A Major Project Report

on

An Empirical Study on the Put Call Parity in the NSE Nifty Options

Submitted for the award of the degree of Executive MBA

by

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2K13/MBA/502

Under the Supervision of

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May 2015

CERTIFICATE

It is to hereby certify that the project titled "**An Empirical Study on the Put Call Parity in the NSE Nifty Options**" submitted by Anupam Kumar in partial fulfilment of the requirements of the degree of Executive MBA in Delhi School of Management, Delhi Technological University, Delhi is a record of original work carried out by him under my guidance and supervision. I further certify that the work is original and is not based, derived or reproduced from existing work and has not been submitted elsewhere for the award of any degree or diploma.

Date:

Place: DSM, DTU, New Delhi.

Dr. P.K. Gupta

Visiting Faculty, DSM, DTU.

DECLARATION

I, Anupam Kumar, do hereby declare that the project entitled **"An Empirical Study on the Put Call Parity in the NSE Nifty Options"** is an original work, carried out as partial fulfilment of the requirement of the degree of Executive MBA in Delhi School of Management, Delhi Technological University, Delhi.

Anupam Kumar
Date:
EMBA (2013-2015)

Acknowledgement

The extant work is written and completed under the guidance and supervision of Dr. P.K. Gupta, Visiting Faculty, Delhi School of Management, DTU.

I thank Dr. P.K. Gupta for being my mentor throughout the completion of this project and for clarifying the problems which I encountered during the preparation of this project. He provided me all the technical knowhow and project related materials.

ABSTRACT

The put and call prices have a deterministic relationship, 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 (for example, current price of the asset, exercise price, risk-free rate and time to maturity). If the actual call or put price is different 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 extant project has been undertaken with an objective to identify if the put-call parity relationship exists in case of index option based on NSE Nifty. If there is a violation of this relationship what are factors responsible for this violation.

Various factors that were studied to determine the quantum of arbitrage profits were:

i. the extent to which options are in the money or out of the money,
ii. if arbitrage profits occurred in the case of in the money options or out of the money options,
iii. time to maturity of the options, and
iv. the number of contracts traded.

It was found that violation of put-call parity relationship did take place for many options of NSE Nifty. It was also found that arbitrage profits are more in case of deeply in the money or deeply out of the money options. Arbitrage profit was not significantly affected by increase or decrease in time to maturity. As expected the quantum of arbitrage profit reduced significantly with increase in liquidity. Out of the money put options led to more arbitrage profits where there were less liquid options. Out of the money put options created more arbitrage profits for not so near the month and far month contracts. Number of contracts traded were positive and significant for high liquid options and were negative and significant for less liquid options. Number of contracts traded were negative and significant for deeply in the money or out of the money option contracts. The gap between Spot price of Nifty and the Strike price of the Nifty index option is directly proportional to the arbitrage profit.

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List of acronyms and abbreviations

AOM	Australian Options Market
BSE	Bombay Stock Exchange
CBOE	Chicago Board of Options Exchange
CBOT	Chicago Board of Trade
CNX	CRISIL NSE Index
CM	Clearing Member
F&O	Futures and Options
FII	Foreign Institutional Investors
LTOM	London Traded Options Market
NEAT	National Exchange for Automated Trading
NIFTY	National Stock Exchange Fifty
NSCCL	National Securities Clearing Corporation Limited
NSE	National Stock Exchange of India Limited
PCP	Put Call Parity
S&P	Standard and Poor’s
SEBI	Security and Exchange Board of India
SPAN	Standard Portfolio Analysis of Risk
TM	Trading Member

1. INTRODUCTION

1.1. Overview

In June 2000, Securities and Exchange Board of India (SEBI) gave permission to the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE) as well as to their clearing houses to commence derivatives trading. This was made possible by introducing index futures contracts based on S&P NSE Nifty index and BSE-30 (Sensex) index. Fifteen years later, the derivatives trading are the most important segment of the securities market in Indian. Following the introduction of derivatives trading, other features such as trading in index options based on the indices of BSE and NSE, options on individual securities and futures on individual securities was started. Trading in index options was started in June 2001, whereas by July 2001, trading in options and by November 2001, trading in futures on individual securities had begun. The Indian stock market saw the beginning of interest rate futures in June 2003.

In just about the five years since it was started in the Indian stock market, the Indian derivatives trading have seen phenomenal growth. In 2003-04, the futures and options (F&O) segment of NSE saw a total turnover of Rs. 21,30,612.00 crores whereas it was Rs. 4,39,863.00 crores during 2002-03, Rs. 1,01,925 crores during 2001-02 and only Rs. 2,365.00 crores in 2000-01. Normally, futures are more popular than options and contracts on individual securities are more popular than those on indices. Yet, there has been massive growth in the turnover of index options.

During 2003-04, the turnover (based on NSE Nifty) for F&O segment of NSE saw an index option x of Rs. 52,816 crores (call index option: Rs. 31,7943 crores; put index option: Rs. 21,022 crores). . The corresponding figures in 2002-03 and 2001-02 were Rs. 9,246.00 crores (call index option: Rs. 5,669.00 crores; put index option: Rs. 3,577.00 crores)and Rs. 3,766.00 crores (call index option: Rs. 2,466.00 crores; put index option: Rs. 1,300.00 crores) during respectively.

In 2013-14 the futures and options (F&O) segment of NSE saw a total turnover of Rs. 3,82,11,408.04 crores which is nearly 1700 % increase over a decade. Similarly the turnover of the Nifty Index options has grown exponentially to Rs. 41,07,215.20 crore in 2013-14.

One of the variants of derivative contracts is the option contracts. They provide its holder the right to buy or sell a specified amount of the underlying asset for a certain agreed price (exercise/strike price) on or before some specified future date (expiration date). However, the holder is not obliged to do so. The underlying asset could be either an individual stock, a stock market index, foreign currency, commodities, gold, silver, or fixed-income securities.

A call option provides its holder the right to buy. On the other hand, a put option provides its holder the right to sell. The holder of the call option (the person who has purchased the call) would exercise his option only if the value of the underlying asset when the asset matures is more than the exercise price. Otherwise, he will not utilise the option.

The holder of the put option will exercise his option if the value of the underlying asset when it matures is less than the exercise price. If it is not, the option will not be utilised. The option holder has to pay a certain amount to purchase the right to buy or sell the underlying asset. This amount is called the option premium.

By paying the call premium, the holder of the Call option purchases the right to purchase the underlying asset. Put option holder pays put premium as the purchase price of the right to sell the underlying asset. The person from whom the buyer purchases the right to buy or sell the underlying asset is known as writer or seller of the option. The option premium is received by the option writer for selling the option. The payoff of option holder on maturity of option is positive or zero and the payoff of option writer on maturity of option is always negative or zero. The option holder makes a profit if the payoff of option holder on maturity is more than the option premium that he has paid to purchase the option. The option writer makes a profit if the premium that he receives for selling the option is more than the amount (negative payoff) that he has paid to the option holder on maturity of the option. The option holder's profit is the value of the option at maturity minus the price originally paid for the right to buy or sell the underlying asset at the exercise price. The option writer's profit is the value of the option at maturity plus the price he received for selling the right.

The put-call parity relationship was first developed by Stoll (1969) and later extended and modified by Merton (1973). Several different studies have empirically tested the put-call parity theorem. Some of these studies are: Stoll (1969); Gould and Galai (1974); Klemkosky and Resnick (1979); Evnine and Rudd (1985); Gray (1989); Taylor (1990); Finucane (1991); Francfurter and Leung (1991); Brown and Easton (1992); Easton (1994); Kamara and Miller (1995); Wagner, Ellis and Dubofsky (1996); Broughton, Chance and Smith (1998) Garay, Mittnick and Rieken (2000), Bharadwaj and Wiggins (2001); Ordonez and Gonzalez (2003).

