DETERMINANTS OF VIOLATION OF PUT-CALL PARITY THEOREM: A STUDY OF NSE NIFTY OPTIONS

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ABSTRACT

This paper aims at finding out whether there is a violation of put-call parity theorem in case of NSE Nifty options and to find out different factors behind this violation. The different factors which have been considered as the determinants of arbitrage profits are: the extent to which options are in the money or out of the money; whether arbitrage profits are more in case of in the money options or out of the money options; time to maturity of the options and number of contracts traded. The results indicate that there is a violation of put-call parity relationship for many options of NSE Nifty. The results further indicate that arbitrage profits are more in case of deeply in the money or deeply out of the money options and for longer time to maturity. In the money put options generate more arbitrage profits in case of less liquid options and for near the month option contracts where as out of the money put options generate more arbitrage profits for not so near the month contracts. Number of contracts traded came out to be positive and significant in case of high liquid options and came out to be negative and significant in

case of less liquid options, not so near the month contracts and in case of deeply in the money or out of the money option contracts.

Derivatives today constitute the most important segment of the Indian securities market since the inception of derivatives trading in June 2000. In June 2000, Securities and Exchange Board of India (SEBI) permitted two stock exchanges, viz., National Stock Exchange (NSE) and Bombay Stock Exchange (BSE), and their clearing houses to commence derivatives trading with the introduction of index futures contracts based on S&P NSE Nifty index and BSE-30 (Sensex) index. This was followed by the introduction of trading in options based on these two indices, options on individual securities and futures on individual securities. Trading in index options commenced in June 2001 while trading in options and futures on individual securities commenced in July 2001 and November 2001 respectively. Interest rate futures in the Indian stock market was introduced in June 2003. Inspite of the fact that it is less than five years since derivatives trading was introduced in the Indian stock market, there has been spectacular growth in the Indian derivatives market. The futures and options (F&O) segment of NSE reported a total turnover of Rs. 21,30,612 crores during 2003-04 against Rs. 4,39,863 crores during 2002-03, Rs. 1,01,925 crores during 2001-02 and only Rs. 2365 crores in 2000-01. The turnover in the first nine months (April – December) of 2004-05 was Rs. 17,29,309 crores. Although futures are more popular than options and contracts on individual securities are more popular than those on indices, even then there has been massive growth in the turnover of index options. The F&O segment of NSE reported an index option turnover (based on NSE Nifty) of Rs. 52,816 crores (call index option: Rs. 31,794 crores; put index option: Rs. 21,022 crores) during 2003-04 as against Rs. 9246 crores (call index option: Rs. 5669 crores; put index option: Rs. 3577 crores) and only Rs. 3766 crores (call index option: Rs. 2466 crores; put index option: Rs. 1300 crores) during 2002-03 and 2001-02 respectively. The index option turnover in the first nine months (April-December) of 2004-05 was Rs. 77,853 crores (call index option: Rs. 45,981 crores; put index option: Rs. 31,872 crores).

Option contract is one of the variants of derivative contracts. Option contacts give its holder the right, but not the obligation, to buy or sell a specified quantity of the underlying asset for a certain agreed price (exercise/strike price) on or befor some specified future date (expiration date). The underlying asset may be individual stock, stock market index, foreign currency, commodities, gold, silver, fixed-income securities. A call option gives its holder the right to buy whereas put option gives its holder the right to sell. The call option holder (purchaser of call) exercises the option only if the value of the underlying asset on the maturity of the option is more than the exercise price, otherwise the option is left unexercised. The put option holder exercises the option if the value of the underlying asset on the maturity is less than the exercise price, otherwise the option is left unexercised. To purchase the right to buy or sell the underlying asset, the option holder has to pay a certain price for purchasing the right, called option premium. Call option holder purchases the right to purchase the underlying asset and pays call premium as the purchase price of the right to buy. Put option holder purchase the right to sell and pays put premium as the purchase price of the right to sell the underlying asset. The person who sells the option to give the buyer the right to buy or sell the underlying asset is called as writer or seller of the option. The option writer receives the option premium for selling the option. The payoff of option holder on expiration is positive or zero whereas payoff of option writer on expiration is always negative or zero. It gives the profit to the option holder if the payoff of option holder on expiration is more than the option premium that he pays to purchase the option. It gives the profit to the option writer if the premium that he receives for selling the option is more than the amount (negative payoff) that he pays to the option holder on expiration.

The profit to the option holder is the value of the option at expiration minus price originally paid for the right to buy or sell the underlying asset at the exercise price. The profit to the option writer is the value of the option at expiration plus price he receives for selling the right.

