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Put-Call Parity in Indian Stock Markets post Turmoil Settlement

Pankaj Kumar Gupta

Abstract

Purpose of the article: Put and call prices have a deterministic relationship for identical options irrespective of the investor dmand. The theoretical put-call parity (PCP) relationship may be analysed to explore the arbitrage opportunity and determine the extent of market efficiency. We have studied the violation of this relationship using a case of options traded on the National Stock Exchange of India (NSE) on various parameters including Moneyness, arbitrage differential, and time to maturity and trade volumes.
Methodology/methods: We use regression models with dummy variables on one-year sample data (Jan-Dec 2017) of the NSE Nifty Call and Put options to examine the existence of arbitrage indicating the inefficiency of market particularly the illiquidity factor. In the selected period (turmoil settlement), the relative volatility is low and it is worth testing the PCP.
Scientific aim: The aim of this research is to improve the knowledge on market efficiency in developing markets highlighting the role of major market participants.
Findings: We have found that the violation of the put-call parity relationship in a large number of cases occurred even during the post turmoil settlement period. Arbitrage profits are found to be significant for deeply in-the-money and deeply out-of-the money options though the differentials are not significantly affected by the increase or decrease in time to maturity and liquidity indicating a direct relationship. Also, the gap between the spot price and the strike price of the Nifty index options is directly proportional to the arbitrage profit.
Conclusions: We have established that in options markets, significant arbitrage opportunities exist violating the Put-Call parity relationship even in the times of low volatility and relatively higher trade volumes. For the policymakers, the immediate concern is to improve the market competitiveness.

Keywords: put-call parity, arbitrage profit, moneyness, NIFTY, liquidity

JEL Classification: D53, G12

Introduction

The derivative segment is the most important constituent segment of the securities market all over the world including Asian countries like India. In June 2000, the regulator at the Indian securities market, i.e. Securities and Exchange Board of India (SEBI), permitted the stock exchanges in India to carry derivative trading in index futures. Accordingly, the National Stock Exchange (NSE) and Bombay Stock Exchange (BSE) introduced futures based on the S&P CNX Nifty index and BSE-30 (Sensex) index respectively. A step further, the stock options and index options were also introduced. Today, the Futures and Options (F&O) segment turnover has grown twenty five thousand times from initial start of $0.37 billion in 2000-01 to $18,091.58 billion in 2017–18 (till Dec 2018) at the NSE.

The NSE as of now provides a variety of equity derivative products in the Futures and Options segment covering nine major indices and over hundred securities. Trades in the F&O segment are particularly dominated by foreign institutional investors in the Indian securities market accounting for more than half of the volumes. In the recent times, we have seen a large shift in the portfolio strategies of the global players especially the Asian markets.

In the options markets, put-call arbitrage is of particular interest to the players in the F&O segment in India because of incidence of mispricing and liquidity concerns. The put and call prices have a deterministic relationship not directly guided by the demand supply factors on identical options with respect to underlying assets, exercise price and expiration date. The theoretical put-call relationship can be developed to determine a put (call) price for a given call (put) price and other relevant information (for example, current price of the asset S_0, exercise price X, risk-free rate r_f and time to maturity T). If the actual call or put price is different from the theoretical price, there would be an arbitrage opportunity that would call the trader to set up a risk-free position and earn more than risk-free rate (r_f).

Stoll (1969) initially developed the put-call parity relationship and his work has been furthered by Merton (1973). We have found extensive research examining the parity conditions, such as Klemkosky, Resnick (1979, 1980); Mittnick, Rieken (2000); Broughton, Chance, Smith (1998); Bharadwaj, Wiggins (2001), Garay *et al.* (2003); Chakrapani (2007); Chakrabarti *et al.* (2017).

However, there is a mixed response to the empirical verification of the PCP. While, some studies support the PCP, there are others that reject it. The research findings on the Indian stock markets typically cover the volatile times, such as the Asian crisis, the global financial crisis and other such market turmoil, thus implicitly refuting the parity relationship or on contrary, confirming the relationship mainly due to large trade volumes during that period. We are motivated to examine the parity relationship for the period that largely demonstrates stability after the shocks.

