post and Ex Ante tests are employed for the full sample period as well as for each year in the sample period.

4. EMPIRICAL RESULTS

In this section, we discuss the empirical results regarding the efficiency of the SET50 index options market. All the results in Tables 6-8 are the Ex Post and Ex Ante test results.

Table 4: Assumptions about options price and transaction costs

Scenario	Closing price	TC	Bid-ask spread
1	Yes	No	No
2	Yes	Yes	No
3	No	No	Yes
4	No	Yes	Yes

Table 5: Conditions for the arbitrage opportunities

Scenario	Long box spread	Short box spread
1	$\{(C_H^{CL}-C_L^{CL})-(P_H^{CL}-P_L^{CL})+(K_H-K_L)\exp(-r_B t)\}200>0$	$\{(C_H^{CL}-C_L^{CL})-(P_H^{CL}-P_L^{CL})+(K_H-K_L)\exp(-r_S t)\}200<0$
2	$\{(C_H^{CL}-C_L^{CL})-(P_H^{CL}-P_L^{CL})+(K_H-K_L)\exp(-r_B t)\}200-363.8>0$	$\{(C_H^{CL}-C_L^{CL})-(P_H^{CL}-P_L^{CL})+(K_H-K_L)\exp(-r_S t)\}200+363.8+(\exp(r_S t)-1)(K_H-K_L)400<0$
3	$\{(C_H^{B}-CL^{A})-(P_H^{A}-PL^{B})+(K_H-K_L)\exp(-r_B t)\}200>0$	$\{(C_H^{A}-C_L^{B})-(P_H^{B}-P_L^{A})+(K_H-K_L)\exp(-r_S t)\}200<0$
4	$\{(C_H^{B}-C_L^{A})-(P_H^{A}-P_L^{B})+(K_H-K_L)\exp(-r_B t)\}200-363.8>0$	$\{(C_H^{A}-C_L^{B})-(P_H^{B}-P_L^{A})+(K_H-K_L)\exp(-r_S t)\}200+363.8+(\exp(r_S t)-1)(K_H-K_L)\ 400<0$

From October 29, 2012, through March 30, 2016, we construct 7,436 box spread parity pairs to identify the opportunities of arbitrage. Table 6 reports the Ex Post and the Ex Ante test results for the box spread arbitrage opportunities under four scenarios over the whole sample.

As shown in Panel A, when there are no transaction costs (Scenario 1), the frequency of the long box spread violation is 48.90% over the whole sample. However, the frequency of the long box spread violation declines to 27.60% when considering brokerage commissions, exchange fees, and interest on initial margin deposit (Scenario 2). The violation frequency is almost disappeared when we include the bid-ask spread as a part of transaction costs. It drops to only 0.44% when considering the bid and ask prices, instead of closing prices, in Scenario 3. When taking all transaction costs (brokerage commissions, exchange fees, interest on initial margin deposit, and bid-ask spread) into account (Scenario 4), the long box spread violation frequency drops further to 0.05%. The Panel B results for the short box spread are fairly similar. The frequency of the short box spread violations is the highest (44.04%) when ignoring any transaction costs (Scenario 1). The frequency violation continues to drop after taking transaction costs into account. It is 23.40% in Scenario 2, 0.28% in Scenario 3, and 0.05% in Scenario 4. The percentages of violations are higher for the long box spread than for the short box spread. Moreover, the Ex Ante test results indicate about 30% (15%) of the long and short box spread arbitrage opportunities are existed even on the day following the violations in Scenario 1 (Scenario 2). Arbitrage opportunities are not persisted on the day following observed violations in both Scenario 3 and 4. The box spread results therefore indicate the internal options market efficiency (in terms of frequency of violation) in the SET50 index options market.

In contrast to the frequency of violations, the Ex Post test shows that the size of the arbitrage profit from the long (short) box

Table 6: Ex Post and Ex Ante violations of the box spreads over the whole sample

Violations	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Ex Post	Ex Ante	Ex Post	Ex Ante	Ex Post	Ex Ante	Ex Post	Ex Ante
Panel A: Mispricing of the long box spread								
Number of observations	7436	3636	7436	2052	7436	33	7436	4
Number of violations	3636	1092	2052	328	33	0	4	0
Percentages of violations	48.90	30.03	27.60	15.98	0.44	0	0.05	0
Size of violations (Baht)	701.11	621.51	745.23	765.64	166.61	-	209.18	-
Panel B: Mispricing of the short box spread								
Number of observations	7436	3275	7436	1740	7436	21	7436	4
Number of violations	3275	903	1740	252	21	0	4	0
Percentages of violations	44.04	27.57	23.40	14.48	0.28	0	0.05	0
Size of violations (Baht)	619.99	569.44	636.36	627.99	305.88	-	764.40	-

