Testing the Efficiency of Indian Index Options Market by Employing the Box - Spread Strategy : Empirical Evidence from S&P CNX Nifty Index

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Abstract

This article examined the efficiency of the Indian index options market by employing the box-spread arbitrage pricing relationship. The data collected for the study consisted of the daily closing prices of S&P CNX Nifty index options contracts from April 1, 2012 to March 31, 2017. The study demonstrated a frequent violation of box-spread parity. However, when the frequency and magnitude of the mispriced signals (violation of box-spread parity) were observed in light of specified liquidity and maturity levels, it was observed that most of the mispriced signals were concentrated at the illiquid levels and options which were going to get expired, and the magnitude of mispriced signals at the illiquid levels and options which were going to get expired were significantly larger than that of the liquid levels and options which were far away from the maturity date. Further, in order to verify whether the differences in the mean magnitude of the mispriced signals at different liquidity and maturity of the options contracts were statistically significant, the hypotheses were formulated and tested. The results of the study suggested that the Indian index options market during the period of study was efficient as most of the abnormal profits from the mispriced signals were not exploitable due to lack of liquidity.

Keywords: arbitrage, box-spread, call option, efficiency , index options, put option

JEL Classification: G10, G13, G14

Paper Submission Date : April 29, 2018 ; Paper sent back for Revision : September 18, 2018 ; Paper Acceptance Date : September 25, 2018

Options are derivatives instrument introduced in the market for risk management purposes. They have unique features from other derivative instruments, their payoffs are non - linear and because of that, they can mimic the payoff of other ordinary securities available in the market. Options are also employed as trading tools to overcome the unfavourable conditions, that is, when the traders develop negative payoffs (Šoltés, 2014).

The options market efficiency can be investigated either by cross-market efficiencies like put-call parity and

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lower boundary conditions or by internal option market efficiencies like the box and butterfly spread strategies. In the first case, it is based on a joint efficiency test of the options and the underlying markets ; whereas, in the case of the internal options market test, no-arbitrage argument within the options market is employed.

For the study, box - spread strategy will be employed as this strategy tests only the options market efficiency and the issue of joint hypothesis, whether the options market is efficient and whether the underlying market efficiency will be overcome. It is a model - free method for testing the pricing efficiency of the options market. Around the globe, this strategy has been applied for testing the pricing efficiency of the options market.

In the Indian context, very few studies have been conducted to test the pricing efficiency of the internal index options market (Girish & Rastogi, 2013 ; Vipul, 2009). However, all these studies were conducted before the microstructure of the Indian exchanges were under the strike rules of the regulators, like the restriction of short selling, tax on the options premium plus strike price. So, it is necessary to test the efficiency of this market from the point of practitioners, regulators, and academicians as this market helps in the hedging (Choksi, 2010 ; Ramanjaneyalu & Hosmani, 2010 ; Ramchandra, Satish, & Krishnamurthy, 2010) and price discovery process (Pathak, Ranajee, & Kumar, 2014 ; Shaikh & Padhi, 2013).

Review of Literature

Box spread is an options trading strategy in which traders simultaneously buy and sell options having the same underlying asset and time to maturity, but at different strike prices. It reduced the joint hypothesis problem because there is no consideration of the pricing model or market equilibrium, no consideration of inter - market non-synchronicity as the box spread considers only the options market, computational simplicity with fewer chances of misspecification error, estimation error, and the fact that buying and selling box spreads more or less replicates risk free lending and borrowing. Billingsley and Chance (1985) were the first one to confirm the price parity of box spread strategy by employing the U.S. stock options.

In the Indian context, few studies have been conducted to test the pricing efficiency of the index options market by employing box spread parity. They are Vipul (2009) and Girish and Rastogi (2013). As mentioned earlier, all these studies were conducted before the microstructure of the Indian exchanges were under the strike rules of the regulators. So, testing the efficiency of this market is necessary as this market helps in the price discovery process, hedging and proper allocation of resources, which are vital for economic development of the nation. The present study is confined to test the efficiency of the S&P CNX Nifty index options market, they are European types (which can be exercised only at maturity) and settled by cash.

