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Arbitrage Opportunities in the Options Market: A Study of the Indian Index Options

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Abstract

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.

An option is a contract, or a provision of a contract, that gives one party (the option holder) the right, but not the obligation, to perform a specified transaction with another party (the option issuer or option writer) according to specified terms. The owner of an asset might sell another party an option to purchase the asset any time during the next three months at a specified price. A lease might contain a provision granting the renter the option to extend the lease for an additional year. A corporate bond might have an option provision allowing the issuer to purchase the bond back from the purchaser five years prior to maturity for a specified price. A speculator might purchase an option to sell at any time during the next three months 100 shares of a specified stock for a specified price.

Option contracts are a form of derivative instrument. Stand-alone options trade on exchanges or OTC. They are linked to a variety of underliers. Most exchange-traded options have stocks or futures as underliers. OTC options have a greater variety of underliers, including bonds, currencies, physical commodities, swaps, or baskets of assets. Options can be embedded in almost any contract. Above, we gave examples of options embedded in a lease and a bond.

THE UNDERLYING ASSETS MAY BE

- Stock
- Index
- Futures

- Interest Rate
- Foreign Currency
- Commodities

THEORETICAL FRAMEWORK

Options take many forms. The two most common are:

Call options These are options which provide the holder the right to purchase an underlier at a specified price.

Put options These are options which provide the holder the right to sell an underlier at a specified price.

The Strike Price of a call (put) option is the contractual price at which the underlier will be purchased (sold) in the event that the option is exercised. The last date on which an option can be exercised is called the expiration date. Options may allow for one of two forms of exercise:

With American exercise, the option can be exercised at any time up to the expiration date.

With European exercise, the option can be exercised only on the expiration date.

(The origins of the names "American" and "European" in this context are unknown. They are unrelated to practices common in any particular geographic region).

A third form of exercise, which is occasionally used with OTC options, is Bermudan exercise. A Bermuda option can be exercised on a few specific dates prior to expiration. Yes, the name was chosen because Bermuda is half way between America and Europe.

Puts and calls are sometimes called vanilla options to distinguish them from more exotic structures.

*To purchase the right to buy or sell the underlying asset, the option holder has to pay a certain price, called **Option Premium**.*

- Call option holder pays call premium to the call seller (call writer).

- Put option holder pays put premium to the put seller (put writer).

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.

Payoffs and Profits

There are certain payoffs and profits associated with the options. These are as follows for the various types of options:

Call Option Buyer (Holder)

Payoff = Max (S_T - X, 0)

Profit = Max (S_T - X, 0) - C

Call Option Seller (Writer)

Payoff = Min (X - S_T, 0)

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

Put Option Buyer (Holder)

Payoff = Max (X - S_T, 0)

Profit = Max (X - S_T, 0) - P

Put Option Seller (Writer)

Payoff = Min (ST - X, 0)

Profit = Min (ST - X, 0) + P

Where:

S_T : Asset price on maturity

X : Exercise price

C : Call premium

P : Put premium

Depending on the kind of returns that options have to offer, they can further be classified as **in-the money, out-of-the money, and at the money options**

In the money

An immediate exercise will generate positive cash flows.

Call : $S_0 > X$

Put : $S_0 < X$

Out of the money

An immediate exercise will not be profitable.

Call : $S_0 < X$

Put : $S_0 > X$

At the money

An immediate exercise will generate zero cash flow.

$S_0 = X$

Put-call parity theorem

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.

We now derive an important relation between put premium(p) and call premium(c):

Consider the following two portfolios constructed and their cost of establishment :

Consider a portfolio of buying a call option and investment of Xe^{-rT} in the risk-free asset.

Value of this portfolio at time T:

	$S_T \leq X$	$S_T > X$
Call Option	0	S_T - X
Risk-free Asset	X	X
	----------	-------------
	X	S_T

Consider another portfolio of buying a put option and investment in the underlying asset.

Value of this portfolio at time T:

	$S_T \leq X$	$S_T > X$
Put Option	X - S_T	0
Underlying Asset	S_T	S_T
	----------	-------------
	X	S_T

We see that the two portfolios are having the same payoff

- If two portfolios are having the same payoff, they must have the same cost to establish:

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

- The above relationship is called put-call parity theorem.
- If above relationship is ever violated, it indicates mispricing and an arbitrage opportunity arises.

In case the put-call parity is violated, the following two situations may arise:

EITHER

$\mathbf{C + Xe^{-rT} > P + S_0}$

Then in this case what one must do is:

* Write Call

* Borrow from risk-free market

* Buy Put

* Buy Asset

The other case might be if:

$$\mathbf{C + Xe^{-rT} < P + S_0}$$

So what a person must do in this case is to:

* Buy Call

* Invest in the risk-free market.

* Write Put

* Short the Stock

For no arbitrage, $\mathbf{C + Xe^{-rT} = P + S_0}$

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.

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); Misra and Misra (2005). 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.

As far as the present study is concerned, it deals with the Indian Index options. The three indices which have been chosen as the underlying asset are **NSE Nifty, BANKEX and CNXIT**. Since options on these Index 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.

MODEL

As mentioned earlier, the objective of this paper is to find out whether put-call parity theorem holds in case of Index options and if it does not hold what are the factors responsible for this violation.