1. Theoretical framework

We use the standard Black Sholes Model (1973) for examining the put-call parity relationship. The payoff and apparent profits of the options to the buyers and writers/sellers follow the linear functions – Max ($ST - X$, 0), Min ($ST - X$, 0) *etc.* The theoretical relationship between option premiums (both call and put) and the exercise price (X), risk-free rate (r_f) and time to maturity (T) can be described using the case of riskless portfolio. A portfolio consisting of buying a call option with an exercise price of X and time to maturity of T and investment *of* $(X+D)\ e^{-rT}$ in the risk-free asset with time to maturity the same as that of expiration date of the option. The value of the portfolio at time T, when the option expi-

Table 1. Portfolio value for the range of spot prices.

Value	$S_T < X$	$S_T > X$
Put option	0	$S_T - X$
Stock	$X + D$	$X + D$
Total	$X + D$	$S_T + D$

Source: Author's own study.

Table 2. Portfolio value for the range of spot prices.

Value	$S_T < X$	$S_T > X$
Call option	$X - S_T$	0
Risk-free asset	$S_T + D$	$S_T + D$
Total	$X + D$	$S_T + D$

Source: Author's own study.

res and investment in risk-free asset matures, is shown in Table 1.

Where r is the risk-free rate (with continuous compounding) and D is dividend per share (if any), the underlying asset is expected to pay on or before maturity. Similarly, a strategy involving a long put option with an exercise price (X) and time to maturity (T) and investment in the underlying asset (stock) in the spot market (protective put) is shown in Table 2.

The above two portfolios have the same payoff. If that is the case, they must have the same cost to establish. The cost of establishing the first portfolio (call plus risk-free asset) = $C + (X + D)e^{-rT}$

The cost of establishing the second portfolio (put plus stock) = $P + S_{0,}$ Therefore,

$$C + (X + D)e^{-rT} = P + S_0 .$$

If the stock (underlying asset) is not expected to pay any dividend before the maturity of the option (*i.e.* $D = 0$), the above relationship will be

$$C + Xe^{-rT} = P + S_0 .$$

This relationship is called as put-call parity theorem because it represents the logical relationship between call and put premiums. If violations occur in this relationship, an arbitrage opportunity will arise. If the above relationship is violated, it indicates mispricing and inefficiency.

To exploit mispricing, one should buy the relatively cheap portfolio and sell the relatively expensive portfolio to earn arbitrage profits. If the cost of establishing call plus risk-free asset is greater than the cost of establishing put plus stock

$$(C + Xe^{-rT} > P + S_0),$$

one can earn arbitrage profits by writing call, buying put, borrowing from the risk-free market and buying the stock. The present value of the profit from the portfolio is

$$C - P - S_0 + Xe^{-rT} = \acute{a}.$$

If the cost of establishing put plus stock is more than the cost of establishing call plus risk-free asset ($C + Xe^{-rT} < P + S_0$), one can earn arbitrage profits by buying call, writing put, lending in risk-free market and acquiring a short position in the stock. The present value of profit from this position is

$$P - C + S_0 - Xe^{-rT} = \hat{a} .$$

There will not be any arbitrage opportunity if $\acute{a} = \hat{a} = 0$.

Stoll (1969) first developed this relationship in which it is assumed that $X = S_0$ (at the money option) without dividends before the time to maturity considering the European and American options on similar footing. Later this model was modified by Merton (1973), who argued that "for a non-dividend paying stock, Stoll's model is applicable only if the options are of European style. According to Merton, Stoll's model cannot be applied for a non-dividend paying stock if the options are of American style because although it not optimal for a non-dividend paying stock to exercise the call option before maturity, it may be optimal to exercise the put option before the maturity. Stoll (1973) conceded the point mentioned by Merton with certain conditions". European style options can overrule the problem of

Table 3. Payoff on the expiration date.

Payoff	$S_T < X$	$S_T > X$
Of put purchased	$X - S_T$	0
Of long futures	$S_T - F_0$	$S_T - F_0$
Total	$X - F_0$	$S_T - F_0$

Source: Author's own study.