In the Indian stock market, the underlying assets are stock market indices and 54 individual securities. As far as the present study is concerned, the underlying asset is broad stock market index based on NSE. Thus, for the present study the underlying asset is S&P CNX NSE Nifty. The option may be either of American style or of European style. An American option allows its holder to exercise the right to purchase (if a call) or sell (if a put) the underlying asset on before the expiration date. European option can be exercised only on the maturity date. In the Indian stock market, index options are of European style where as individual stock options are of American style. Since the present study is concerned only with index option, a European option is only relevant to us as far as the present study is concerned.

There exists a deterministic relationship between put and call prices, irrespective of the investor demand for the option, if both options are purchased on the same underlying asset and have the same 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 (such as current price of the asset, exercise price, risk-free rate and time to maturity). If the actual call or put price differs from the theoretical price, there exists an arbitrage opportunity and an arbitrageur can set up a risk-less position and earn more than the risk-free rate of return.

The put-call parity relationship was originally developed by Stoll (1969) and later on extended and modified by Merton (1973). There are many studies which have empirically tested the put-call parity theorem. The major studies are: Stoll (1969); Klemkosky and Resnick (1979); Gray (1989); Garay, Ordonez and Gonzalez (2003); Broughton, Chance and Smith (1998); Mittnick and Rieken (2000); Taylor (1990); Evnine and Rudd (1985); Finucane (1991); Francfurter and Leung (1991); Brown and Easton (1992); Easton (1994); Kamara and Miller (1995); Wagner, Ellis and Dubofsky (1996); Gould and Galai (1974); Bharadwaj and Wiggins (2001). Regarding the empirical verification of put-call parity relationship, the response is mixed. There are some studies which are in support of the put-call parity relationship and there are some which do not support the put-call parity theorem.

The objective of this paper is to find out whether the put-call parity relationship holds in case of index options in the Indian stock market. The index which has been chosen as the underlying asset is NSE Nifty. This paper further aims at finding out different factors responsible for the violation of put-call parity relationship, if any.

This paper is divided into five sections. Section 1 deals with the theoretical framework. Sections 2 and 3 deal with the empirical model and the data base of the study respectively, section 4 discusses the empirical results and section 5 gives the summary and conclusion.

1. THEORETICAL FRAMEWORK:

In option contract, there are two parties involved – the writer (seller) of the contract and the buyer of the contract (option holder). The writer of the contract receives the premium paid by the buyer of the contract. The buyer of call option and writer of put option believe that the asset prices will increase in the future. The writer of call and buyer of put believe that the asset prices will decline in the future. The option buyer may earn unlimited profits but will incur only limited losses. This is the reason, they pay premium. The option writers can earn only limited profits but may incur unlimited losses. This is the reason why they receive premium. Option contract gives its holder the right, but not the obligation, to buy or sell a specified quantity of the underlying asset for a certain agreed price on or before some specified future date. A call option gives its holder the right to buy whereas the put option gives the right to sell. In the discussion in the present section, stock has been assumed as the underlying asset.. The payoff and profits of the options writers and buyers are as follows:

Payoff to call holder = Max (S_T – X, 0)

Payoff to call writer = Min (X -S_T , 0)

Payoff to put holder = Max (X - S_T , 0)

Payoff to put writer = Min (S_T – X, 0)

Profit to call holder = Max (S_T – X, 0) – C

Profit to call writer = Min (X - S_T , 0) + C

Profit to put holder = Max (X - S_T , 0) – P

Profit to put writer = Min (S_T – X, 0) + P

Where:

X: exercise price of the option

S_T: the market price of the underlying asset on the maturity of the option

C: current market price of European call option (call premium)

P: current market price of European put option (put premium)

There exists a theoretical relationship between call premium, put premium and other relevant variables such as current asset price, exercise price, risk-free rate and time to maturity. If current asset price, exercise price, risk-free rate, dividend and time to maturity are given to us, for a given call (put) premium, there will exist a unique theoretical put (call) premium. If actual put (call) premium is different from theoretical put (call) premium, there will exist a pure arbitrage opportunity and the investor will be able to earn the cash flow that will yield him more than the risk-free rate of return.

Consider 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 this portfolio at time T, when the option expires and investment in risk-free asset matures is:

	S_T X	**$S_T > X$**
Value of call option	0	S_T - X
Value of risk-free asset	X + D	X + D
	------------	------------
Total	X + D	S_T + D

Where r is the risk-free rate with continuous compounding and D is the dividend per share (if any) the stock is expected to pay on or before the maturity.

Consider another portfolio which involves buying a put option with an exercise price of

X and time to maturity of T and investment in the underlying asset (stock) in the spot market (protective put).

The value of this portfolio at time T when the option expires is:

	S_T X	**$S_T > X$**
Value of put option	$X - S_T$	0
Value of stock	$S_T + D$	$S_T + D$
	------------	------------
Total	$X + D$	$S_T + D$

The two portfolios mentioned above are having the same payoff. If the two portfolios are having the same payoff, they must have the same cost to establish.