➯ **Theoretical Framework of Box - Spread Parity :** The box spread strategy involves simultaneous employing of four options, that is, two pairs of European put and call options having the same underlying and maturity date. One pair of call and put has a higher strike price (K_H) than that of the other pair with the strike price (K_L). The costs involved in this strategy are C_L (call option with strike price K_L), P_L (put option with strike price K_L), C_H (call option with strike price K_H), and P_H (put option with strike price K_H). The result of this strategy gives a payoff of (K_H - K_L) on expiration, which is analogues to a riskless borrowing or lending. If the market is efficient, then the return from this strategy would be the same as the yield on a risk-free asset of the same maturity. Else, there is an arbitrage opportunity.

The Table 1 shows the cash flow of the long box-spread and borrowing strategies and Table 2 shows the cash flow of the short box spread and lending strategies. It is observed from both the Tables 1 and 2 that long box strategy mimics the investment of ($K_H - K_L$) and short box strategy mimics the lending of ($K_H - K_L$).

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

Table 1. Cash Flow of the Long Box Spread and Borrowing Strategies

Action	Initial Cash Flows	Cash Flow at the Time of Expiration		
		$S_T \le K_L < K_H$	$K_L < S_T \le K_H$	$K_L < K_H < S_T$
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	$- P_H$	$K_H - S_T$	$K_H - S_T$	-
Borrow	$(K_H - K_L)\, e^{-r\,(T-t)}$	$-(K_H - K_L)$	$-(K_H - K_L)$	$-(K_H - K_L)$
Total	$C_H - C_L - P_H + P_L + (K_H - K_L)\, e^{-r\,(T-t)}$	0	0	0

Note: C_L and C_H is the market price of the call options with lower (K_L) and higher strike (K_H) price, respectively; P_L and P_H is the market price of the put options with lower (K_L) and higher strike (K_H) price, respectively ; S_T is the expiration day settlement value of the underlying asset ; r is the continuously compounded annual risk-free rate of return ; T-t is the time to maturity of the options at time t (measured in years).

Table 2. Cash Flow of the Short Box Spread and Lending Strategies

Action	Initial Cash Flows	Cash Flow at the Time of Expiration		
		$S_T \le K_L < K_H$	$K_L < S_T \le K_H$	$K_L < K_H < S_T$
Sell call with K_L	C_L	-	$-(S_T - K_L)$	$-(S_T - K_L)$
Buy call with K_H	$- C_H$	-	-	$S_T - K_H$
Buy put with K_L	$- P_L$	$K_L - S_T$	-	-
Sell put with K_H	P_H	$-(K_H - S_T)$	$-(K_H - S_T)$	-
Lend	$-(K_H - K_L)\, e^{-r\,(T-t)}$	$K_H - K_L$	$K_H - K_L$	$K_H - K_L$
Total	$C_L - C_H + P_H - P_L - (K_H - K_L)\, e^{-r\,(T-t)}$	0	0	0

Note: C_L and C_H is the market price of the call options with lower (K_L) and higher strike (K_H) price, respectively; P_L and P_H is the market price of the put options with lower (K_L) and higher strike (K_H) price, respectively ; S_T is the expiration day settlement value of the underlying asset ; r is the continuously compounded annual risk-free rate of return ; T-t is the time to maturity of the options at time t (measured in years).

$$C_L - C_H + P_H - P_L = (K_H - K_L)\, e^{-r(T-t)} \qquad (1)$$

In the above equation (1), C_L and C_H is the market price of the call options with lower (K_L) and higher strike (K_H) price, respectively ; P_L and P_H is the market price of the put options with lower (K_L) and higher strike (K_H) price, respectively ; r is the continuously compounded annual risk-free rate of return ; and T-t is the time to maturity of the options at time t (measured in years).