However, there is a mixed response to the empirical verification of put-call parity relationship. Some studies support the put-call parity relationship while others don't support the put-call parity theorem.

The underlying assets in the Indian stock market are stock market indices and 54 individual securities. For the purpose of this project, the underlying asset is S&P CNX NSE Nifty. The option could be either European style or American style. The European option can only be exercised on the maturity date. An American option allows its holder the right to purchase (if a call) or sell (if a put) the underlying asset on or before the expiration date. In the Indian stock market, index options are of European style but individual stock options are of American style. Since this project deals only with index option, a European option is only relevant for the purpose of the study.

The put and call prices have a deterministic relationship, independent of the investor demand for the option, if both options are purchased on the same underlying asset and have the same exercise price and maturity date. It is possible to theoretically develop a put-call relationship to ascertain a put (call) price for a given call (put) price and other relevant information (for example, current price of the asset, exercise price, risk-free rate and time to maturity). If it is found that the actual call or put price is different from the price derived theoretically, an arbitrage opportunity is present and an arbitrageur can set up a risk- less position and earn more than the risk-free rate of return.

1.2. Derivative Trading mechanism at NSE

This section provides a brief overview of the derivatives segment of the National Stock Exchange. All the relevant data in this section has been sourced from www.nseindia.com.

1.2.1. Equity Derivatives at NSE

The National Stock Exchange of India Limited (NSE) started trading in derivatives with the launch of index futures on 12th June, 2000. The futures contracts are based on the benchmark CNX Nifty Index.

The Exchange introduced trading in Index Options (also based on Nifty) on June 4, 2001. NSE also became the first exchange to launch trading in options on individual securities from July 2, 2001. Futures on individual securities were introduced on November 9, 2001. Futures and Options on individual securities are available on 145 securities stipulated by SEBI. The Exchange has also introduced trading in Futures and Options contracts based on CNX-IT, BANK NIFTY, and NIFTY MIDCAP 50 indices.

1.2.2. Volume and Turnover

The total volume of futures and options contracts (F&O) at NSE on close of 10th April 2015 was 61,35,142 and the turnover for the same was Rs. 1,57,174.61 crores.

The break-up of the volume and the turnover is as follows:

Table 1.1 Instrument wise Volume and Turnover

As on 10th April 2015		
Product	**No. of contracts**	**Traded Value (Rs crores)**
Index Futures	3,58,129	10,301.99
Stock Futures	8,13,425	25,763.39
Index Options	45,47,679	1,08,460.98
Stock Options	4,15,909	12,648.25
F&O Total	**61,35,142**	**1,57,174.61**

Source: www.nseindia.com

1.2.3. <u>Products</u>

Since the launch of the Index Derivatives on the popular benchmark CNX Nifty Index in 2000, the National Stock Exchange of India Limited (NSE) today have moved ahead with a varied product offering in equity derivatives. The Exchange currently provides trading in Futures and Options contracts on 9 major indices and more than 100 securities.

Derivatives on the following Products

- CNX Nifty Index
- CNXIT Index
- BANK Nifty Index
- Nifty Midcap 50 Index
- CNX Infrastructure Index
- CNX PSE Index
- Individual Securities

NSE introduced trading in index options on June 4, 2001. The options contracts are European style and cash settled and are based on the popular market benchmark CNX Nifty index.

1.2.4. Contract Specifications

Security descriptor

The security descriptor for the CNX Nifty options contracts is:

- Market type : N
- Instrument Type : OPTIDX
- Underlying : NIFTY
- Expiry date : Date of contract expiry
- Option Type : CE/ PE
- Strike Price: Strike price for the contract
- Instrument type represents the instrument i.e. Options on Index.
- Underlying symbol denotes the underlying index, which is CNX Nifty
- Expiry date identifies the date of expiry of the contract
- Option type identifies whether it is a call or a put option, CE - Call European, PE - Put European.

Underlying Instrument

The underlying index is CNX NIFTY.

Trading cycle

CNX Nifty options contracts have 3 consecutive monthly contracts, additionally 3 quarterly months of the cycle March / June / September / December and 5 following semi-annual months of the cycle June / December would be available, so that at any point in time there would be options contracts with atleast 3 year tenure available.

On expiry of the near month contract, new contracts (monthly/quarterly/ half yearly contracts as applicable) are introduced at new strike prices for both call and put options, on the trading day following the expiry of the near month contract.

Expiry day

CNX Nifty options contracts expire on the last Thursday of the expiry month. If the last Thursday is a trading holiday, the contracts expire on the previous trading day.

1.2.5. Trading Parameters

Contract size

The value of the option contracts on Nifty may not be less than Rs. 2 lakhs at the time of introduction. The permitted lot size for futures contracts & options contracts shall be the same for a given underlying or such lot size as may be stipulated by the Exchange from time to time.

Price steps

The price step in respect of CNX Nifty options contracts is Re.0.05.

Base Prices

Base price of the options contracts, on introduction of new contracts, would be the theoretical value of the options contract arrived at based on Black-Scholes model of calculation of options premiums.

The options price for a Call, computed as per the following Black Scholes formula: $C = S * N(d_1) - X * e^{-rt} * N(d_2)$

and the price for a Put is : $P = X * e^{-rt} * N(-d_2) - S * N(-d_1)$

where :

$d_1 = [\ln(S / X) + (r + \sigma^2 / 2) * t] / \sigma * \text{sqrt}(t)$

$d_2 = [\ln(S / X) + (r - \sigma^2 / 2) * t] / \sigma * \text{sqrt}(t)$

$= d_1 - \sigma * \text{sqrt}(t)$

C = price of a call option

P = price of a put option

S = price of the underlying asset

X = Strike price of the option

r = rate of interest

t = time to expiration

σ = volatility of the underlying

N represents a standard normal distribution with mean = 0 and standard deviation = 1 ln represents the natural logarithm of a number. Natural logarithms are based on the constant e (2.71828182845904).

Rate of interest may be the relevant MIBOR rate or such other rate as may be specified.

The base price of the contracts on subsequent trading days, will be the daily close price of the options contracts.

The closing price is calculated as follows:

- If the contract is traded in the last half an hour, the closing price shall be the last half an hour weighted average price.
- If the contract is not traded in the last half an hour, but traded during any time of the day, then the closing price will be the last traded price (LTP) of the contract.
- If the contract is not traded for the day, the base price of the contract for the next trading day shall be the theoretical price of the options contract arrived at based on Black-Scholes model of calculation of options premiums.

1.2.6. Trading

NSE introduced for the first time in India, fully automated screen based trading. It uses a modern, fully computerised trading system designed to offer investors across the length and breadth of the country a safe and easy way to invest.

NSE's automated screen based trading, modern, fully computerised trading system designed to offer investors across the length and breadth of the country a safe and easy way to invest. The NSE trading system called 'National Exchange for Automated Trading' (NEAT) is a fully automated screen based trading system, which adopts the principle of an order driven market

1.2.7. Clearing and Settlement

National Securities Clearing Corporation Limited (NSCCL) is the clearing and settlement agency for all deals executed on the Derivatives (Futures & Options) segment. NSCCL acts as legal counter-party to all deals on NSE's F&O segment and guarantees settlement.