This Table 6 reports the frequency and the size of the Ex Post and Ex Ante violations of the long and the box spreads. The sample consists of 7436 box spread parity pairs from October 29, 2012, through March 30, 2016.

spread mispricing increases from 701.11 Baht (619.99 Baht) when excluding all transaction costs to 745.23 Baht (636.36 Baht) when considering brokerage commissions, exchange fees, and interest on initial margin deposit. However, using the bid-ask prices rather than closing prices, the size of the arbitrage profit from the long (short) box spread mispricing is 166.61 Baht (305.88 Baht) in Scenario 3 and 209.18 Baht (764.40 Baht) in Scenario 4. As compared with these Ex Post test results, the Ex Ante test results for the size of the arbitrage profit are lower, except the long box spread mispricing in Scenario 2. The magnitude of the mispricing for the long box spread combinations are higher (lower) than those for the short box spread combinations in Scenario 1 and 2 (Scenario 3 and 4).

Tables 7 and 8 report the frequency and the size of the Ex Post and Ex Ante violations of the long box spread and the short box spread, respectively, for each year in the 2012-2016 sample period. The results provide no evidence that the SET50 index options market efficiency improved over the sample period.

For the Ex Post (Ex Ante) violations of the long box spread, the frequency of the violations in Scenario 1 and 2 is highest in 2013 (2014). The highest size of the Ex Post (Ex Ante) violations occurs in 2016 (2013). When using the bid-ask prices rather than closing prices, the results for Scenario 3 (Scenario 4) show that the mispricing of the long box spread occurs in year 2013 and

Table 7: Ex Post and Ex Ante violations of the long box spread by year

Violations	Ex Post					Ex Ante				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Panel A: Scenario 1										
Number of observations	190	1505	2257	2688	796	89	835	1193	1186	333
Number of violations	89	835	1193	1186	333	9	217	454	333	79
Percentage of violations	46.84	55.48	52.86	44.12	41.83	10.11	25.99	38.06	28.08	23.72
Size of violations (Baht)	691.70	851.80	638.34	613.10	864.11	355.27	891.00	583.21	519.23	562.82
Panel B: Scenario 2										
Number of observations	190	1505	2257	2688	796	51	552	659	600	190
Number of violations	51	552	659	600	190	2	93	127	81	25
Percentage of violations	26.84	36.68	29.20	22.32	23.87	3.92	16.85	19.27	13.50	13.16
Size of violations (Baht)	718.61	834.98	646.68	687.15	1,016.86	60.02	963.60	720.91	708.56	497.80
Panel C: Scenario 3										
Number of observations	190	1505	2257	2688	796	0	2	31	0	0
Number of violations	0	2	31	0	0	-	0	0	-	-
Percentage of violations	0	0.13	1.37	0	0	-	0	0	-	-
Size of violations (Baht)	-	99.18	170.96	-	-	-	-	-	-	-
Panel D: Scenario 4										
Number of observations	190	1505	2257	2688	796	0	0	4	0	0
Number of violations	0	0	4	0	0	-	-	0	-	-
Percentage of violations	0	0	0.18	0	0	-	-	0	-	-
Size of violations (Baht)	-	-	209.18	-	-	-	-	-	-	-

This Table 7 reports the percentage and the size of the Ex Post and Ex Ante violations of the long box spread using daily data for the SET50 index options for each year in the October 29, 2012, through March 31, 2016, sample period.