Equation (2) gives the testable form of equation (1) :

$$C_H - C_L - P_H + P_L + (K_H - K_L)\, e^{-r(T-t)} = 0 \qquad (2)$$

If the box spread parity, that is, Equation (2) is violated, arbitrageurs can make risk free profit by pursuing the long or the short box spread strategy as follows :

$$C_H - C_L - P_H + P_L + (K_H - K_L)\, e^{-r(T-t)} > 0 \qquad (3)$$

$$C_H - C_L - P_H + P_L + (K_H - K_L)\, e^{-r(T-t)} < 0 \qquad (4)$$

In the case of equation (3), the arbitrageur can achieve risk free profit by employing long box spread (positively violated box spread parity, PVBP) while in the case of equation (4), the arbitrageur can achieve risk free profit by employing short box spread (negatively violated box spread parity, NVBP).

Objectives of the Study

The main objective of the study is to test the efficiency of the index options market by employing the box-spread parity, a model-free approach. For this, the mispriced signals obtained for the box-spread , that is, the frequency and magnitude is examined in light of liquidity and maturity of the options contracts. This has been done in view of the fact that mere mispricing of options does not indicate the efficiency of the options market. It is the opportunity to extract abnormal profit which gives a serious threat to the market efficiency.

Methodology

(1) The Data : The index options data were collected from the National Stock Exchange (NSE), India. It consists of closing prices of the option, deal dates, maturity dates, strike prices, and number of contracts traded in a day. To overcome the bias associated with non - synchronous trading, option contacts that had at least one contract traded in a day were considered. This process is analogous with Dixit, Yadav, and Jain (2009, 2011). For the study, only the near-month (current month) options contracts are considered as other options contracts, that is, next, far, and long-term option contracts lack liquidity (Dixit et al., 2009, 2011 ; Mohanti & Priyan, 2013). The second data set consisted of monthly average yield on the 91-day T-bill collected from the Reserve Bank of India (RBI). They were converted into continuously compounded annual rate of return. All these two categories of data were collected from April 1, 2012 to March 31, 2017.

(2) Formations of Box-Spread Parity

- Step1: Put and call options with the same strike price, maturity date, and deal date were matched together.
- Step 2: For a particular deal date, the lowest strike price was taken and was paired with the other remaining higher strike prices. Leaving this first lowest strike price, pairs were made with the second lowest strike price and the remaining higher strike prices. This process continued till the second highest strike price was paired with the highest strike price.
- Step 3: The above process (i.e. Step 2) was continued for the remaining deal dates.
- Step 4: After the parity was formed, the data were fitted to Equation (2) to check the possibility of arbitrage.

Data Analysis and Empirical Results

The total number of box spread parity observed is 247478. This parity is fitted to Equation (2) to check the possibility of arbitrage (mispriced signals). The Table 3 represents the violated and non-violated parity.

It is observed from the Table 3 that the frequent violation of box spread parity is observed at the Indian index options market. There are 182600 violated signals in which long box-spread parity can be applied to extract abnormal profit and there are 64688 violated signals in which short box spread parity can be applied to extract abnormal profit.

Table 3. Box Spread Parity : Violated and Non-Violated Signals

Particular	Number of Observations
Non-violated box spread parity	190
Violated box spread parity (Positively)	182600
Violated box spread parity (Negatively)	64688
Total	247478

To get more meaningful explanation on the behaviours of the mispriced signals, the frequency and magnitude of the mispriced signals are observed in light of specified liquidity and maturity levels. This has been done with the view that mere mispriced signals do not indicate inefficiency of the index options market. It is the opportunity to extract abnormal profit (arbitrage) from these observed mispriced signals which gives a serious threat to the market efficiency.