Cost of establishing the first portfolio (call plus risk-free asset) = $C + (X+D)e^{-rT}$

Cost of establishing the second portfolio (put plus stock) = $P + S_0$

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

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 can be written as:

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

The above relationship is called as put-call parity theorem because it represents the proper relationship between call and put premiums. If this relationship is ever violated, an arbitrage opportunity arises. If the above relationship is violated it indicates mispricing. To exploit mispricing, one should buy the relatively cheap portfolio and sell the relatively expensive portfolio to earn arbitrage profits. If cost of establishing call plus risk-free asset is greater than 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 profit from this is:

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

If cost of establishing put plus stock is more than 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 $\acute{a} = \hat{a} = 0$

The above put-call parity relationship was originally developed by Stoll (1969). Stoll's original model assumed $X = S_0$ (at the money option) and further assumed that the stock is not expected to pay any dividend before the maturity of the option. He did not differentiate between the American and European options. He implicitly stated that his model can be applied both in case of American and European options. Later on Stoll's model was modified by Merton (1973). Merton argued that for a non-dividend paying stock, Stoll's model is applicable only if the options are of European style. According to him, Stoll's model is not applicable 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 but it may be optimal to exercise the put option before the maturity. Stoll (1973) conceded the point mentioned by Merton with certain conditions.

As far as the present study is concerned, it deals with the index options. The index which has been chosen as the underlying asset is NSE Nifty. Since options on NSE Nifty are of European style and the underlying asset is the performance index, we avoid problems arising out of dividend estimation and the early exercise effect, which are encountered in the model given by Merton (1973) and other existing studies [Klemkosky and Resnick (1979); Gould and Galai (1974)]. Thus, as far as the present study is concerned, the put call parity model developed by Stoll (1969) can be applied to find out whether there exists an arbitrage profit due to violation of put call pricing theorem. Stoll's model can be extended to incorporate in-the-money and out-of-the money options also. Another problem which is encountered to exploit arbitrage profits is that there are short selling restrictions as far as spot market is concerned. To overcome this problem, one can use NSE Nifty futures for acquiring a short or long position with the same time to maturity as that of options. The expiration date of NSE Nifty futures is the same as that of NSE Nifty options, the problem of acquiring a short or long position can easily be resolved.

Consider the portfolio of buying a European put option on NSE Nifty with an exercise price of X and time to maturity of T and acquiring a long position in NSE Nifty futures with time to maturity of T (same as that of option). The payoff of this portfolio on expiration date is:

	S_T X	**$S_T > X$**
Payoff of put purchased	$X - S_T$	0
Payoff of long futures	$S_T – F_0$	$S_T – F_0$
	------------	------------
Total	$X - F_0$	$S_T – F_0$

Consider another portfolio consisting of buying a call option with an exercise price of X and time to maturity of T and an investment of $(X – F_0)e^{-rT}$ in the risk-free asset with time to maturity of T (same as that of option).

The payoff of this portfolio on expiration date is:

	S_T X	**$S_T > X$**
Payoff of call purchased	0	$S_T - X$

Payoff of risk-free asset	$X - F_0$	$X - F_0$
	------------	------------
Total	$X - F_0$	$S_T - F_0$

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

Thus:

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

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 profit of this position is:

$$P - C - (X - F_0)e^{-rT} = ã$$

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:

$$C - P + (X - F_0)e^{-rT} = ä$$

For no arbitrage condition, ã = ä = 0.

Thus Stoll's model (with slight modifications) can be applied in case of NSE Nifty options to exploit arbitrage profit arising out of violation of put-call parity theorem. The present study aims at finding out whether there exists an arbitrage profit due to violation of put-call parity theorem in case of NSE Nifty options and if there is a violation what are the factors responsible for the violation of this relationship.. The different factors considered are: the extent to which options are in the money or out of the money; whether violation is more in case of in-the money option or out of the money option; time to maturity; and number of contracts traded. This follows in the following sections.

2. MODEL:

As mentioned earlier, the objective of this paper is to find out whether put-call parity theorem holds in case of NSE Nifty options and if it does not hold what are the factors responsible for this violation. To verify the put-call relationship, theoretical put price is computed for a given call price, exercise price, value of NSE Nifty, risk-free rate and time to maturity. As far as the present study is concerned, the risk-free rate has been assumed as 5% with continuous compounding. The theoretical put price has been computed as follows:

$$P_{Th,\,t} = C_{A,\,t} + S_{A,\,t} - Xe^{-rT}$$

Where:

$C_{A,\,t}$: actual call premium for NSE Nifty call option with an exercise price of X and time to maturity of T on day t.