A Clearing Member (CM) of NSCCL has the responsibility of clearing and settlement of all deals executed by Trading Members (TM) on NSE, who clear and settle such deals through them.

1.2.8. Risk Management

A sound risk management system is integral to an efficient clearing and settlement system. NSE introduced for the first time in India, risk containment measures that were common internationally but were absent from the Indian securities markets.

Risk containment measures include capital adequacy requirements of members, monitoring of member performance and track record, stringent margin requirements, position limits based on capital, online monitoring of member positions and automatic disablement from trading when limits are breached, etc.

Risk Management for Derivative products is managed with Standard Portfolio Analysis of Risk (SPAN)® is a highly sophisticated, value-at-risk methodology that calculates performance bond/margin requirements by analyzing the "what-if's" of virtually any market scenario.

1.3. Objective of the Study

This project aims to study whether the put-call parity relationship holds in case of index options in the Indian stock market. The index chosen as the underlying asset is NSE Nifty. This project also seeks to find out different factors responsible for the violation of put-call parity relationship, if any.

This project analysis is divided into five sections. Section 2 deals with the theoretical framework. Sections 3 literature review, section 4 deals with Research Methodology, section 5 discusses analysis of data, conclusion, limitations of the research and scope of further research.

2. THEORETICAL FRAMEWORK

Two parties are involved in an option contract -- the writer or the seller of the contract and the buyer or the option holder of the contract. The buyer of the contract pays the premium to the writer of the contract. The writer of the put option and the buyer of the call option believe that in future, the price of the asset will increase. On the other hand, the buyer of the put option and the writer of the call option believe that in future, the price of the asset will decline. The buyer of the option will suffer only a limited loss but may earn unlimited profits. That is why they pay the premium.

The option writers can earn only limited profits but may incur unlimited losses. That is why they receive premium.

The holder of the option contract has the right to buy or sell a specific quantity of the underlying asset for a certain agreed price on or before some specified future date. However, he is under no obligation to do so. The holder of the call option has the right to buy whereas the holder of the put option has the right to sell. For the purpose of the following discussion, it is assumed that the underlying asset is the stock. 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

ST: 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)

The call premium, put premium and other relevant variables such as current asset price, exercise price, risk- free rate and time to maturity are all theoretically related. If current asset price, exercise price, risk-free rate, dividend and time to maturity are known, for a given call (put) premium, the unique theoretical put (call) premium can be calculated. If this theoretical put (call) premium is different from the actual put (call) premium, there will be a pure arbitrage opportunity and the investor will be able to earn the cash flow greater than the risk- free rate of return.

For example, a portfolio comprising 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.

Table 2.1: Value of portfolio at Time T (call plus investment in risk free asset)

	$S_T < X$	$S_T > X$
Value of call option	0	S_T - X
Value of stock	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.

Let's take another example 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).

Table 2.2: Value of portfolio at Time T (Put plus underlying asset)

	$S_T < X$	$S_T > X$
Value of put option	$X - S_T$	0
Value of risk-free asset	$S_T + D$	$S_T + D$
Total	$X + D$	$S_T + D$

The above two portfolios have the same payoff. If that is the case, 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:

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

Since it represents the proper relationship between call and put premiums, such a relationship is called put-call parity theorem. If this relationship is ever violated. An arbitrage opportunity is created when the above relationship is violated and this indicates mispricing.

By taking advantage of such mispricing, arbitrage profits can be earned if one buys the relatively cheap portfolio and sells the relatively expensive portfolio. If cost of establishing call plus risk- free asset is greater than the cost of establishing put plus stock ($C + Xe^{-rT} > P + S_0$), arbitrage profits can be earned by writing call, buying put, borrowing from the risk-free market and buying the stock. The present value of profit from this is:

$C – P – S_0 + Xe^{-rT} = á$

If cost of establishing put plus stock is more than the cost of establishing call plus risk-free asset ($C + Xe^{-rT} < P + S_0$), arbitrage profits can be earned 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:

$P - C + S_0 - Xe^{-rT} = â$

There will not be any arbitrage opportunity if á = â = 0

Stoll developed this put-call parity relationship for the first time in 1969. For this, Stoll assumed $X = S_0$ (at the money option) and also assumed that the stock is not expected to pay any dividend before the maturity of the option. His original model did not differentiate between the European and American options. He believed that his model would work both in the case of European and American options.

In 1973, Merton modified Stoll's model. Merton stated that for a non-dividend paying stock, Stoll's model can be applied only if the options are of European style. This is because although it is 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. Hence, Stoll's model cannot be applied if the options are of American type. Stoll conceded Merton's arguments with certain conditions.

This project deals with the index options. The underlying asset index is NSE Nifty. It has been possible to avoid problems arising out of dividend estimation and the early exercise effect since options on NSE Nifty are of European style and the underlying asset is the performance index. Such problems were faced in Merton's model and other studies [Klemkosky and Resnick (1979); Gould and Galai (1974)]. Thus, for this project, Stoll's put call parity model developed in 1969 can be applied to find out if violation of put call pricing theorem can lead to an arbitrage profit. The same model can be extended to include in-the-money and out-of-the money options.

Another problem hampering exploitation of arbitrage profits are the restrictions in the spot market regarding short selling. To avoid this problem, NSE Nifty futures for acquiring a short or long position with the same time to maturity as that of options can be used. If the maturity date of NSE Nifty futures is the same as that of NSE Nifty options, the problem of acquiring a short or long position can be avoided.

For example, 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 T (same as that of option).

Table 2.3: Value of portfolio on maturity date

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

Now take another example of a portfolio comprising 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).

Table 2.4: Payoff of the portfolio on maturity date

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

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 establishing call plus risk- free asset is $C + (X – F0)e^{-rT}$.

Thus:

$P = C + (X – F_0)e^{-rT}$

If there is a violation of the above relationship, it will create an arbitrage opportunity. 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, with the help of slight modifications in Stoll's model, arbitrage profit opportunities arising from violation of put-call parity theorem can be applied exploited when applied to NSE Nifty options. This project tries to find out if violation of put-call parity theorem in case of NSE Nifty options leads to an arbitrage and the factors responsible for the violation of this relationship. For this, the following factors have been considered: the extent to which options are in the money or out of the money; if the 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 is described in the following sections.

3. LITERATURE REVIEW

Before the review of the empirical literature on Put Call parity, the effects of the use of non-synchronous data in tests of the Put Call Parity relation is discussed below:

3.1 Effects of the use of non-synchronous data in previous empirical studies of the PCP relation

Various empirical studies on the PCP relation have suggested that apparent mispricing of options lead to real opportunities for arbitrage in markets. Very often, the transaction costs are not given 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. 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.

Brown and Easton[8] (1992) propose that for liquid options and stock markets, the following recommendations should be considered in the sampling process when only the closing price of options and stocks is known:

— The sample should only be used if the spread is within the bid-ask spread and then the closing stock price should be used. If the spread is not within the bid-ask spread, the sample must be discarded.

— Only those put and call options that fulfill the following characteristics should be considered:

a) Their volume of transactions is different from zero on the sampled day;

b) That the date and time of closing of the market should be the same as that for the stock; and

c) That the closing price of put and call options should be within the closing bid-ask spread.

A large amount of empirical literature on the Put Call Parity relation in the European, American, and Australian markets is available. Given below is a short review of this literature.

3.2 Previous studies of the PCP relation in Europe

Nisbet[13] (1992) has done an empirical study based on negotiated American options traded on the London Traded Options Market (LTOM). For this, he has used the intra-daily data, including transaction costs and dividend payments. In this study, Nisbet has found that a large number of violations of the PCP relation are present when the only transaction cost taken into consideration is the bid-ask spread.