Table 8: Ex Post and Ex Ante violations of the short box spreads by year

Violations	Ex Post					Ex Ante				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Panel A: Scenario 1										
Number of observations	190	1505	2257	2688	796	99	603	874	1,279	420
Number of violations	99	603	874	1279	420	13	119	232	371	168
Percentage of violations	52.11	40.07	38.72	47.58	52.76	13.13	19.73	26.54	29.01	40
Size of violations (Baht)	449.92	747.95	563.75	608.67	627.83	520.59	703.40	544.46	514.35	634.47
Panel B: Scenario 2										
Number of observations	190	1505	2257	2688	796	49	355	414	664	258
Number of violations	49	355	414	664	258	6	41	75	74	56
Percentage of violations	25.79	23.59	18.34	24.70	32.41	12.24	11.55	18.12	11.14	21.71
Size of violations (Baht)	364.60	769.65	628.74	628.73	536.45	307.16	814.20	610.38	596.05	591.80
Panel C: Scenario 3										
Number of observations	190	1505	2257	2688	796	1	3	14	3	0
Number of violations	1	3	14	3	0	0	0	0	0	-
Percentage of violations	0.53	0.20	0.62	0.11	0	0	0	0	0	-
Size of violations (Baht)	62.05	190.91	366.98	217.03	-	-	-	-	-	-
Panel D: Scenario 4										
Number of observations	190	1505	2257	2688	796	0	0	3	1	0
Number of violations	0	0	3	1	0	-	-	0	0	-
Percentage of violations	0	0	0.13	0.04	0	-	-	0	0	-
Size of violations (Baht)	-	-	1008.16	33.12	-	-	-	-	-	-

This Table 8 reports the percentage and the size of the Ex Post and Ex Ante violations of the short box spread using daily data for the SET50 index options for each year in the October 29, 2012, through March 31, 2016, sample period.

2014 (2014) and none of these arbitrage opportunities is persisted into the next day.

For the Ex Post and Ex Ante violations of the short box spread, the highest frequency of the violations for Scenario 1 and 2 occurs in 2016. Nevertheless, the frequency violation in 2016 drops to zero when accounting for the bid-ask prices. The mispricing of the short box spread occurs from 2012 to 2015 in Scenario 3 and only in year 2014 and 2015 in Scenario 4; however, none of these arbitrage opportunities is persisted into the next day. The size of the violations, on the other hand, is at the highest in 2013 when using the closing prices (Scenario 1 and 2) and in 2014 when using the bid ask prices (Scenario 3 and 4).

5. CONCLUSION

This paper examines the efficiency of the SET50 index options market using the box spread arbitrage pricing relationship. It reports the Ex Post and Ex Ante violations in the 2012-2016 sample period. The results show that the maximum number of arbitrage opportunities is observed under the no transaction costs case (Scenario 1). The frequency of the violations decreases by almost half when considering brokerage commissions, exchange fees, and interest on initial margin deposit (Scenario 2). Moreover, when using the bid-ask prices rather than closing prices (Scenario 3 and 4), the box spread arbitrage opportunities drops to <1%, and none of them is persisted on the following trading day. Market frictions appear to have a significant effect on arbitrageurs' abilities to take advantage of the mispricing of the box spreads. Accounting for transaction costs, the results therefore confirm the internal options market efficiency (in terms of frequency of violations) in the SET50 index options market. However, the results do not provide support for the argument that the SET50 index options market efficiency improved over time.

The efficiency of the SET50 index options market should boost investors' confidence in the SET50 index options market. However, there has been nothing to guarantee that the historical prices used in this study to detect arbitrage opportunities were the real prices at which the strategies could have been executed to gain arbitrage profits. Therefore, future research should consider the intraday bid-ask prices in real time to examine the efficiency of the SET50 index options market. Moreover, this paper does not investigate the determinants of the box spread arbitrage condition violations. It is worthwhile to explore whether the violations are related to factors previously cited in the literature such as time to expiration, open interest, option moneyness, etc.

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REFERENCES

Ackert, L.F., Tian, Y.S. (2000), Evidence on the efficiency of index options markets. Economic Review-Federal Reserve Bank of Atlanta, 85(1), 40-52.

Ackert, L.F., Tian, Y.S. (2001), Efficiency in index options markets and trading in stock baskets. Journal of Banking and Finance, 25(9), 1607-1634.

Benzion, U., Danan, S., Yagil, J. (2004), Box spread strategies and arbitrage opportunities. Journal of Derivatives, 12(3), 47-62.

Capelle-Blancard, G., Chaudhury, M. (2001), Efficiency Tests of the French Index (CAC 40) Options Markets. EFMA 2002 London Meetings.

Fung, J.K.W., Mok, H.M.K., Wong, K.C.K. (2004), Pricing efficiency in a thin market with competitive market makers: Box spread strategies in the Hang Seng index options market. Financial Review, 39(3), 435-454.

Lertburapa, J. (2015), A Test of Put-Call Future Parity in TFEX. 8th SEC Working Papers Forum. (In Thai).

Ronn, A.G., Ronn, E.I. (1989), The box spread arbitrage conditions: Theory, tests, and investment strategies. Review of Financial Studies, 2(1), 91-108.

Vipul. (2009), Box-spread arbitrage efficiency of nifty index options: The Indian evidence. Journal of Futures Markets, 29(6), 544-562.