$P_{Th,\,t}$: theoretical put premium for NSE Nifty put option with an exercise price of X and time to maturity of T on day t.

$S_{A,\,t}$: actual value NSE Nifty on day t.

r: risk-free rate per annum with continuous compounding.

T: time to maturity of the option on day t.

After computing the theoretical put premium of day t for a given call price , exercise price, risk-free rate and time to maturity, this theoretical put premium is compared with actual put premium of day t with the same exercise price and time to maturity. This is done by subtracting theoretical put premium from actual put premium with the same exercise price and same time to maturity. That is,

$A = P_{A,t} - P_{Th,t}$

$P_{A,t}$: actual put premium for NSE Nifty put option with the exercise price of X and time to maturity of T.

|A| : arbitrage Profit.

If A is significant and greater than zero, it means that put price is too high relative to call price and an arbitrageur can exploit this situation by earning arbitrage profit. In this scenario, he should write put option, buy call option, short NSE Nifty and lend in the risk-free market. By acquiring this position, he will be able to generate sufficient cash flow that will yield him more than the risk-free rate of return.

If A is significant and less than zero, it means put price is too low relative to call and an arbitrageur can exploit this situation by buying put option, writing call option, acquiring long position in NSE Nifty and borrowing from the risk-free market.

That is, if the value of A comes out to be significant (either positive or negative), arbitrageur can set up a position where he will be able to generate good amount of arbitrage profit.

The next objective of this paper is to find out if there is a violation of put-call parity theorem, what are the different factors responsible for this violation. The variables which have been considered as the determinants of this violation are:

a. The extent to which option is in the money or out of the money. That is, the absolute value of difference between the value of NSE Nifty and exercise price.

b. Whether the violation is more in case of in the money option or out of the money option. This has been measured by introducing dummy variable:

   D = 0, if put option is in the money (if $S_0 - X < 0$)

D = 1, if put option is out of money (if $S_0 - X > 0$)

c. Time to maturity of the options. That is number of days after which the options will expire.

d. Number of contracts. In case of NSE Nifty options, 200 index options is equal to one contract.

Thus the final model which has been considered for the present study is:

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

Where:

$\| P_{A, Xi} - P_{Th, Xi} \|$	:	Absolute difference between 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 NSE Nifty and i^{th} exercise price on day t. The trading in NSE Nifty options on day t may be with different exercise prices.
D	:	Dummy variable D = 1, if $S_A - X_i > 0$ D = 0, if $S_A - X_i < 0$
T_t	:	Time to maturity of the option on day t.
NOC_t	:	Number of NSE Nifty put options traded on day t.
U	:	Random disturbance term.

If estimated â is positive and significant it means that arbitrage profits are more if the option is deeply in the money or out of the money. If estimated â is negative and significant , it means that narrower the gap between actual value of index and exercise price, higher the arbitrage profit,

If estimator of ã is positive and significant, it means that arbitrage profits are more if put option is out of the money (call option is in the money) than if the put option is in the money (call option is out of the money).

Positive and significant estimator of ä will indicate that higher the time to maturity of the option, higher the arbitrage profit. That is, near month options generate less arbitrage profits than not so near month options for the same exercise price and Nifty value. If estimated ä is negative and significant, it indicates that near month option contracts generate more arbitrage profits than not so near month contracts,

If estimated è is positive and significant, it means that options which are more liquid generate more arbitrage profits than options which are less liquid. Negative estimated è will indicate that less liquid options generate more arbitrage profits than more liquid options.

The model discussed above has been tested for NSE Nifty option. This follows in the following sections.

3. Data:

The basic data for this study have been collected from www.nseindia.com, an official website of National Stock Exchange. The put-call parity relationship has been verified using daily data on exercise prices available for trading; value of NSE Nifty; call premium for different exercise prices; put premium for different exercise prices; time to maturity for different exercise prices available for trading; and number of contracts traded for different exercise prices.

To verify the put-call parity relationship, the sample carrying one year time period from 1st January 2004 to 31st December 2004 has been chosen. From 1st January 2004 to 31st December 2004, there were total 254 days available for trading and the number of observations for which trading was available with different exercise prices and/or time to maturity were 21,122. . On an average, there were 80 observations per day for which trading was available for different exercise prices and/or time to maturity.

At any point of time, there were only three contracts available with 1 month, 2 months and 3 months to expiry. The expiry date for these contracts is last Thursday of expiry month and these contracts have a maximum of three months expiration cycle. A new contract is introduced on the next trading day following the expiry of the near month contract. On the date of the start of the new option contract, there are minimum of seven exercise prices available for trading – three 'in the money', one 'at the money' and three 'out of the money' for every call and put option. The new exercise prices can be added in between for each contract. The minimum increment in exercise prices in case of NSE Nifty option is 10 or in multiples of 10 thereof. Out of the total observations of 20,122, there were 13,458 observations for which there was no trading with different exercise prices and/or time to maturity. These observations were not considered as far as the present study is concerned.