Table 4. Payoff on the expiration date.

Payoff	$S_T < X$	$S_T > X$
Of call purchased	0	$S_T - X$
Of risk-free assets	$X - F_0$	$X - F_0$
Total	$X - F_0$	$S_T - F_0$

Source: Author's own study.

incorporating dividend and early exercise in Merton's (1973) model and other existing studies (Klemkosky, Resnick, 1979; Gould, Galai, 1974). In order to handle the case of short selling restrictions associated with spot market, we use NSE Nifty futures for acquiring a short or long position with the same time to maturity as that of options.

A portfolio of buying a European put option at the NSE Nifty (with the exercise price X and time to maturity T) and acquiring a long position at the NSE Nifty futures with time to maturity of T (same as that of option) will have the following payoff on expiration date (Table 3).

Similarly, the portfolio consisting of buying a European call option at the NSE Nifty (with the exercise price X and time to maturity T) and an investment of $(X - F_0)\, e^{-rT}$ in the risk-free asset with time to maturity of T (the same as that of the option) will have the following payoff on the expiration date (Table 4).

Thus, the two portfolios have the same payoff. If that is the case, they must have the same cost to establish. The cost of establishing put plus long futures is P, whereas the cost of setting call plus risk- free asset is $C + (X - F_0)e^{-rT}$. Therefore,

$$P = C + (X - F_0)e^{-rT}.$$

If there is a violation of the above relationship, the arbitrage opportunity will arise. If $P > (X - F_0)e^{-rT}$, one should buy call, write put, short futures and invest in the risk-free market. The present value of the profit of this position is

$$P - C - (X - F_0)e^{-rT} = \tilde{a} .$$

If $P < (X - F_0)e^{-rT}$, one should write call, buy put, long futures and borrow from the risk-free market. The present value of profit of this position is:

$$C - P + (X - F_0)e^{-rT} = \ddot{a}.$$

For no arbitrage condition, $\tilde{a} = \ddot{a} = 0$.

2. Literature review

Various empirical studies into the put-call parity (PCP) relation suggest that apparent mispricing of options lead to real opportunities for arbitrage in markets. Frequently, the transaction costs are not provided and this leads to the mispricing. Sometimes, options and the price of underlying assets do not match and this leads to a violation of the PCP relation. In order to correct this apparent *non-synchronicity*, a suitable form of sampling should be selected, depending on the liquidity of the options and underlying assets that are used in the empirical study, to remove the effect of non-synchronous trading.

Nisbet (1992) study into the intra-daily data derived for the London Traded Options Market (LTOM) shows violations of the PCP if the transactions cost are embedded into the bid-ask spread. Furthermore, the arbitrage opportunities dry up when commissions and dividends are considered. Capelle-Blanchard, Chaudhury (2001) find support for the PCP relation in France. The studies into the US markets conducted by Stoll (1969); Gould, Galai (1974) have found that the *magnitude of assumed transaction costs* is an important variable to hold the PCP. Evnine, Rudd (1985), Klemkosky, Resnick (1992) have identified the following three important factors which may have caused the possible inefficiencies: (a) not using the intra-daily or daily closing data, (b) the use of weekly or monthly closing prices that increase the probability of errors caused by data non-synchronicity, and (c) the absence of transactions costs. Kamara, Miller (1995) establishes that the number of PCP violations was much smaller than what was found in earlier studies which had used only American options.

In India, Misra, Misra (2005) found a violation of the PCP. Vipul (2008) establishes that the violation is mainly due to the restriction on short sales. The PCP relation violations pattern is associated with a 'premium' value that results from the liquidity risk and moneyness. The prominent studies in Australia have been carried by Loudon (1988); Gray (1989); Taylor (1990); Easton (1994); Brown, Easton (1992); Cusack (1997). Some studies show diametrically opposite conclusions. Cusack (1997) included the transaction costs and excluded the bid-ask spread and show that their results are consistent with the existence of inefficiencies in the Australian market, even when the transaction costs were included in the analysis. The use of intra-daily data versus the use of closing daily data did not make any difference to the results obtained. Chakrabarti *et al*. (2017) study into the NIFTY 50 stocks also establishes the presence of arbitrage opportunities. We draw motivation to examine the existence of the PCP and explore the determinants of its violation in the dynamic global scenario especially the period of the post-crisis recovery. We argue that the efficiency and strength of the market can be better judged during such regimes of low volatility jumps.