First, the frequency of mispriced signals has been studied in terms of liquidity. This classification is done based on the fact that more the liquidity, the higher is the opportunity to extract abnormal profit from the mispriced signals and higher liquidity also ensures execution of trading strategies required to trap the abnormal profits. However, care should be taken because the liquidity level for the call and put options might be different in a pair (Equation (2)) and the issue of wrong interpretation of analysis might occur. This means that when the mispriced call options are liquid, the mispriced put options might be illiquid and vice-versa, which results in no extraction of abnormal profit. This might be interpreted as an opportunity to extract abnormal profit by seeing only the liquid side to overcome this difficulty. The liquidity is classified into four levels: Low Low (LL) liquidity (i.e. 1-500 contracts for both the call and put options), Low High (LH) liquidity (i.e. 1-500 contracts for call and above 500 contracts for put options), High Low (HL) liquidity (i.e. above 500 contracts for call and 1-500 contracts for put options), and High High (HH) liquidity (i.e. above 500 contracts for both the call and put options). They are again clustered into two levels: Liquid level (HH) and illiquid levels (LL, LH, and HL). The Tables 4 and 5 report the frequency of mispriced signals in light of different liquidity levels.

It is observed from the Table 4 that more violated signals are observed at the liquid level in terms of positively violated box spread and in terms of the negatively violated box spread, more violated signals are observed at an

Table 4. Positively Violated Box Spread Parity in Terms of Liquidity

Liquidity	*N*	Mean	*SD*	Min	Q1	Q2	Q3	Max
Illiquid	53348	15.61	20.72	0.01	3.77	8.93	19.40	442.40
Liquid	129252	6.20	4.82	0.01	2.63	5.25	8.55	83.21
Total	**182600**	**8.95**	**12.66**	**0.01**	**2.87**	**5.86**	**10.28**	**442.40**

Note: *SD*, Q1, Q2, Q3, Min, and Max denote standard deviation, first quartile, second quartile, third quartile, minimum, and maximum, respectively.

Table 5. Negatively Violated Box Spread Parity in Terms of Liquidity

Liquidity	*N*	Mean	*SD*	Min	Q1	Q2	Q3	Max
Illiquid	35621	14.99	21.53	0.01	2.85	7.36	18.25	450.30
Liquid	29067	3.23	4.34	0.01	0.85	2.03	4.10	73.16
Total	**64688**	**9.71**	**17.26**	**0.01**	**1.45**	**3.81**	**9.89**	**450.30**

Note: *SD*, Q1, Q2, Q3, Min, and Max denote standard deviation, first quartile, second quartile, third quartile, minimum, and maximum, respectively.

illiquid level as observed in the Table 5. However, the magnitude of mispriced signals (mean size and quartile distribution) at the liquid levels is significantly smaller than that of the illiquid levels. This means that most of the mispriced signals lack abnormal profit.

Further analysis has been conducted in terms of the number of days left for the options to expire, as the maturity of the options also plays a significant role in determining the exploitability of the observed mispriced signals. This is due to the fact that most of the arbitrageurs try to unwind their arbitrage positions when the options are near expiry and there will be more sellers than buyers, which results in increasing the bid-ask spread (high transaction costs). Therefore, lesser the days left for the options to expire, lesser the opportunity to extract abnormal profits from the observed mispriced signals.

The Tables 6 and 7 reports the classification of the frequency of mispriced signals with a different maturity of the options contracts, that is, 0 -7, 8 -14, 15 -21, and 22 -30 days left for maturity. It is observed from the Tables 6 and 7 that the frequency of mispriced signals for both the positive and negatively violated box spread parity are concentrated at 0 -7, 8 -14 days left for maturity.

In terms of the magnitude of mispriced signals (absolute terms), it is observed that the mean size and quartile distribution of the mispriced signals decrease as the options are going to get expired. This means that there might be an opportunity for abnormal profit as more are the days left for expiration, the more is an increase in the mean magnitude and quartile distribution of the mispriced signals.

To better understand the behaviours of the observed mispriced signals with respect to liquidity and maturity both in terms of frequency and magnitude, cross tables between liquidity and maturity for both positively violated box spread and in terms of negatively violated box spread are reported in Tables 8 and 9, respectively. This has been done in view of the fact that both the liquidity and maturity constitute the basis for extracting the abnormal profit. As high liquidity and more days left for maturity assume low bid-ask spread, it ensures execution of the trading strategies required to trap the abnormal profit.