Thus, there were total 6664 observations, trading on which was on at least one contract with different exercise prices and/or time to maturity. Thus, as far the present study is concerned, 6664 observations were used to verify the put-call parity relationship and to find out different factors responsible for this violation, if any.

4. EMPIRICAL RESULTS:

The model described above has been tested for the NSE Nifty option. NSE Nifty option is of European style. At any point of time, there are three contracts available for trading with one month, two months and three months to expiry. If today is 15th January 2005, three contracts are available for trading: January option, February option and March option. January option will expire on last Thursday of January. A new contact (April option) will be introduced on the next trading day following the expiry of January option (near month contract). For each expiry date, NSE Nifty option trading is available with different exercise prices. Some are in the money, some are out of the money and some are at the money. The first objective of this study is to find out whether there is a violation of put-call parity theorem in case of NSE Nifty option and if there is a violation what amount of arbitrage can be earned due to this violation. Three main factors which have been identified as the main cause of violation are: number of contracts traded, the extent to which option is in the money or out of the money and time to maturity of the option.

In the present study, arbitrage profits have been computed for different ranges of number of contracts traded, for different ranges of gap between actual value of Nifty and exercise price and for different ranges of time to maturity.

The arbitrage profits for different ranges of number of contracts and for different ranges of time to maturity have been shown in tables 4.1 and 4.2 respectively. The arbitrage profits for different ranges of gap between NSE Nifty value and exercise price have been shown in table 4.3.

Table 4.1: Arbitrage Profits and Number of Contracts Traded

	Arbitrage Profits Per Contract (Rupees)

	Arbitrage Profits Per Contract (Rupees)			
	Mean	Maximum	Minimum	Standard Deviation
1-100	4128	56092	0	5324
100-500	1928	25708	0	2012
500-1000	1786	12720	0	1684
> 1000	2066	7088	22	1644

Table 4.2: Arbitrage Profits and Time to Maturity

Time to Maturity	Arbitrage Profits Per Contract (Rupees)			
	Mean	Maximum	Minimum	Standard Deviation
30	3062	56092	0	4474
31-69	5220	38322	8	5038
>60	6254	23294	174	1684

Table 4.3: Arbitrage Profits and Gap Between NSE Nifty Value and Exercise Price

If Exercise Price is:	Arbitrage Profits Per Contract (Rupees)			
	Mean	Maximum	Minimum	Standard Deviation
< 0.90 Nifty	8670	56092	0	10154
0.90 Nifty – 0.95 Nifty	4052	32176	4	4352
0.95 Nifty – 1.0 Nifty	2104	19634	2	2180
1.0 Nifty – 1.05 Nifty	2476	20714	0	2540
1.05 Nifty – 1.10 Nifty	4600	29438	0	4990
> 1.10 Nifty	6586	52858	4	8362

The arbitrage profits for different ranges of number contracts traded have been shown in Table 4.1. The results in Table 4.1 show that arbitrage profits are more for less liquid options. For number of contracts traded between 1 to 100, the mean arbitrage profit is Rs. 4128 per contract as against Rs. 1928, Rs. 1786 and Rs. 2066 for number of contracts traded between 100-500, 500-1000 and greater than 1000 respectively. The results further show that there is the largest variation in the arbitrage profits for the number of contracts traded between 1 to 100. The standard deviation of the arbitrage profits for the number of contracts traded between 1-100 is Rs. 5324 as against around Rs. 1800 for the number of contracts traded more than 100. The mean profits are almost the same for the number of contracts traded between 100 – 500, 500-1000 and greater than 1000.

Table 4.2 shows the amount of arbitrage profits earned for different time to maturity. The results indicate that larger the time to maturity, higher the mean arbitrage profit. The maximum profit earned for different ranges of time to maturity is the highest in case of number of contracts traded less than or equal to 30. It means although the mean profit is low in case of short maturity options, even then there are some options with less time to maturity can earn high amount of arbitrage profits.

Arbitrage profits earned for different ranges of gap between value of NSE Nifty and exercise price have been shown in Table 4.3. The results indicate that the arbitrage profits are more when options are deeply in the money or deeply out of the money. The same results hold even for the standard deviation of arbitrage profits. But the mean and standard deviation of arbitrage profits are more for in the money put option than for out of money put option.