3. Methodology

We conduct an empirical analysis of the presence of an apparent arbitrage using the put and call prices on the Nifty Index Options in the time period from 1st January 2017 to December 2017. Within the selected period, we accounted for the policy reforms such as the Demonetisation and Goods and Services Tax (GST). We emphasise the frequently traded options, since with the increase in the number of transactions, the process of price discovery improves. The shortlisted data make use of the theoretical value of the put option. Arbitrage profit is defined as the monetary profit arising out of the difference between the actual value and theoretical value of selected put-call sets. We also use the framework of Brown, Easton (1992) for liquid options and stock markets, the in the sampling process.

Of the options traded on the NSE, we have found three variants of options namely 1 month, 2 months and 3 months: they are settled in cash and expire on the last Thursday of the expiry month. The strike level varies with the index level and with a minimum value contract of Rs. two lakhs with the initial tick of Re. 0.05. The data of the number of contracts is grouped as – (a) 1–100, (b) 100–500, and (c) 5000–1000 and (d) >1000. For the analysis based on the time to maturity, the data is grouped in the categories – (a) <30 days, (b) 30–60 days, and (c) > 60 days. Moneyness is the strike price ratio classified as (a) <0.90 * Nifty, (b) 0.90 * Nifty to less 0.95 * Nifty, (c) 0.95 * Nifty to less than Nifty, (d) Nifty to less than 1.05 * Nifty, (e) 1.05 * Nifty to less than 1.10 * Nifty, and (f) >1.10 * Nifty. The risk-free rate has taken the yield on the 10-year Government of India treasury bonds during 2015 – 8.5% with continuous compounding. The arbitrage opportunity

$$A = P_{A,t} - P_{Th,t}, \quad (1)$$

where:

$P_{A,t}$ quoted premium for NSE Nifty put option (X, T),

$|A|$ arbitrage profit.

If A is positive and significant, it would imply that the put price is relatively high relative to the call and arbitrageur can exploit the opportunity. In the converse case, the arbitrager can otherwise create riskless portfolio for the guaranteed profit. The opportunity depends upon (*S-X*), the extent of violation measured by the dummy variable – $D=0$, if the put option is in the money (if $S_0 - X < 0$) and $D=1$, if the put option is out of money (if $S_0 - X > 0$), *T* and *NOC*. The multiplier for the underlying NIFTY is 75.

We use the **final model** as

$$|P_{A,\,Xi} - P_{Th,\,Xi}| = á + â\,|S_A - X_i| + \\ + ãD + äT_t + èNOC_t + U, \qquad (2)$$

where:

$|P_{A,\,Xi} - P_{Th,\,Xi}|$ – absolute difference between the actual put premium and theoretical put premium on day *t* with an exercise price of X_i and time to maturity of T_t,

$|S_A - X_i|$ difference between value of the NSE Nifty and its exercise price on day *t*; the trading in NSE Nifty options on day *t* may be with different exercise prices,

D dummy variable,
$D = 0$ *if* $S_A - X_i < 0$,
$D = 1$ *if* $S_A - X_i > 0$,

T_t time to maturity of the option on day t,

NOC_t number of Nifty put options traded on day *t*,

U random error term.

The value of *â* indicates the extent of the arbitrage profit. If the estimated *è* is positive and significant, it would mean that options that are more liquid are likely to generate more arbitrage profits compared to options that are less liquid. Conversely, if the estimated è is negative, less liquid options are likely to generate more arbitrage profits compared to highly liquid options. We used the published data from the NSE website yielding 53,116 observations on trading days for which the desired sets of puts and calls varying for exercise prices and maturity are available. We used only half of the selected observations due to the unavailability of confirmed trades. Return on 10-year GOI bonds has been used as a surrogate to the risk free rate.