Table 6. Positively Violated Box Spread Parity in Terms of Maturity

Maturity (in days)	*N*	Mean	*SD*	Min	Q1	Q2	Q3	Max
0-7	58770	8.13	11.99	0.01	2.68	5.60	9.35	442.40
8-14	39469	9.04	12.75	0.01	2.83	5.75	10.13	241.64
15-21	38514	9.25	12.08	0.01	2.93	5.95	10.81	184.57
22-30	45847	9.67	13.78	0.01	3.10	6.30	11.42	302.91
Total	**182600**	**8.95**	**12.66**	**0.01**	**2.87**	**5.86**	**10.28**	**442.40**

Note: *SD*, Q1, Q2, Q3, Min, and Max denote standard deviation, first quartile, second quartile, third quartile, minimum, and maximum , respectively.

Table 7. Negatively Violated Box Spread Parity in Terms of Maturity

Maturity (in days)	*N*	Mean	*SD*	Min	Q1	Q2	Q3	Max
0-7	26224	8.16	15.43	0.01	1.40	3.42	7.97	450.30
8-14	14340	9.99	16.43	0.01	1.50	4.09	10.86	236.35
15-21	12246	10.40	16.74	0.01	1.49	4.05	11.33	170.73
22-30	11878	12.07	21.71	0.01	1.48	4.45	12.91	384.67
Total	**64688**	**9.71**	**17.26**	**0.01**	**1.45**	**3.81**	**9.89**	**450.30**

Note: *SD*, Q1, Q2, Q3, Min, and Max denote standard deviation, first quartile, second quartile, third quartile, minimum, and maximum, respectively.

Table 8. Cross - Table Between Liquidity and Maturity for the Positively Violated Box Spread Parity

Maturity (in days)	Liquidity	*N*	Mean	*SD*	Min	Q1	Q2	Q3	Max
0-7	Illiquid	13282	16.31	22.05	0.01	4.14	9.61	20.05	442.40
	Liquid	45488	5.75	4.31	0.01	2.44	5.04	8.10	58.70
		58770	**8.13**	**11.99**	**0.01**	**2.68**	**5.60**	**9.35**	**442.40**
8-14	Illiquid	12945	15.52	19.85	0.01	3.57	8.88	19.17	241.64
	Liquid	26524	5.88	4.36	0.01	2.62	5.08	8.10	47.41
		39469	**9.04**	**12.75**	**0.01**	**2.83**	**5.75**	**10.13**	**241.64**
15-21	Illiquid	12586	15.23	18.46	0.01	3.72	8.75	19.42	184.57
	Liquid	25928	6.35	5.046	0.01	2.68	5.27	8.80	83.21
		38514	**9.25**	**12.08**	**0.01**	**2.93**	**5.95**	**10.81**	**184.57**
22-30	Illiquid	14535	15.39	22.01	0.01	3.71	8.37	19.01	302.91
	Liquid	31312	7.004	5.55	0.01	2.91	5.74	9.69	64.13
		45847	**9.67**	**13.78**	**0.01**	**3.09**	**6.30**	**11.42**	**302.91**

Note: *SD*, Q1, Q2, Q3, Min, and Max denote standard deviation, first quartile, second quartile, third quartile, minimum, and maximum, respectively.

Table 9. Cross-Table Between Liquidity and Maturity for the Negatively Violated Box Spread Parity

Maturity (in days)	Liquidity	*N*	Mean	*SD*	Min	Q1	Q2	Q3	Max
0-7	Illiquid	9898	15.62	22.52	0.01	3.08	7.80	18.98	450.30
	Liquid	16326	3.64	4.55	0.01	1.03	2.37	4.67	73.16
		26224	**8.16**	**15.43**	**0.01**	**1.40**	**3.42**	**7.97**	**450.30**
8-14	Illiquid	9196	14.01	19.21	0.01	2.86	7.08	17.21	236.35
	Liquid	5144	2.81	3.48	0.01	0.75	1.78	3.56	52.35
		14340	**9.99**	**16.43**	**0.01**	**1.50**	**4.09**	**10.86**	**236.35**
15-21	Illiquid	8156	14.26	19.08	0.01	2.79	7.13	17.44	170.73
	Liquid	4090	2.69	4.86	0.01	0.69	1.67	3.35	70.59
		12246	**10.40**	**16.74**	**0.01**	**1.49**	**4.05**	**11.33**	**170.73**
22-30	Illiquid	8371	16.04	24.70	0.01	2.67	7.40	19.27	384.67
	Liquid	3507	2.60	3.49	0.01	0.61	1.50	3.32	50.21
		11878	**12.07**	**21.71**	**0.01**	**1.48**	**4.45**	**12.91**	**384.67**