Another objective of this paper is to analyse the different factors responsible for the violation of put-call parity theorem. The model specified in section 2 has been used to find out different variables responsible for this violation. The independent variables which have been chosen as the determinants of violation of put-call parity theorem are: the extent to which options are in the money or out of the money; dummy variable indicating whether the violation is more in case of in the money option or out of the money option; time to maturity of the option and number of contracts traded. The regression models have been estimated for different ranges of contracts, for different ranges of time to maturity and for different ranges of gap between NSE Nifty value and exercise price.

The different estimated regression models on the basis of the above have been shown in the following tables:

Table 4.4: Regression Model: Number of Contracts

| $P_{A, Xi}$ – $P_{Th, Xi}$ | = á + â | S_A – X_i | + ãD + äT_t + èNOC_t + U

Number of Contracts	á	â	ã	ä	è	R^2	Number of Observations
1-100	0.23	0.15* (28.54)	1.02 (1.39)	0.45* (17.97)	-0.13* (9.12)	0.21	4600
100 – 500	1.51	0.06* (13.46)	-0.97** (1.98)	0.34* (17.04)	-0.0002 (0.08)	0.24	1452
500 – 1000	-1.56	0.10* (9.8)	-2.17* (2.60)	0.32* (9.81)	0.0042*** (1.80)	0.42	327
> 1000	-0.12	0.08* (4.47)	0.22 (0,21)	0.35* (7.25)	0.0014** (2.36)	0.25	285
Overall (NOC>100)	0.76	0.06* (16.63)	-0.87** (2.23)	0,34* (21,02)	0.0016* (5.01)	0.26	2064

Figures in parentheses show t-values

* significant at 1% level.

** significant at 5% level.

*** significant 1t 10% level.

Table 4.4: Regression Model: Time to Maturity

| $P_{A, Xi}$ – $P_{Th, Xi}$ | = á + â | S_A – X_i | + ãD + äT_t + èNOC_t + U

Time to Maturity (T)	á	â	ã	ä	è	R^2	Number of Observations

30	-0.60	0.13* (33.97)	-1.07*** (1.86)	0.38* (12.56)	-0.0001 (0.22)	0.20	5510
31- 60	-8.03	0.20* (17.82)	6.15* (4.30)	0.45* (4.60)	-0.0007** (2.31)	0.25	1094
> 60	-11.08	0.61* (9.21)	-6.61 (1.09)	0.31 (0.75)	-0.01 (0.66)	0.64	60

Figures in parentheses show t-values

* significant at 1% level.

** significant at 5% level.

*** significant 1t 10% level.

Table 4.4: Regression Model: In-The-Money/Out-Of-The-Money

| $P_{A, Xi}$ – $P_{Th, Xi}$ | = á + â | S_A – X_i | + äT_t + èNOC_t + U

Number of Contracts	á	â	Ä	è	R^2	Number of Observations
0.90 Nifty	-15.99	0.18* (4.24)	1.06* (4.36)	-0.10* (2.76)	0.14	295
0.90–0.95 Nifty	-1.36	0.14* (3.29)	0.30* (3.45)	-0.002 (0.36)	0.06	368
0.95-1.0 Nifty	3.63	0.05* (4.89)	0.29* (15.24)	-0.0008 (1.32)	0.14	1608
1.0-1.05 Nifty	1.23	0.07* (7.44)	0.40* (26.83)	-0.0005 (1.03)	0.23	2600
1.05-1.10 Nifty	-9.52	0.18* (6.99)	0.66* (13.06)	-0.01* (3.65)	0.14	1368
> 1.10 Nifty	-18.00	0.19* (3.40)	0.86* (4.33)	-0.04*** (1.68)	0.07	425

Figures in parentheses show t-values

* significant at 1% level.

** significant at 5% level.

*** significant 1t 10% level.

The results of different estimated regression models show that gap between NSE Nifty value and exercise price and time to maturity have come out to be positive and significant in all the estimated regression models except in one case when time to maturity is more than sixty days where time to maturity has come out to be positive but insignificant determinant of arbitrage profits. The results show that arbitrage profits are more if the options are deeply in the money or out of the money. The results further indicate that longer the time to maturity of the option, higher the arbitrage profit. That is, arbitrage profits are more in case not so near month contracts than near the month contracts.