4. Results and discussions

The arbitrage profits computed for various ranges of NOC (number of contracts) and varying ranges of time to maturity respectively implicate that with increasing liquidity, the arbitrage profit decreases (Table 5 and Table 6). The maximum arbitrage opportunity is nearly the same irrespective of the category. In addition, the variance in the arbitrage profit also decreases with liquidity.

It can be inferred that the arbitrage profit quantum is neutral to time to maturity. The maximum arbitrage opportunity is nearly the same irrespective of the category. However, the variance in the arbitrage quantum decreases with increase in time to maturity.

Also, the arbitrage profits are likely to be higher when put options are deeply in/out of money. The maximum profit and calculated

Table 5. Arbitrage profits and number of contracts traded.

Number of contracts traded		Arbitrage profits per contract (in rupees)			
Range	**Count**	**Mean**	**Maximum**	**Minimum**	**Standard deviation**
1–100	12,964	293.85	2,614.99	0.00	472.95
100–500	3,836	158.41	2,614.05	0.00	381.81
500–1000	1,636	147.24	2,610.78	0.00	375.51
>1000	8,121	96.28	2,653.79	0.00	316.98

Source: Author's own computation, 2018.

Table 6. Arbitrage profits and time to maturity.

Time to maturity		Arbitrage profits per contract (in rupees)			
Range	**Count**	**Mean**	**Maximum**	**Minimum**	**Standard Deviation**
<30 days	14,061	191.67	2,626.99	0.00	444.53
31 to 60 days	8,656	222.72	2,584.01	0.00	428.45
>60 days	4,853	199.19	2,242.46	0.00	327.51

Source: Author's own computation, 2018.

Table 7. Arbitrage profits and gap between the Nifty spot and exercise price.

If the exercise price is		Arbitrage profits per contract (in rupees)			
Range	**Count**	**Mean**	**Maximum**	**Minimum**	**Standard Deviation**
< 0.90 Nifty	10,598	371.84	2,626.99	0.00	608.79
0.90 Nifty – 0.95 Nifty	3,896	131.87	764.99	0.00	175.28
0.95 Nifty – 1.0 Nifty	4,104	54.34	385.58	0.00	76.68
1.0 Nifty – 1.05 Nifty	3,569	46.36	695.96	0.00	77.82
1.05 Nifty – 1.10 Nifty	2,508	120.99	853.64	0.00	173.40
>1.10 Nifty	2,896	153.12	1,514.93	0.00	263.16

Source: Author's own computation, 2018.

variance also mirror the arbitrage profit behaviour vis-à-vis the in/out of money criteria. We found interesting that the NOC for which transactions took place are significantly higher for deeply out-of-money put options.

The results indicate that apparent arbitrage profits are higher for less liquid NIFTY options. A higher variation in arbitrage profits has been observed for the NOC between 1 and 100. The standard deviation of the arbitrage profits for the number of contracts traded between 1 and 100.

Mean profits are similar for the *NOC* – (a) 100 – 500 and (b) 500–1000, being considerably lower for the number of contracts greater than 1,000. The maximum arbitrage opportunity is nearly the same for all groups and the variation decreases with liquidity.

We have also analysed the determinants of the put-call parity violation theorem, using the variable (*S-X*), *T* and the *NOC*. We have established the regression models for varying ranges of the *NOC*, *T* and (*S-X*). The estimating re**gression model is**

$$|P_{A,Xi} - P_{Th,Xi}| = x_0 + x_1|S_A - X_i| + x_2M + x_3T_t + x_4C + e, \quad (3)$$

where:

$|P_{A,Xi} - P_{Th,Xi}|$ – difference (absolute) between the theoretical put premium and actual premium on day t that has an exercise price of X_i and time to maturity T_t,

$|S_A - X_i|$ the difference between the Nifty spot and option's i^{th} exercise price on day *t*,

M moneyness, $M = 1$, if $S\text{-}X > 0$, $M = 0$ if $S\text{-}X < 0$,

T_t time to maturity of the option on day *t*,

C number of underlying put options traded on day *t*,

e random disturbance term.