In another model, Nisbet found that when the costs of commission and the effect of dividends were taken into consideration, in addition to the bid-ask spread, the volume and frequency of the violations in relation to the PCP were so low that there are very low possibilities of potential arbitrage gains.

In a paper on study of PCP in European bourses, Capelle-Blancard and Chaudhury[14] (2001) find support for the PCP relation in France and presents a review of the literature on the PCP relation in different European countries.

3.3 Previous studies of the PCP relation in the USA

The PCP relation has been tested very extensively in the US markets. Stoll[1] (1969) as well as Gould and Galai.[9] (1974) who conducted the initial studies, established support for the PCP theory Gould and Galai found that depending on the magnitude of assumed transaction costs, the PCP relation held.

Evnine and Rudd,[10] (1985) Klemkosky and Resnick,[3,4,5] (1979, 1980, 1992) and Chance[11] (1987) have also tested the PCP relation in the formal US markets (for example, Chicago Board Options Exchange (CBOE), Chicago Board of Trade (CBOT)). They found possible inefficiencies for options in these formal markets.

These early studies had the following three important factors, which may have caused the possible inefficiencies:

— These studies did not use intra-daily or daily closing data. The samples mostly used weekly or monthly closing prices, which increase the probability of errors caused by non-synchronicity in data;

— These studies did not take into account the transaction costs. Since all studies were made on American options, it was not possible to isolate the effect of the value of the early exercise of options in most cases;

— The registration of over-the-counter (OTC) transactions is not very precise because these transactions take place directly between financial institutions and corporations, and not through a formal market. An empirical study of the PCP relation on European options on the S&P 500, which is negotiated on the CBOE was done by Kamara and Miller[12] (1995).

By using European type options contracts, the authors eliminated the problem caused by the value of the early exercise of a US option. Kamara and Miller found that the number of PCP violations was much smaller than what was found in earlier studies which had used only American options. The authors also reached the conclusion that the PCP relation violations pattern is associated with a 'premium' value that results from liquidity risk. This is the risk that an investor incurs when he is trying to carry out arbitrage transactions and is unable to complete one of the transactions at the correct price.

Authors Kamara and Miller also found that the number of violations and their frequency is related to moneyness. This means that the options which are farther from being at-the-money present a greater number of violations to the PCP relation than those that are closer to being at-the-money.

3.4 Previous studies of the PCP relation in Australia

The prominent studies in Australia were done by Loudon[15] (1988), Gray[16] (1989) Taylor[17] (1990), Easton[18] (1994), Brown and Easton[8] (1992) and Cusack[7] (1997).

Both Loudon and Taylor independently made empirical tests of the PCP relation in the Australian Options Market (AOM). Although they used the same model and the same source of information, they reached diametrically opposite conclusions. A study conducted by Brown and Easton tried to reconcile the results obtained by Loudon and Taylor.

The authors then present the model employed by Loudon and Taylor, and later by Brown and Easton, in addition to a comparative table of the results obtained in each study.

$$C\text{-}S+Ke^{-rT}<=P<=C\text{-}S+K+Vp(D)$$

Brown and Easton got results which are similar to those of Loudon. From this, they conclude that the main reason for the different result obtained by Taylor was the use of non-synchronous data. About 60 per cent of their samples were invalid. On the other hand, Taylor used only monthly closing data and included closing data for days for which the volume of put or call transactions was zero. In addition, Brown and Easton found some computational errors in the procedure used to calculate the put-call values.
The studies of Loudon and Brown and Easton show the existence of apparent inefficiencies in the AOM. These inefficiencies come from an underestimation of the price of puts (lower boundary), in most cases. This is the reason why apparent arbitrage opportunities were present.

In his study on the AOM, Gray[16] (1989) used a model that included transaction costs, the value of early exercise of option contracts and the effects of dividends. He also used closing prices for options and stocks that were traded during the day. Gray found major violations of the PCP relation, even when commission costs were included. However, the frequency and volume of violations was much less when transaction costs include the bid-ask spread.

An empirical study on the AOM for American options was conducted by Cusack[7] (1997). He included transaction costs and excluded the bid-ask spread. He did not include the effect of dividends and used intra-daily data for time intervals between five and 15 minutes. He verified that their results were consistent with those obtained by Loudon, Brown and Easton and Gray. These results were found to be consistent with the existence of inefficiencies in the Australian market, even when transaction costs were included in the analysis. It was also found that the use of intra-daily data versus the use of closing daily data did not make any difference to the results obtained.

Comparison of empirical studies of the PCP relation in Australia: Loudon[15] (1988), Taylor[17] (1990), Brown & Easton[8] (1992).

Table 3.1: Comparison of empirical studies of PCP relation in Australia

	Loudon	**Taylor**	**Brown and Easton**
Non-violation (%)	60	83.8	70.8
Lower Boundary Violation (%)	38.5	0	26.3
Upper Boundary violations (%)	1.5	16.2	3

Thus it appears that there is a mixed response to the empirical verification of put-call parity relationship. Some studies support the put-call parity relationship while others don’t support the put-call parity theorem.

4. RESEARCH METHODOLOGY

4.1 Research Type and General Goal

The proposed research is descriptive and causal. The proposed research is developed from quantitative point of view.

4.2 Data Population

For the purpose of the project put and call prices on the Nifty Index Options in the time period of 1st January 2014 till 24th December 2014 will be taken. Further, in order to enhance the efficacy of the research, only those options will be shortlisted for the study for which atleast one transaction has taken place. This has been done as transactions indicate sanctity of price atleast to some extent. Further, with the increase in the number of transactions the process of price discovery also improves. For the shortlisted data the theoretical value of the put option will be calculated. The difference between the actual value and the theoretical value of the put call is the possible monetary profit that can be achieved through arbitrage.

The Data thus collected will be analysed on following three broad categories:

i. Number of Contracts
ii. Time to Maturity
iii. Moneyness

For the analysis based on the number of contracts, the data is grouped in following categories:

i. 1-100
ii. 100-500
iii. 5000-1000
iv. >1000

For the analysis based on the time to maturity, the data is grouped in following categories:

i. <30 days
ii. 30 to 60 days
iii. > 60 days

For the analysis based on the moneyness, the data is grouped in following categories:

Strike price is

i. < 0.90 * Nifty
ii. 0.90 * Nifty to less 0.95 * Nifty
iii. 0.95 * Nifty to less than Nifty
iv. Nifty to less than 1.05 * Nifty
v. 1.05 * Nifty to less than 1.10 * Nifty
vi. > 1.10 * Nifty

4.3 Methods and Techniques

Descriptive Statistics (count, maximum, minimum, mean and standard deviation) will be generated on the data in the categories listed above to discern any apparent characteristic or pattern.

A Causal research (through multiple regression) will be carried out to find out the significance of various factors in determining profit quantum through arbitrage. A model for the regression analysis is described in the following section.

4.4 Developing a Model for Causal Research on factors responsible for violation of PCP in NSE Nifty options.

The objective of this study is to find out if put-call parity theorem holds in case of NSE Nifty options and if it does not hold, 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. For the purpose of this project, the risk- free rate has been taken as 8.5% with continuous compounding. (8.5% was the yield on the 10 year Government of India treasury bonds during 2014). 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 case, 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 study is to find out if there is a violation of put-call parity theorem, the different factors responsible it. The variables 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 project 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 ith 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 Nift y 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 is discussed in the following sections.