Regarding the significance of dummy variable (which indicate whether arbitrage profits are more in case of in the money option or out of the money option), the response is mixed. The positive and significant coefficient of dummy variable indicate that arbitrage profits are more in case of out of the money put option than in the put option and vice versa. The results indicate that in case of number of options traded are 100 or more, arbitrage profits are more in case of in the money put option than out of the money put option. For number of options traded 1-100, dummy variable came out to be insignificant which just show that arbitrage profits are more if the options are deeply in the money or out of the money but is not clear where arbitrage profits are more in case of in the money options or in case of out of the money options. That is, the results indicate that in case of more liquid options (NOC > 100), arbitrage profits are more in case of in the put options than out of the money put options. For less liquid options (NOC 100), arbitrage profits may be equally more both in case of deeply in the money and deeply out of the money options. Comparing the coefficient of dummy variable for different time to maturity, we observe that for the near the month option contracts (time to maturity less than 30) arbitrage profits are more in case of in the money put option than out of the money put options. For time to maturity of 31-60 (not so near the month contract), arbitrage profits are more for out of the put options than in the put options. Regarding the time to maturity of more than 60 days (far the month options contract), dummy variable coefficient came out to be insignificant which indicate that arbitrage profits are more both incase of deeply in the money and deeply out of the money options but it is not clear whether the arbitrage profits are more in case of in the money put options or out of the money put options.

Another variable which has been analysed as the determinant of arbitrage profits is the number of contracts traded. The coefficient of number of contracts came out to be negative and significant in case of number contracts traded is 1-100, coefficient is positive and significant for number of contracts traded more than 500. It shows that in case of less liquid options (NOC < 100) higher the number options traded with in less liquid options, lower the arbitrage profits and vice versa.

In case of high liquid options (NOC >500), higher the number of contracts traded, higher the arbitrage profits and vice versa. Regarding the moderate liquid options, the coefficient of number contracts traded came out to be insignificant which shows that number of contracts traded with in moderate liquid options (NOC = 100-500) does not influence the arbitrage profits.

When we compare the effect of number of contracts traded according to different ranges time to maturity we find that coefficient of number of contracts traded came out be significant only in case of time to maturity of the option is 31 – 60. For time to maturity of less than 30 or more than 60, coefficient came out to be insignificant which shows that number of contracts traded does not influence arbitrage profits in case of near the month contracts (T < 30) and far the month contracts (T > 60). In case of not so near the month contracts (0 < T < 60), arbitrage profits are more in case of less liquid options than for more liquid option.

Lastly we compared the effect of number of contracts traded on arbitrage profits according to different ranges of gap between current value of NSE Nifty and exercise price. The results indicate that coefficient of number of contracts traded is negative and significant incase of deeply in the money (X 0.90 Nifty) and deeply out of the money put options (X 1.05 Nifty). For other ranges of gap between NSE Nifty value and exercise price (0.90 Nifty < X <1.05 Nifty), coefficient of number of contracts came out to be insignificant which shows that number of contracts traded does not influence the arbitrage profits if the options are slightly/moderately in the money or out of the money. In case of deeply in the money or out of the money options, lower the number of contracts traded with in the range contract is deeply in the money or our of the money, higher the arbitrage profits.

5. Conclusion:

Options have constituted an important segment of the Indian derivatives market. In the Indian securities market, trading in index option commenced in June 2001. It is less than four years since index options trading was introduced in the Indian stock market, there has been spectacular growth in the turnover of index options. The index option (based on NSE Nifty) turnover increased from Rs. 3766 crores during 2001-02 to Rs 77,853 crores during the first nine months of 2004-05. There are three kinds of participants in the index option market: speculator, hedger and arbitrageur. Hedgers use index options to eliminate the price risk associated with an underlying asset. Speculators use index options to bet on future movement in the price of the underlying asset. Arbitrageurs use index options to take advantage of mispricing. There exists a deterministic relationship between call and put prices if both the options are purchased on the same underlying asset and have the same exercise price and expiration date. If the actual call price differs from the theoretical call price (for a given put price) or actual put price differs from the theoretical put price (for a given call price) , there exists an arbitrage opportunity and an arbitrageur can set up a risk-less position and earn more than the risk-free rate of return.

The objective of this paper is to find out whether the put-call parity relationship in case of index option based on NSE Nifty. If there is a violation of this relationship what are factors responsible for this violation. The results indicate that there is a violation of put-call parity relationship for many options incase of NSE Nifty option. The average arbitrage profit earned is Rs. 3446 per contract where as maximum arbitrage profit of Rs. 56092 was possible in one of the options.

Another objective of this paper is to find out the factors behind the violation of put-call parity theorem. The different factors considered are : the extent to which options are in the money or out of the money; whether violation is more incase of in the money options or out of the money options; time to maturity of the option; and number of contracts traded. The results of estimated regression models indicate that arbitrage profits are more if the options are deeply in the money or out or out of the money. The results further show that arbitrage profits are more in case of not so near month contracts than near the month contracts. When we compare the profit potentials of in the and out of the money option contracts, we find that for more liquid options (NOC > 100), arbitrage profits are more in case of in the money put options. Regarding less liquid options, arbitrage profits are equally more both in case of deeply in the money and out of the money options.