The data for the regression has been tested assuming that the dependent variable (quantum of the arbitrage) is on a continuous scale. All the independent variables are on the continuous scale. The independence of the

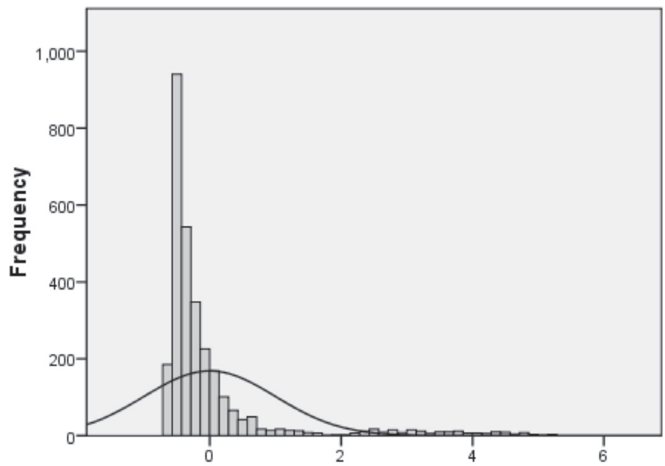

Figure 1. Regression standardized residual. Source: Author's own computation, 2018. Mean = 4.95 E-16, Std. Dev. = 0.999, N = 2955.

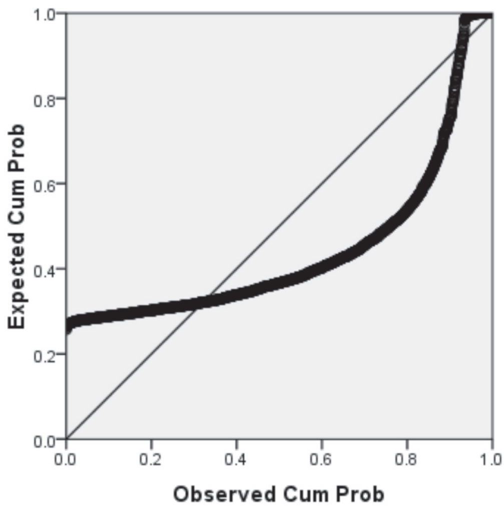

Figure 2. Normal P-P plot of regression standardized residual. Source: Author's own computation, 2018.

residuals has been established through the Durbin-Watson test. For all the regressions, the value of the Durbin-Watson test is near 2.0, indicating the independence of the residuals. The residuals (errors) tested using a histogram with a superimposed normal curve (Figure 1) and a Normal P-P Plot (Figure 2) are found to be normally distributed. For the purpose of the study, the following conditions have been assumed to be satisfied by the data:

- there is a linear relationship between dependent and independent variables,
- the sample data confirms the homoscedasticity,
- absence of multi-collinearity and significant outliers,
- there are no high leverage/influential points.

The results of the estimated regression models are shown in Tables 8–10.

We have found that the gap between the exercise price and NIFTY is significant and

Table 8. Regression model: the number of contracts.

Number of contracts	Constant	*S-X*	Moneyness	Time	*C*	R^2	No. of observations
1–100	6.47658	0.179* (48.036)	94.27* (11.482)	0.7659* (5.089)	–2.323* (–14.326)	0.222	13460
100–500	–49.0446	0.165* (18.546)	41.574* (3.145)	0.862* (3.527)	–0.338 (–.641)	0.106	4023
500–1000	–31.3038	0.181* (11.239)	17.866 (0.817)	0.964** (2.348)	–0.025 (–0.421)	0.091	1716
>1000	–53.7521	0.229* (37.643)	–10.932 (–1.378)	1.261* (6.786)	0.00007550* (3.406)	0.159	8517
>100	–52.7492	0.193* (42.922)	14.643** (2.272)	0.937* (7.204)	0.00005792** (2.333)	0.131	14256

Source: Author's own computation, 2018.

Figures in brackets are t-values.

** Significant at 1% significance level; ** significant at 5% significance level; *** significant at 10% significance level.*

Table 9. Regression model: time to maturity.