Theoretical value of the premium was calculated by using the Put-Call Parity theorem;

$$\mathbf{P = C - So + Xe^{-rT}}$$

Where:

P	:	theoretical put premium
C	:	call premium
S_0	:	value of the index on that day
r	:	risk-free rate (taken as = 5%).
T	:	time to maturity of the option.
X	:	Exercise price

The market values of the put premium were compared to the theoretical or calculated values of the premium, and the difference between the two values calculated to judge the arbitrage opportunity available. That is,

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

$P_{A,t}$: 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 part of this paper attempts to find out if there is a violation of put-call parity theorem, what are the different factors responsible for this violation.

The various factors considered for this regression are;

1. The time to maturity for an option
2. The number of contracts
3. So/X (Extent to which option is in the money or out of the money).
4. So/x * time to maturity.

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

$$\boxed{| P_{Actual} - P_{Theoretical} | = \alpha + \beta | S_A/X_i | + \gamma D + \delta T_t + \theta C_t + U}$$

Where:

| PActual - PTheoretical | : Absolute difference between actual put premium and theoretical put premium.

| SA/X_i |: Ratio of value of NSE Nifty and exercise price. The trading in NSE Nifty options on day t may be with different exercise prices.

D : Dummy variable

$D = 1$, if $SA / X_i > 1$

$D = 0$, if $SA / X_i < 1$

T_t : Time to maturity of the option.

NOC_t : Number of NSE Nifty put options traded on day t.

U : Random disturbance term.

If estimated β 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 β 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 γ 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 δ 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 δ is negative and significant, it indicates that near month option contracts generate more arbitrage profits than not so near month contracts.

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

DATA

Data was taken for the following 3 indices;

- NIFTY
- BANKEX, and
- CNXIT index

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 index options; 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.

All of these have the following common features

European Style(Put European And Call European)

Trading Cycle: 3 month trading cycle - the near month (one), the not so near the month (two) and the far the month (three)

Expiry Day: Last Thursday of the expiry month. If the last Thursday is a trading holiday, then the previous trading day.

Time Period: 1st December 2004 to 31st November 2005.

EMPIRICAL RESULTS

The model described above has been tested for the three index options, namely NSE Nifty, BANKEX, and CNXIT options, which are 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. 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.

The 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 index and exercise price and for different ranges of time to maturity.

The arbitrage profits for different ranges of gap between index value and exercise price have been shown in the table below;

$$| P_{Actual} - P_{Theoretical} | = \alpha + \beta \mid S_A/Xi \mid + \gamma D + \delta Tt + \theta Ct + U$$

S_A : Actual stock price in the spot market

INDEX	α	β	γ	δ	θ	R^2	Number of Obser-vations
NIFTY	-445.771	497.22	-1.570	1.8757	-0.009	0.1558	23873
BANK NIFTY	-980.171	1228.774	-15.785	15.030	-87.097	0.1378	19172
CNXIT	-853.045	996.747	-10.314	9.726	-9.433	0.205	27678

The above regression results show the varied impact of the chosen factors on exploitation of the arbitrage opportunity available in the options market.

All three index chosen for the study of violation of Put-Call parity theorem show similar results with reference to the sign of the coefficients for the various factors undertaken.

A positive and significant coefficient for the Time to Maturity shows that the higher is the time to maturity of the option, higher the arbitrage profit. That is, near the month options generate less arbitrage profits than not so near month options for the same exercise price and index value. (If estimated coefficient is negative and significant, it indicates that near month option contracts generate more arbitrage profits than not so near month contracts).

A negative coefficient for the number of contracts available for trading shows that less liquid options generate more arbitrage profits than more liquid options.(If estimated coefficient is positive and significant, it means that options which are more liquid generate more arbitrage profits than options which are less liquid). Though for the CNXIT INDEX, this parameter is insignificant.

A positive and significant coefficient is the regression outcome for the factor So/X, which implies the difference between the between index value and the option exercise price. The results show that arbitrage profits are more if the options are deeply in the money or out of the money.

When we study the impact of time to maturity and the status of the option, i.e. whether in the money or out of money (So/X * time to maturity), we see a negative and significant coefficient for the various index. This implies that 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.

Bottlenecks while carrying out the empirical research

Though the empirical study may seem very simple, but there are quite a few complications associated with the same.

A few of these bottlenecks are:

1. It is important to ensure that the option prices and the stock prices are being observed at the same time. For example, testing for arbitrage opportunities by looking at the price at which the last trade is done each day is inappropriate.
2. It is important to consider carefully whether a trader can take advantage of any observed arbitrage opportunity. If the opportunity exists only momentarily, there may in practice be no way of exploiting it.
3. Transaction costs must be taken into account when determining whether arbitrage is possible.
4. Put-call parity holds only for European options. Exchange traded stock options are American.
5. Dividends to be paid during the life of the option must be estimated.

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.

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.

This project tries 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 in case of in the money options or out of the money options
- Combined effect of the time to maturity and status of the option, i.e. whether the option is In or Out of the Money
- Time to maturity of the option and
- Number of contracts traded.

The results of the estimated regression models indicate that arbitrage profits are more if the options are deeply in the money 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.

Considering the underdeveloped status of the derivative market in India as of today, we can conclude that there is an ocean of opportunity available here for people who would like to adopt any of the following roles, namely, either of the speculator, hedger or an arbitrageur.