When we compare the arbitrage profits of in the money and out of the money option contracts according to different time to maturity, we observe that for near the month option contracts, arbitrage profits are more in case of in the money put options where as arbitrage profits are more for out of the money put options in case of not so near the month option contracts. For far the month option contracts, arbitrage profits are equally more both in case of in the money and out of the money option contracts.

The last variable which has been considered as the determinant of arbitrage profits is number of contracts traded. The results indicate that in case of less liquid options (NOC < 100), higher the number of options traded with in less liquid options, lower the arbitrage profits. In case of high liquid options, arbitrage profits are more when large number of contracts traded with in high liquid options (NOC > 1000). Regarding moderate liquid options (NOC = 100 -500), number of contracts traded does not influence arbitrage profits. When we compare the effect of number of contracts traded according to different ranges of time to maturity, we find that in case of not so near month contracts, arbitrage profits are more for less liquid options. Regarding near the month contracts and far the month contracts, liquidity of the option does not influence arbitrage profits. When we compare the effect of number of contracts traded on arbitrage profits according to different ranges of gap between Nifty value and exercise price, we observe that in case of deeply in the money and out of the money options, lower the number of contracts traded with in the range contract is deeply in the money or out of the money, higher the arbitrage profit.

References:

1. Bharadwaj, Anu and Wiggins, James B., “Box Spread and Pt-Call Prity Test for

the S&P 500 Index LEAPS Market", Journal of Derivatives, Volume 8, No. 4, Summer 2001, 62-71.

2. Broughton, John B., Chance, Don M. and Smith, David M., "Implied Standard Deviation and Put-Call Parity Relations Around Primary Security Offerings", The Journal of Applied Business Research, Volume 15, No. 1, 1998, 1-12.

3. Brown, R.L. and Easton, S.A., "Empirical Evidence on Put-Call Parity in Australia: A Reconciliation and Further Evidence", Australian Journal of Management, Volume 17, No. 1, June 1992, 11-20.

4. Easton, Stephen A., "Non-Simultaneity and Apparent Option Mispricing in Test of Put-Call Parity", Australian Journal of Management, Volume 19, No. 1, June 1994, 47-60.

5. Evnine, Jeremy and Rudd, Andrew, "Index Options: The Early Evidence", The Journal of Finance, Volume XL, NO. 3, July 1985, 743-756.

6 Finucane, Thomas J., "Put-Call Parity and Expected Returns", Journal of Financial and Quantitative Analysis, Volume 26, No. 4, December 1991., 445-457.

7 Frankfurter, George M., Leung, Wai K., "Further Analysis of Put-Call Parity Implied Risk-Free Interest Rate", The Journal of Financial Research, Volume XIV, No. 3, Fall 1991, 217-232.

8. Garay, Urbi, Ordonez, Maria Celina and Gonzalez, Maximiliano, "Tests of the Put-Call Parity Relation Using Options on Futures on the S&P 500 Index", Derivatives Use, Trading & Regulation, Volume 9, No. 3, 2003, 259-280.

9. Gould, J.P. and Galai, D., "Transaction Costs and the Relationship Between Put and Call Prices", Journal of Financial Economics, Volume 1, No. 2, July 1974, 105-139.

10. Gray, Stephen F., " Put Call Parity: An Extension of Boundary Conditions", Australian Journal of Management, Volume 14, No. 2, December 1989, 151-169.

11. Kamara, Avraham and Miller (Jr.), Thomas W., "Daily and Intradaily Tests of European Put-Call Parity", Journal of Financial and Quantitative Analysis, Volume 30, No. 4, December 1995, 519-539.

12. Klemkosky, Robert C. and Resnick, Bruce G., "Put-Call Parity and Market Efficiency", The Journal of Finance, Volume XXXIV, No. 5, December 1979, 1141-1155.

13. Merton, Robert C., "The Relationship Between Put and Call Option Prices: Comment", Journal of Finance, Volume 28, March 1973, 183-184.

14. Mittnik, Stefan and Rieken, Sascha, "Put-Call Parity and the Informational Efficiency of the German DAX-Index Options Market", International Review of Financial Analysis, 9 (2000), 259-279.

15. Stoll, Hans R., "The Relationship Between Put and Call Option Prices", The Journal of Finance, Volume XXIV, No. 5, December 1969, 801-824.

16. Stoll, Hans R., "The Relationship Between Put and Call Option Prices: Reply", Journal of Finance, Volume 28, March 1973, 185-187.

17. Taylor, Stephen L., "Put-Call Parity: Evidence From the Australian Options Market", Australian Journal of Management, Volume 15, No. 1, June 1990, 203-216.

18 Wagner, Drew, Ellis, David M. and Dubofsky, David A., "The Factors Behind Put-Call Parity Violations of S&P 100 Index Options", The Financial Review, Volume 31, No. 3, August 1996, 535-552.

19. www.nseindia.com.