Time to maturity	Constant	*S-X*	Moneyness	Time	*C*	R^2	No. of observations
< 30	–48.292	0.206* (55.459)	–2.182 (–0.282)	1.744* (4.685)	0.00004930*** (1.645)	0.204	14304
31–60	–128.782	0.215* (45.519)	65.122* (7.246)	2.484* (4.984)	0.000 (–0.910)	0.233	8806
>60	–91.806	0.164* (30.347)	88.245* (9.384)	1.469* (2.853)	–0.0319* (–0.066)	0.210	4937

Source: Author's own computation, 2018.

Figures in brackets are t-values.

** Significant at 1% significance level; ** significant at 5% significance level; *** significant at 10% significance level.*

Table 10. Regression model: in-the-money/out-of-the-money.

K % of Nifty	Constant	*S-X*	Time	*C*	R^2	No. of observations
< 0.90 Nifty	–78.3819	0.220* (40.397)	2.140* (8.861)	–0.00199* (–1.888)	0.138	11030
0.90 – 0.95 Nifty	–65.0464	0.289* (12.338)	1.289* (11.225)	–0.0000023* (–4.075)	0.080	4055
0.95 – 1.0 Nifty	–9.33764	0.169* (15.683)	0.898* (17.719)	–0.000001825 (–0.236)	0.136	4272
1.0 – 1.05 Nifty	–4.40938	0.195* (–1.298)	0.504* (16.020)	0.00003670 (.370)	0.86	3715
1.05 – 1.10 Nifty	–85.3289	0.381* (12.835)	0.392** (2.540)	–0.0089* (–4.0328)	0.73	2610
>1.10 Nifty	143.7423	0.012 (0.964)	0.062 (0.286)	–0.0269* (–3.067)	0.004	3014

Source: Author's own computation, 2018.

Figures in brackets are t-values.

** Significant at 1% significance level; ** significant at 5% significance level; *** significant at 10% significance level.*

positive for all categories. Similar results have been obtained for time to maturity (*T*). The number of contracts is significant at 1% significance level only for the categories with less than 100 or more than 1,000 contracts. The Moneyness variable is positive and significant for the categories with the number of contracts less than 500. This implies that the arbitrage profit is higher for out of money put options under these conditions.

The gap (*S-X*) is positive and highly significant for all categories for various maturity periods. The number of contracts is significant at 1% significance level only for contracts with the maturity of >60 days. The Moneyness variable is positive and significant for options with time to maturity >30 days. This implies that the arbitrage profit is higher for out of money put options under these conditions.

It has been observed that the gap between the exercise price and the spot price of the index is positive, while also being significant for all regression results. The time to maturity is also positively significant for all regressions except when the puts are “deeply in the money”. The coefficient of time variable decreases in value as the put call moves from “deeply out of money” to “deeply in the money”. In most of the cases where the number of contracts (*C*) is significant, the coefficients are negative. This implies that with the increase in liquidity, the profit from arbitrage reduces. Also, the Moneyness variable is positive and significant for options with less than 500 contracts and time to maturity >30 days. This implies that the arbitrage profit is higher for out of money put options under these conditions.

The results obtained from the regression model(s) show that the gap between the Nifty spot and exercise price for time to maturity is significant and positive for all regressions except in one case when the exercise price is more than 10% of the Nifty where coefficients have come out to be a positive yet insignificant determinant of arbitrage profits. The results show higher arbitrage profits for options that are *deeply* in/out of the money. The results further indicate that *T* has little impact on the arbitrage profit. This means that arbitrage profits are nearly the same in “not so near month contracts” and “near the month contracts”.

Also, the significance of the dummy variable (which indicate whether arbitrage profits are higher in the case of in the money option or out of the money option), responses are mixed. The positive and significant coefficient of the dummy variable show that arbitrage profits are higher in the case of out of the money put option than in the money put option and vice versa. Where the number of options traded is 100 or more, arbitrage profits are higher in the case of *out of the money* put option. Moneyness is positive and significant where the *NOC* < 500. The results show that in the case of more liquid options (*NOC* > 500), arbitrage profits are not significantly determined by the Moneyness of the option.