5. DATA ANALYSIS

The basic data for this project 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 2014 to 24th December 2014 was chosen. From 1st January 2014 to 24th December 2014, there were total 240 days available for trading and the number of observations for which trading was available with different exercise prices and/or time to maturity were 51,216 (each for call and put option). (sample data at Annexure I) On an average, there were 71 observations per day for which trading were available for different exercise prices and/or time to maturity.

At any given 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 51,216, there were 23,083 observations for which there was no trading with different exercise prices and/or time to maturity. These observations were not considered for this project.

Thus, there were total 28,133 observations, trading on which was on at least one contract with different exercise prices and/or time to maturity. Thus, for this project, 28,133 observations were used to verify the put-call parity relationship and to ascertain different factors responsible for this violation, if any.

5.1 Empirical Results

5.1.1 <u>Descriptive Statistics</u>

The model described above has been tested for the NSE Nifty option which is of European style. At any given time, there are three contracts available for trading with one month, two months and three months to expiry. If today is 15th January 2015, 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 project 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 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.

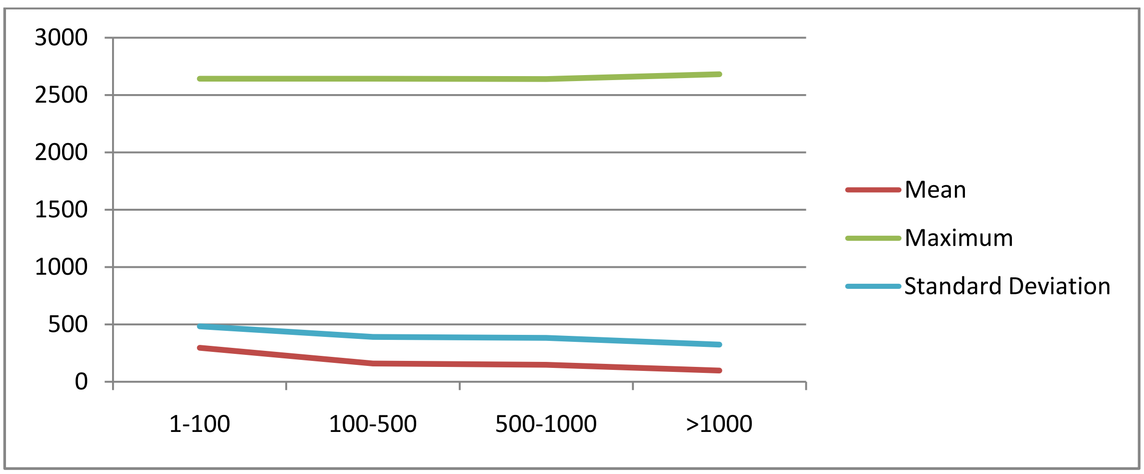
In this project, arbitrage profits have been computed for different ranges of number of contracts traded, for different ranges of gap between actual value of Nifty and exercise price and for different ranges of time to maturity.

The arbitrage profits for different ranges of number of contracts and for different ranges of time to maturity have been shown in tables 5.1 and 5.2 respectively. The arbitrage profits for different ranges of gap between NSE Nifty value and exercise price have been shown in table 5.3.

Table 5.1: 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	13733	296.82	2641.40	0.00	482.60
100-500	4064	160.01	2640.45	0.00	389.60
500-1000	1733	148.73	2637.15	0.00	383.17
>1000	8603	97.25	2680.60	0.00	323.45

Fig. 5.1 Arbitrage descriptive statistics against number of contracts traded

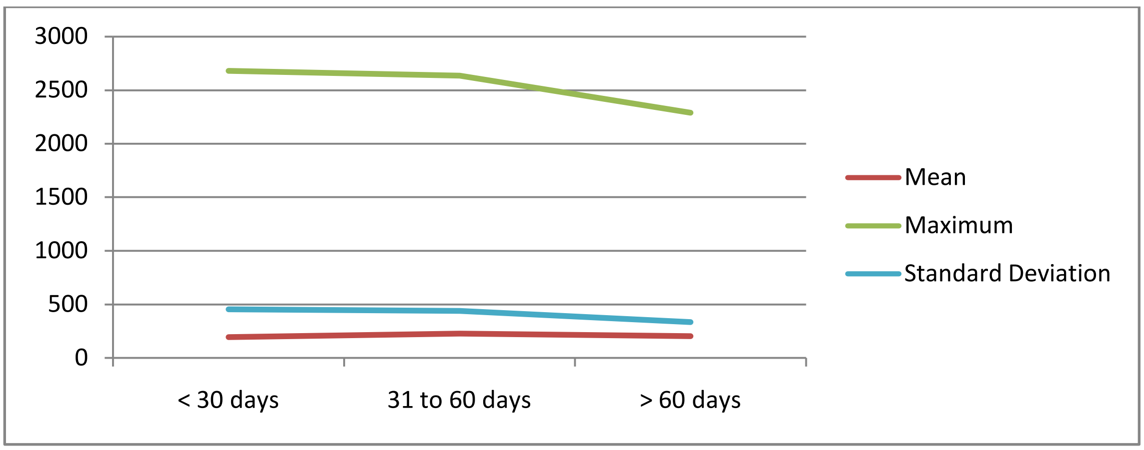


- With increasing liquidity the arbitrage profit decreases
- The maximum arbitrage opportunity is nearly the same irrespective of the category
- The variance in the arbitrage profit also decreases with liquidity

Table 5.2: Arbitrage Profits and Time to Maturity

Time to Maturity		Arbitrage Profits Per Contract (in Rupees)			
Range	**Count**	**Mean**	**Maximum**	**Minimum**	**Standard Deviation**
< 30 days	14348	195.58	2680.60	0.00	453.60
31 to 60 days	8833	227.27	2636.74	0.00	437.19
> 60 days	4952	203.25	2288.22	0.00	334.19

Fig. 5.2 Arbitrage descriptive statistics against time to maturity

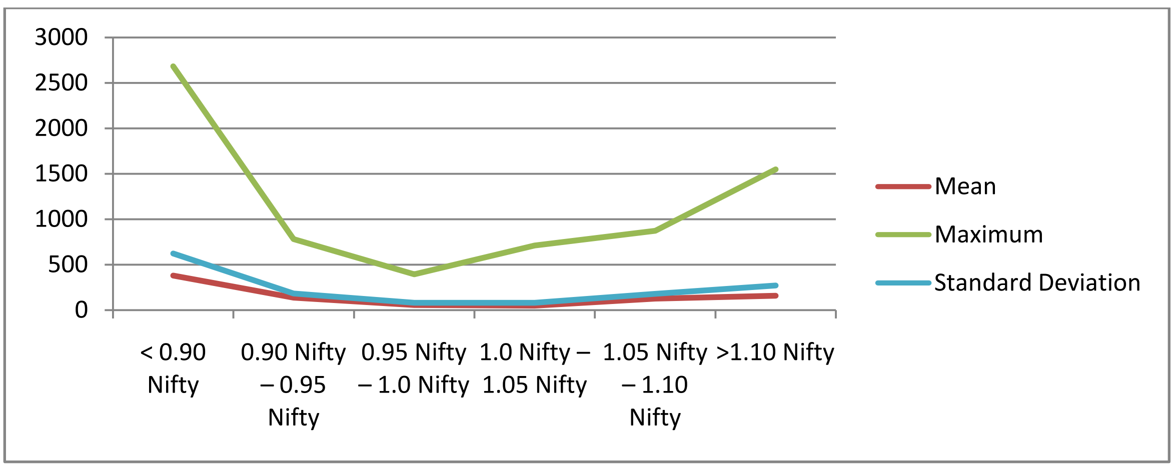


- The arbitrage profit quantum is neutral to time to maturity
- The maximum arbitrage opportunity is nearly the same irrespective of the category
- Though the variance in the arbitrage quantum decreases with increase in time to maturity