Note: *SD*, Q1, Q2, Q3, Min, and Max denote standard deviation, first quartile, second quartile, third quartile, minimum, and maximum, respectively.

After the cross tabulation (Tables 8 and 9) of the mispriced signals, it becomes clear that extracting abnormal profit will be quite impossible as the frequency of mispriced signals is concentrated at the illiquid level, and the mean magnitude as well as the quartile distribution of the liquid levels is significantly lower than that of the illiquid levels for both the positive and negatively violated box spread parity. This gives a very important finding of the abnormal profits from the mispriced signals. The abnormal profits in the case of liquid traded options (where the mispriced signals may have the opportunity to extract abnormal profit because bid-ask spread is assumed to be low) might disappear in the presence of transaction costs as the mean magnitude and quartile distribution of the mispriced signals seems to be significantly lower than that of the illiquid traded options. On the other hand, although the mean magnitude and quartile distribution of the mispriced signals is quite high for the

Table 10. Summary of One - Sample Kolmogorov - Smirnov Statistics to Assess Normality

Variables		Positively Violated Box Spread Parity	Negatively Violated Box Spread Parity
Number of observations		182600	64688
Normal parameters (a, b)	Mean	8.95	9.71
	Std. Dev	12.66	17.26
Most Extreme Differences	Absolute	0.24	0.29
	Positive	0.21	0.29
	Negative	-0.24	-0.25
Kolmogorov-Smirnov *Z*		102.54	73.03
Asymp. Sig. (2-tailed)		**0.00**	**0.00**

Note:

1. a. Test distribution is Normal. b. Calculated from data.
2. Significant at the 5% level of significance.

illiquid traded options, they may lack abnormal profits due to high bid-ask spread. All these signs are good for the market as they all indicate a lack of abnormal profits from both the positive and negatively violated box spread parity.

Following the descriptive statistics of the absolute amount of mispriced signals, further analysis has been carried out to identify whether there exists a significant difference among the mean magnitude across different liquidity and maturity levels as specified in Tables 4, 5, 6, and 7. To validate whether these differences are statistically significant, student's *t* - test and analysis of variance (ANOVA) test are to be applied. These analyses will provide better insights in explaining the exploitability of abnormal profits indicated by the observed mispricing signals. Before applying the test statistics on the sampled data, the main assumption of student's *t* - test and ANOVA that the samples have been drawn from a normally distributed population has been validated by employing the one-sample Kolmogorov - Smirnov (KS) statistic. The results are summarized in the Table 10.

The Table 10 reveals that the sample data are violating the main assumption of student's *t* - test and ANOVA. So, student's *t* - test and ANOVA cannot be employed, instead, their analogous non-parametric statistics, which do not require data to follow any specified distribution, Mann -Whitney *U* test and Kruskal-Wallis (*H*-statistics), are employed for the study. The hypotheses have been formulated to test whether there is a significant difference between the mean magnitude of different liquidity and maturity levels. For liquidity levels, the Mann-Whitney *U* test is employed and the results are summarized in the Table 11.

Table 11. Mann - Whitney *U* Statistics for the Difference Among the Mispriced Signals Across Different Liquidity Levels for the Positively and Negatively Violated Box Spread Parity

Positively violated box spread parity	*N*	Test Statistics		Negatively violated box spread parity	*N*	Test Statistics	
Illiquid	53348	Mann-Whitney *U*	2346882867	Illiquid	35621	Mann-Whitney *U*	798247544
Liquid	129252	Wilcoxon *W*	10699987245	Liquid	29067	Wilcoxon *W*	1220707322
Total	182600	*Z*	-107.46	Total	64688	*Z*	118.75
		Asymp. Sig (2-tailed)	**0.00**			Asyamp. Sig (2-tailed)	**0.00**

Note: Significant at the 5% level of significance.