On comparing the coefficient of the dummy variable for various maturities, it has been noted that for the near-month option contracts (*T*<30), the dummy variable coefficient was insignificant which shows that arbitrage profits are not determined by the Moneyness of the near-month contracts. For *T between* 31–60 (not-so-near-the-month contract) and for maturity of more than 60 days (for the far-month-options contract), the dummy variable coefficient was both significant and positive.

The coefficient of the number of contracts was negative and significant in the case of the number contracts traded between 1–100; the observed coefficient is positively significant for the *NOC*>1,000. This indicates that in the case of options that are relatively less liquid (*NOC*<100), the higher the number options traded, the lower is the arbitrage profit and vice-versa.

In the case of options that are highly liquid (*NOC*>1000), the higher the number of contracts traded, the higher the arbitrage profits and vice versa. In the case of options that are moderately liquid, the coefficient of the number contracts traded is insignificant implying that where the *NOC* = 100–1,000, there is no influence on arbitrage profits.

The analysis of the relationship between the *NOC* and maturities reveals that the coefficient of the number of contracts traded was significant only if *T* is less than 30 or greater than 60. For time to maturity between 30 and 60, the coefficient is insignificant, which indicates that the number of contracts traded does not influence arbitrage profits in the case of contracts ranging between $30<T<60$. In the case of far-month contracts ($T>60$), arbitrage profits are higher for less liquid options as compared to more liquid options.

Furthermore, we have analysed the effect of the *NOC* traded on arbitrage profits for varying ranges of gaps (*S-X*) for the underlying NIFTY. The results show that the coefficient of the number of contracts traded is negative and significant in the case of options that are deeply out of the money ($X<0.95$ Nifty) and deeply in of the money put options ($X>1.05$ Nifty). For other ranges of gaps (0.95 Nifty$<X<$1.05 Nifty), the coefficient of the number of contracts is insignificant, which indicates that the number of contracts traded does not influence the arbitrage profits if options traded are marginally in or out of the money. Options that are deeply out of or in the money, the lower the number of contracts traded, the higher is the arbitrage profit. This indicates the inefficiency of the market and use of these options for effective risk management.

5. Conclusion

Index Options is an important and growing constituent of the Indian derivatives market dominated by large institutional players, both domestic and foreign. Liquidity as witnessed by the number of contracts traded is an important concern to the options market, since we have found that the quantum of the arbitrage profit decreases with an increase in the number of contracts traded and vice-versa. We have established that the arbitrage profit is neutral to time to maturity. The arbitrage profit is similar for options of varying maturities. Put options dominate the apparent arbitrage profits when these (put options) are deeply in/out of the money. With respect to the exercise price, the arbitrage profits are in direct relationship to the gap between the underlying spot prices and exercise price of the asset (Nifty Options). The time to expiration also contributes positively to the arbitrage profit except when the options (put) are deeply out of money. It has also been seen that the categories where the number of contracts variable ise significant, it contributes negatively to the arbitrage profit. This means that with the increase in liquidity, the arbitrage profit reduces. If the put contract is out of the money, then it contributes positively towards to the arbitrage profit for not-so--near and far-month contracts. The arbitrage profit also increases for contracts as days to maturity increases. We have also highlighted two limitations of our study: the use of the coefficient of determination in two cases is low, indicating the strong presence of error terms, and another is that a substantial portion of the FII activity is disguised as retail investment. However, these may not have any a significant impact on the implications derived therefrom.

Finally, we have established that the trading in NSE Options Index is highly inefficient as it provides ample opportunities for risk-free profits. Therefore, the immediate concern is to improve the market competitiveness through policy measures. Some of the initiatives undertaken by the regulator SEBI in this regard include a ban on programme trading, surveillances and controlled exposure of the institutional players. It may be concluded that even in times of low volatility and relatively higher trade volumes that Indian markets are inefficient offering a plethora of arbitrage opportunities, thus calling for immediate policy actions.

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Prof. Pankaj Kumar Gupta
JMI University
Centre for Management Studies,
Jamia Nagar, New Delhi-110025
India
Phone: 0091-11-26985519
E-mail: pkgfms@gmail.com