Table 5.3: Arbitrage Profits and Gap between NSE Nifty Value and Exercise Price

If Exercise price is:		Arbitrage Profits Per Contract (in Rupees)			
Range	Count	Mean	Maximum	Minimum	Standard Deviation
< 0.90 Nifty	10814	379.43	2680.60	0.00	621.21
0.90 Nifty – 0.95 Nifty	3975	134.56	780.60	0.00	178.86
0.95 Nifty – 1.0 Nifty	4188	55.45	393.45	0.00	78.24
1.0 Nifty – 1.05 Nifty	3642	47.31	710.16	0.00	79.41
1.05 Nifty – 1.10 Nifty	2559	123.46	871.06	0.00	176.94
>1.10 Nifty	2955	156.24	1545.85	0.00	268.53

Fig. 5.3 Arbitrage descriptive statistics against moneyness



- The arbitrage profits are more when the put options are deeply in the money or deeply out of money.
- The maximum profit and the variance also mirror the arbitrage profit behavior vis-à-vis the in/out of money criteria.
- Important point to note is that the number of contract for which transaction took place are significantly higher for deeply out of the money put options.

The arbitrage profits for different ranges of number contracts traded have been shown in Table 5.1. The results in Table 5.1 show that arbitrage profits are more for less liquid options. For number of contracts traded between 1 and 100, the mean arbitrage profit is Rs. 296 per contract as against Rs. 160, Rs. 148 and Rs. 97 for number of contracts traded between 100-500, 500-1000 and greater than 1000 respectively. The results further show that the largest variation in the arbitrage profits is for the number of contracts traded between 1 and 100. The standard deviation of the arbitrage profits for the number of contracts traded between 1 and 100 is Rs. 482 as against around Rs. 380 for the number of contracts traded more than 100. The mean profits are almost the same for the number of contracts traded between 100 and 500, 500 and 1000, and is considerably less for number of contracts greater than 1000. The maximum arbitrage opportunity is nearly the same for all groups and the variation decreases with liquidity.

Table 5.2 shows the amount of arbitrage profits earned for different time to maturity. The results indicate that arbitrage profit remains nearly the same for all ranges of time to maturity. The maximum arbitrage opportunity is nearly the same irrespective of the category. Though the variance in the arbitrage quantum decreases with increase in time to maturity. The maximum profit earned for different ranges of time to maturity is the slightly more 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, 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 are shown in Table 5.3. The results indicate that the arbitrage profits are more when put 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 except for the extreme range. Important point to note is that the number of contract for which transaction took place are significantly higher for deeply out of the money put options.

5.1.2 Causal Research

Another objective of this paper is to analyse the different factors responsible for the violation of put-call parity theorem. The model developed in section 4 has been used to find out different variables responsible for this violation. The independent variables 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 regression model is:

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

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 $T_{t.}$

$|S_A\text{-}X_i|$: 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 price.

M : Moneyness

M = 1, if S-X > 0

M = 0 if S-X < 0

T_t : Time to maturity of the option on day t.

C : Number of NSE NIFTY put options traded on day t.

e : Random disturbance term

5.1.3 Assumptions for the multiple regression

The data for the regression has been tested for the following assumptions for the multiple regression analysis:

- The dependent variable (quantum of the arbitrage) is on a continuous scale.
- All the independent variables are on the continuous scale.
- Independence of the 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 independence of the residuals. (refer Annexure-II)
- The residuals (errors) are approximately normally distributed. This has been tested using a histogram (with a superimposed normal curve) and a Normal P-P Plot. (refer Annexure-II)

In the extant study, for the multiple regression following conditions have been assumed to be satisfied by the data.

- The data is homoscedastic i.e. .variances along the line of best fit remain similar along the line.
- There is no multicollinearity, i.e. two or more independent variables are not highly correlated with each other.
- There is a linear relationship between the dependent variable and each of the independent variables, and the dependent variable and the independent variables collectively.
- There are no significant outliers, high leverage points or highly influential points.

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

Table 5.4 : Regression mode: Number of Contracts

Number of Contracts	**Constant**	**S-X**	**Moneyness**	**Time**	**C**	**R^2**	**Number of Observations**
1-100	6.542	0.179* (48.229)	94.65* (11.528)	0.769* (5.101)	-2.333* (-14.380)	0.223	13733
100-500	-49.540	0.166* (18.621)	41.740* (3.158)	0.866* (3.542)	-0.34 (-.644)	0.106	4064
500-1000	-31.620	0.182* (11.284)	17.938 (0.820)	0.968** (2.358)	-0.026 (-0.422)	0.09	1733
>1000	-54.295	0.230* (37.795)	-10.976 (-1.384)	1.266* (6.814)	0.00007987* (3.420)	0.158	8603
>100	-53.282	0.194* (43.095)	14.702** (2.281)	0.941* (7.233)	0.00005815** (2.346)	0.132	14400

Figures in brackets are t-values

* significant at 1% significance level

** significant at 5% significance level

*** significant at 10% significance level

- The gap between exercise price and NIFTY is positive and significant for all categories.
- The time to maturity is also positive and significant for all categories.
- Number of contracts is significant at 1% significance level only for categories with less 100 or more 1000 contracts.
- The Moneyness variable is positive and significant for categories with number of contracts less than 500. This implies that the arbitrage profit is higher for out of money put options under these conditions.

Table 5.5: Regression mode: Time to Maturity

Time to Maturity	Constant	S-X	Moneyness	Time	C	R^2	Number of Observations
< 30	-48.438	0.207* (55.626)	-2.189 (-0.283)	1.750* (4.700)	0.00004945*** (1.650)	0.205	14348
31 - 60	-129.170	0.216* (46.659)	65.318* (7.268)	2.492* (4.999)	0.000 (-0.913)	0.234	8833
>60	-92.083	0.165* (30.439)	88.515* (9.413)	1.474* (2.862)	-0.032* (-0.067)	0.211	4952

Figures in brackets are t-values

* significant at 1% significance level

** significant at 5% significance level

*** significant at 10% significance level

- The gap between exercise price and NIFTY is positive and significant for all categories.
- The time to maturity is also positive and significant for all categories.
- Number of contracts is significant at 1% significance level only for contracts with maturity of more than 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.

Table 5.6: Regression mode: In-the-Money/Out-Of-The-Money

K % of Nifty	Constant	S-X	Time	C	R^2	Number of Observations
< 0.90 Nifty	-78.855	0.221* (40.559)	2.149* (8.897)	-0.002* (-1.896)	0.138	10814
0.90 – 0.95 Nifty	-65.439	0.290* (12.388)	1.294* (11.270)	-0.0000023* (-4.092)	0.080	3975
0.95 – 1.0 Nifty	-9.394	0.170* (15.746)	0.902* (17.790)	-0.000001833 (-0.237)	0.136	4188
1.0 – 1.05 Nifty	-4.436	0.196* (-1.303)	0.506* (16.084)	0.00003685 (.376)	0.86	3642
1.05 – 1.10 Nifty	-85.844	0.383* (12.887)	0.394** (2.550)	-0.009* (-4.049)	0.73	2559
>1.10 Nifty	144.610	0.012 (0.968)	0.062 (0.287)	-0.027* (-3.075)	0.004	2955

Figures in brackets are t-values

* significant at 1% significance level

** significant at 5% significance level

*** significant at 10% significance level

- The gap between exercise price and NIFTY is positive and significant for all regressions.
- The time to maturity is also positive and significant for all regressions except when the put options are deeply in the money. Coefficient of the time variable decreases in value as the put call moves from deeply out of money to deeply in the money.
- Most of the cases where the number of contracts (C) are significant, the coefficients are negative. This implies that with increase in liquidity the arbitrage profit reduces.