↬ **H01:** There is no significant difference among the mean sizes of the absolute amount of different liquidity levels for the positively violated box spread parity.

↬ **H02:** There is no significant difference among the mean sizes of the absolute amount of different liquidity levels for the negatively violated box spread parity.

It is observed from the Table 11 that the test results are significant at the 5% level of significance. Therefore, we reject both the null hypotheses (H01 and H02), and we conclude that there is a significant difference between the mean magnitudes of illiquid and liquid levels for both the positively and negatively violated box spread parity.

Further, to validate whether the mean magnitude of mispriced signals at different maturity levels are statistically significant from one another, the hypotheses have been formulated and tested by using a non-parametric test, Kruskal-Wallis test. The test results are summarized in the Table 12 for the positively and negatively violated box spread parity. In addition to this, Dunn's multiple comparison test has been employed for the post-hoc analyses of all possible pairs, and the test results are summarized in the Table 13 for the positively and negatively violated box spread parity.

Table 12. Kruskal - Wallis (*H*-Statistics) Test for the Difference Among the Mispriced Signals Across Different Maturity Levels for Positively and Negatively Violated Box Spread Parity

Maturity		Positively Violated Box Spread Parity				Negatively Violated Box Spread Parity				
(in days)		Ranks	Test Statistic (a, b)			Ranks		Test Statistic (a, b)		
	N	Mean Rank	Chi-Square	*df*	Sig.	*N*	Mean Rank	Chi-Square	*df*	Sig.
0-7	58770	87328.46				26224	33924.08			
8-14	39469	90511.96	703.48	3	**0.00**	14340	31592.50	334.82	3	**0.00**
15-21	38514	92873.01				12246	31490.35			
22-30	45847	95750.00				11878	30645.62			
Total	**182600**					**64688**				

Note:
1.a. Kruskal - Wallis Test b. Grouping Variable: Liquidity.
2.Significant at the 5% level of significance.

Table 13. Dunn's Test for Multiple Comparisons Amongst the Different Maturity Levels for Positively and Negatively Violated Box Spread Parity

Dunn's Multiple Comparison	Positively Violated Box Spread Parity			Negatively Violated Box Spread Parity		
Sample 1 vs Sample 2	Test Statistic	Std. Test Statistic	Adj. Sig. ($p < 0.05$)	Test Statistic	Std. Test Statistic	Adj. Sig. ($p < 0.05$)
0-7 vs 8-14	-3183.50	-9.28	**Yes**	-2331.57	-2.02	**Yes**
0-7 vs 15-21	-5544.56	-16.04	**Yes**	-2433.73	-11.91	**Yes**
0-7 vs 22-30	-8421.54	-25.64	**Yes**	-3278.46	-15.87	**Yes**
8-14 vs 15-21	-2361.06	-6.25	**Yes**	-102.16	-0.45	**No**
8-14 vs 22-30	-5238.04	-14.47	**Yes**	-946.89	-4.09	**Yes**
15-21 vs 22-30	-2876.99	-7.90	**Yes**	-844.73	-3.51	**Yes**

Note: Each row tests the null hypothesis that Sample 1 and Sample 2 distributions are the same. Asymptotic significance (2-sided tests).

↳ **H03:** There is no significant difference among the mean sizes of the absolute amount of different maturity levels for the positively violated box spread parity.

↳ **H04:** There is no significant difference among the mean sizes of the absolute amount of different maturity levels for the negatively violated box spread parity.

From the Table 12, it is observed that the test results for both the positively and negatively violated box spread parity show statistical significance at the 5% level, and both the hypotheses are rejected (H03 and H04). So, we can conclude that there is a significant difference between the mean magnitudes of the different maturity levels for both the positively and negatively violated box spread parity. The post-hoc test, Dunn's multiple comparison test, was conducted for all the possible pairs of maturity for both the positively and negatively violated box spread parity, and the results are reported in the Table 13.

It is observed from the Table 13 that the test results show statistical significance at the 5% level for all the possible pairs except for 8-14 vs 15-21 in the negatively violated box spread parity. This will not cause major issues and will interpret the results of analysis as 0 -7 days to maturity, which is designated as non-exploitable for abnormal profit and is significantly different from all the possible pairs.

In operational terms, the results show that the mean magnitude of mispriced signals for the illiquid traded index options is significantly different from those of liquid traded for both the positively and negatively violated box spread parity. In the case of the days left for maturity, for the positively violated box spread parity, the mean magnitude of the mispriced signals for all the possible pairs is significantly different from each other. However, in the case of the negatively violated box spread parity, all the level pairs of the days left for the maturity are significantly different, except 8-14 vs 15-21. All these findings are a good sign for the Indian index options market as it indicates that the truly exploitable mispriced signals are significantly different from the non-exploitable mispriced signals. This means that the mispriced signals, which are designated to have abnormal profits, are significantly different from the mispriced signals, which are not designated to have abnormal profits.

Conclusion and Policy Implications

The pricing efficiency of Indian index options market is examined empirically by testing the box spread parity. The study finds frequent violations of box spread parity in the Indian index options market. In terms of frequency of mispriced signals, the majority of the mispriced signals are concentrated at the illiquid level and options which are going to get expired for both the positive and negatively violated box spread parity. This observation is in line with the study results of Dixit et al. (2009, 2011), who obtained similar results while testing the lower boundary conditions on the Nifty index option, a type of testing of the options's market efficiency.

In terms of the magnitude of the mispriced signals, mean size and quartile distribution of mispriced signals at the illiquid levels is much larger than that of the liquid levels, which means there is no or lack of opportunity to extract abnormal profit from the observed mispriced signals. However, in terms of maturity, the mean magnitude and quartile distribution of mispriced signals increase as the day of maturity increases. This means that there might be a possibility for extracting abnormal profit from the mispriced signals. To better understand the possibilities of extracting abnormal profit, cross tables between the liquidity and maturity in terms of frequency and magnitude are constructed. The cross-tables reveal that though the mean magnitude of mispriced signals increases as the days of maturity increase, extracting abnormal profit will be quite impossible as the mean magnitude and quartile distribution of the liquid traded regions are significantly smaller than that of the illiquid traded regions.

It becomes clear that in spite of frequent violations of box spread parity prevailing in the Indian index options market, extracting abnormal profit is not possible as the magnitude of mispriced signals at liquid regions is significantly lower than what is present at the illiquid regions, and meantime majority of the mispriced signals are concentrated at options which are going to get expired. The study concludes that the Indian index options market, during the period of the study, was efficient as most of the abnormal profits were not exploitable due to lack of liquidity, that is, most of the mispriced signals were at thinly traded levels and options which were going to get expired. This finding of the study is in line with the findings of previous studies (Girish & Rastogi, 2013 ; Vipul, 2009), who also conducted their studies at the initial development stage of the Nifty index options market.

The findings of this study will be useful to all types of investors, stock exchanges, policymakers, regulators, portfolio managers, and other concerned authorities as the findings would enable markets and stakeholders to facilitate hedging, price discovery, and allocation of resources to their most productive uses. The study also contributes to the literature on market efficiency of the index options, particularly in the case of the Indian index options market.

Limitations of the Study and Scope for Further Research

There are some limitations in the study that can be considered as scope for further research. In the study, closing prices of the index were taken because the problem of data non-synchronization may arise, and the only solution to overcome this was to employ intraday data ; also, the study was conducted assuming no transaction costs as they are difficult to estimate. They differ for different participants in the market and with the types of trading strategies employed. So, future studies can incorporate transaction costs and can employ intraday data while testing the box spread parity in the Indian index options market.

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