The results of different estimated regression models show that gap between NSE Nifty value and exercise price and time to maturity are positive and significant in all the estimated regression models except in one case when the exercise price is more than 10% of the Nifty where coefficients have 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 the time to maturity of the option, has little impact on the arbitrage profit. That is, arbitrage profits are nearly the same in not so near month contracts and 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 show that arbitrage profits are more in case of out of the money put option than in the money put option and vice versa. The results show that in case of number of options traded are 100 or more, arbitrage profits are more in case of out of the money put option. Moneyness is positive and significant where number of contracts traded is less than 500. That is, the results show that in case of more liquid options (NOC > 500), arbitrage profits are not significantly determined by the moneyness of the option.

Comparing the coefficient of dummy variable for different time to maturity, it is noticed that for the near the month option contracts (time to maturity less than 30) dummy variable coefficient was insignificant which show that arbitrage profits are not determined by the moneyness of the near month contracts. For time to maturity of 31-60 (not so near the month contract) and for maturity of more than 60 days (for the far month options contract), dummy variable coefficient was both significant and positive.

Another variable which was analysed as the determinant of arbitrage profits is the number of contracts traded. The coefficient of number of contracts was negative and significant in case of number contracts traded is 1-100, coefficient is positive and significant for number of contracts traded more than 1000. It indicates that in case of less liquid options (NOC < 100) higher the number options traded, lower the arbitrage profits and vice versa.

In case of high liquid options (NOC >1000), higher the number of contracts traded, higher the arbitrage profits and vice versa. As for the moderate liquid options, the coefficient of number contracts traded was insignificant which indicates that number of contracts traded with in moderate liquid options (NOC = 100-1000) does not influence the arbitrage profits.

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.

When the effect of number of contracts traded according to different ranges of time to maturity is compared, it is found that coefficient of number of contracts traded was significant only in case of time to maturity of the option is less than 30 or greater than 60. For time to maturity of between 30 and 60, coefficient was insignificant which indicates that the number of contracts traded does not influence arbitrage profits in case of not so near month contracts (30 < T < 60). In case of far month contracts (T > 60), arbitrage profits are more in case of less liquid options than for more liquid option.

Finally, 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 was evaluated. The results show that coefficient of number of contracts traded is negative and significant in case of 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 gap between NSE Nifty value and exercise price (0.95 Nifty < X <1.05 Nifty), coefficient of number of contracts was insignificant which indicates 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, higher is the arbitrage profits.

5.1.4 **Conclusion**

Options have been an important segment of the Indian derivatives market. In the Indian securities market, trading in index option began in June 2001.The index options trading was introduced in the Indian stock market less than four years ago. Yet, there has been spectacular growth in the turnover of index options. The index option (based on NSE Nifty) turnover increased from Rs. 3,766.00 crores during 2001-02 to Rs 3,99,22,663.48 crores during the financial year 2014-15. 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 is 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 is 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 study is to identify if the put-call parity relationship exists 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 show that there is a violation of put-call parity relationship for many options in case of NSE Nifty option. The average arbitrage profit earned is Rs. 206.88 per contract whereas maximum arbitrage profit of Rs. 2680.60 was possible in one of the options.

The most obvious observation from the data is the fact that the quantum of arbitrage profit decreases with increase in the number of contracts traded i.e. increase in liquidity. Further, the arbitrage profit quantum is neutral to time to maturity. The arbitrage profit remains nearly the same for near, not so near and far month expirations. It is also seen that the arbitrage profits are more when the put options are deeply in the money or deeply out of the money.

Another objective of this study is to find out the factors behind the violation of put-call parity theorem. The different factors taken into consideration 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;
- 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 gap between the exercise price and the NIFTY spot price increases. The time to maturity also contributes positively to the arbitrage profit except when the options (put) are deeply out of money. It is also seen that the categories where the variable number of contracts are significant, it contributes negatively to the arbitrage profit. That is, 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.

It can be concluded that the trading in NSE options Index is highly inefficient as it provides ample opportunity for risk-less profits. The lack of competitiveness in the Indian capital market allows for existence of exploitable arbitrage opportunities. Though SEBI has permitted Futures and Options trading on two stock exchanges in India i.e. Bombay Stock Exchange of India (BSE) and National Stock Exchange of India (NSE) but virtually, NSE account for 99% trading activity in the Futures and Options segment in India. In addition, SEBI has restricted the total exposure of institutional traders in the market, which has allowed retail traders to dominate the market who base their decision on firm-specific or insider information, which is often little stale or late. Therefore, this study suggests that increase in market competitiveness may help to improve price discovery efficiency by reducing arbitrage opportunities.

5.1.5 Limitations of the study

The time period for selection Nifty Index option contracts is arbitrary. There may be different outcomes in different time periods. Further in the selected time period there was a major event (i.e. change in Central Government) which had a very positive impact on the stock markets. The FII component in the Indian stock market went up considerably. This along with the irrational exuberance of the masses may have had an impact on the prices of the derivatives in the Stock Markets. This study does not take into account these factors.

5.1.6 Scope for Further Studies

The coefficient of determination for all but two of the regressions are below 25% indicating presence of other factors that determine the arbitrage quantum in the trade of Nifty options. This is expected as stock markets depend on many psychological factors as well which are not possible to quantify. One of the most important factors, though difficult to quantify in Indian context, is the activity of the Foreign Institutional Investors (FII). The problem is compounded due to the fact that a substantial portion of FII activity is disguised as retail investment. Nevertheless, a study can be carried out to establish, even though partially, the impact of FII activities on the prices of options in the Indian stock exchanges.

Further, the extant study presents a picture of arbitrage opportunity and its factors for a period of time. A study may be conducted to judge the significance of the factors over different time periods in the history of options trading in the Indian stock market.

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7. Annexure

I. SAMPLE DATA

Date	Call Close	Put Close	Put (Th)	Arbitrage	S-X	Moneyness	Time to maturity	NOC	%nifty
24-Feb-14	2700	0.1	13.90	13.80	2686.1	1	31	2	56.58
24-Feb-14	2201.65	0.2	15.55	15.35	2186.1	1	31	28	64.66
24-Feb-14	1700.2	0.6	14.10	13.50	1686.1	1	31	143	72.74
24-Feb-14	1606.85	0.6	20.75	20.15	1586.1	1	31	320	74.36
24-Feb-14	1465	0.65	-21.10	21.75	1486.1	1	31	15	75.97
24-Feb-14	1405.7	0.6	19.60	19.00	1386.1	1	31	5	77.59
24-Feb-14	1232	0.8	-54.10	54.90	1286.1	1	31	28	79.21
24-Feb-14	1210.85	1	24.75	23.75	1186.1	1	31	1301	80.83
24-Feb-14	1107.15	0.95	21.05	20.10	1086.1	1	31	150	82.44
24-Feb-14	1007.9	1.05	21.80	20.75	986.1	1	31	150	84.06
24-Feb-14	918.3	1.4	32.20	30.80	886.1	1	31	230	85.67
24-Feb-14	817.25	2.1	31.15	29.05	786.1	1	31	561	87.29
24-Feb-14	721.7	3.2	35.60	32.40	686.1	1	31	5352	88.91
24-Feb-14	616.95	4.35	30.85	26.50	586.1	1	31	4166	90.53

24-Feb-14	776.45	6.9	240.35	233.45	536.1	1	31	60	91.33
24-Feb-14	521.95	7.05	35.85	28.80	486.1	1	31	7846	92.14
24-Feb-14	689.25	11.1	253.15	242.05	436.1	1	31	12	92.95
24-Feb-14	428.35	10.8	42.25	31.45	386.1	1	31	13989	93.76
24-Feb-14	605.8	13.2	269.70	256.50	336.1	1	31	63	94.57
24-Feb-14	338.1	17.6	52.00	34.40	286.1	1	31	19780	95.37
24-Feb-14	290	22.4	53.90	31.50	236.1	1	31	901	96.18
24-Feb-14	252.4	29.5	66.30	36.80	186.1	1	31	38975	96.99
24-Feb-14	207.95	38.4	71.85	33.45	136.1	1	31	921	97.80
24-Feb-14	173	48.7	86.90	38.20	86.1	1	31	51008	98.61
24-Feb-14	136.45	63.4	100.35	36.95	36.1	1	31	2674	99.42
24-Feb-14	105.9	80.05	119.80	39.75	13.9	0	31	42944	100.22
24-Feb-14	80.25	104.4	144.15	39.75	63.9	0	31	151	101.03
24-Feb-14	56.9	128.85	170.80	41.95	113.9	0	31	6056	101.84
24-Feb-14	40	195	203.90	8.90	163.9	0	31	16	102.65
24-Feb-14	26.7	193.55	240.60	47.05	213.9	0	31	3068	103.46

II. SAMPLE SPSS OUTPUT

For set of data where exercise price is more than 10% of Nifty.

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS CI BCOV R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT arbmorethan110nifty
  /METHOD=ENTER sdiffx dummy time noc
  /RESIDUALS DURBIN HIST(ZRESID) NORM(ZRESID).
```

Regression

Notes

Output Created		28-Apr-2015 12:47:03
Comments		
Input	Data	D:\DTU\Sem 4\Project\spss\more than 110 nifty.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	4190
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.

Syntax		REGRESSION /DESCRIPTIVES MEAN STDDEV CORR SIG N /MISSING LISTWISE /STATISTICS COEFF OUTS CI BCOV R ANOVA CHANGE /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT arbmorethan110nifty /METHOD=ENTER sdiffx dummy time noc /RESIDUALS DURBIN HIST(ZRESID) NORM(ZRESID).
Resources	Processor Time	00:00:00.625
	Elapsed Time	00:00:00.687
	Memory Required	2300 bytes
	Additional Memory Required for Residual Plots	632 bytes

Warnings

For models with dependent variable arbmorethan110nifty, the following variables are constants or have missing correlations: dummy. They will be deleted from the analysis.

Descriptive Statistics

	Mean	Std. Deviation	N
arbmorethan110nifty	156.2433	268.53003	2955
sdiffx	1143.1068	398.05746	2955
dummy	.00	.000	2955
time	36.33	23.264	2955
noc	163.82	581.067	2955

Correlations

		arbmorethan110nifty	sdiffx	dummy	time	noc
Pearson Correlation	arbmorethan110nifty	1.000	.021	.	.015	-.059
	sdiffx	.021	1.000	.	-.018	-.059

	dummy	.	.	1.000	.	.
	time	.015	-.018	.	1.000	-.176
	noc	-.059	-.059	.	-.176	1.000
Sig. (1-tailed)	arbmorethan110nifty	.	.126	.000	.205	.001
	sdiffx	.126	.	.000	.165	.001
	dummy	.000	.000	.	.000	.000
	time	.205	.165	.000	.	.000
	noc	.001	.001	.000	.000	.
N	arbmorethan110nifty	2955	2955	2955	2955	2955
	sdiffx	2955	2955	2955	2955	2955
	dummy	2955	2955	2955	2955	2955
	time	2955	2955	2955	2955	2955
	noc	2955	2955	2955	2955	2955

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	noc, sdiffx, time[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: arbmorethan110nifty

Model Summary[b]

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.062[a]	.004	.003	268.14500	.004	3.830	3	2951	.009	1.988

a. Predictors: (Constant), noc, sdiffx, time

b. Dependent Variable: arbmorethan110nifty

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	826108.672	3	275369.557	3.830	.009[a]
	Residual	2.122E8	2951	71901.741		

Total	2.130E8	2954				

a. Predictors: (Constant), noc, sdiffx, time

b. Dependent Variable: arbmorethan110nifty

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	144.610	17.381		8.320	.000	110.530	178.691
	sdiffx	.012	.012	.018	.968	.333	-.012	.036
	time	.062	.216	.005	.287	.774	-.361	.484
	noc	-.027	.009	-.058	-3.075	.002	-.044	-.010

a. Dependent Variable: arbmorethan110nifty

Coefficient Correlations[a]

Model			noc	sdiffx	time
1	Correlations	noc	1.000	.063	.178
		sdiffx	.063	1.000	.029
		time	.178	.029	1.000
	Covariances	noc	7.470E-5	6.762E-6	.000
		sdiffx	6.762E-6	.000	7.707E-5
		time	.000	7.707E-5	.046

a. Dependent Variable: arbmorethan110nifty

Residuals Statistics[a]

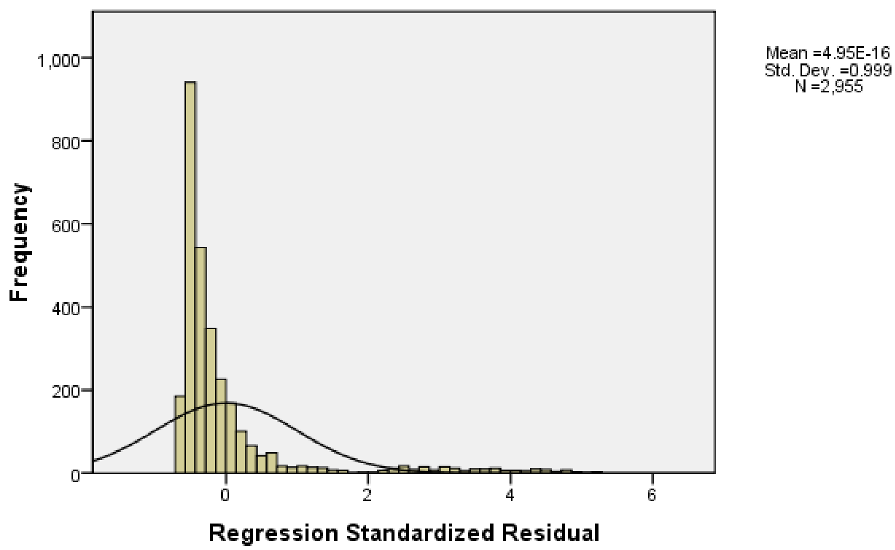
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-115.8445	181.4620	156.2433	16.72297	2955
Residual	-174.59610	1407.01770	.00000	268.00881	2955
Std. Predicted Value	-16.270	1.508	.000	1.000	2955
Std. Residual	-.651	5.247	.000	.999	2955

a. Dependent Variable: arbmorethan110nifty

Charts

Histogram

Dependent Variable: arbmorethan110nifty



Normal P-P Plot of Regression Standardized Residual

Dependent Variable: arbmorethan110nifty