An Empirical Test of Cross-Market Efficieny of Indian Index Options Market Using Put-Call Parity Condition

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Abstract

The purpose of the present study is to examine the cross market efficiency of the Indian index options, futures and cash market by testing S&P CNX Nifty index options, by Put-Call Parity condition using spot index values and futures prices. Over a period from April 01, 2008 to March 31, 2012, the daily closing prices of nifty index options contracts, spot values and futures contracts have been used in this research. The results of the sensitivity analysis of violations with respect to time to maturity and moneyness demonstrates that the majority of violations in options contract are exploitable, however, the proportion of exploitable violations severely falls after considering the transaction cost, as most of the profits were wiped out and showing negative profits. Thus, although the Indian index options market shows traces of inefficiency, in totality it is suggested that the Indian index options market is efficient as majority of violations are un-exploitable after incorporating transaction cost.

Keywords: *Market Efficiency, Options Market, Put-Call Parity Condition*

INTRODUCTION

Index options have been developed into a highly popular financial instrument, since its inception on Chicago Board Options Exchange (CBOE) in 1983. The success is largely attributed to its cash settlement mechanism which makes it an inexpensive instrument to manage the systematic risk of large portfolio and investment strategies. The introduction of S&P CNX Nifty index options (traded on National Stock Exchange, India) on June 2001, in the Indian derivatives market, considered being

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one of the major footsteps aimed towards improving the efficiency and the liquidity of the Indian financial markets. In 2010-11, the volume of trade of index options market captures more than 63 percent of the total derivative trading. This escalation in the volume of trade in index option market made it is necessary that the options market should perform its functions in the finest possible way because well functioning of financial markets is critical to the developing economy in terms of price discovery and risk hedging (Ackert and Tian, 2000). However, for well functioning of options market, it is essential that market should be efficient. Jensen in 1978, defined "market efficiency" in terms of economic profits, according to Jensen, risk adjusted economic profits net all transaction costs are zero from trading. This implies that no trader can consistently generate abnormal returns after incorporating all transaction costs.

From the literature, it has been found that the Black-Scholes option pricing model with a dynamic hedging approach is a common method to test the efficiency of the options market. However, this approach has a major disadvantage of jointly testing two hypotheses. First hypothesis is that the Black-Scholes option pricing model is valid and the second hypothesis is that the options market is efficient. However, Jensen in 1978 proposed a "pure arbitrage test" as an alternative to Black-Scholes dynamic hedging strategy to identify the risk free arbitrage opportunity. The main advantage of pure arbitrage test is it simply tests the hypothesis, whether the options market is efficient.

Stoll (1969) was the first to propose the Put-call Parity (PCP) Theory that developed into a central role in option pricing; later this theory was extended by Merton (1973). Stoll very first empirically tested the PCP theory on the options trade on Put-Call Dealer Association (an OTC market in United States) using the "*conversion mechanism*" over a period of two years from 1966 to 1967. The conversion mechanism converts a call (put) into a put (call) by taking long and short position in call, put and their underlying asset. The process of conversion resulted into a riskless hedged portfolio and is costless in the absence of transaction cost. Stoll concluded that by and large the PCP theory is applicable to the options traded on American OTC market and also supported by the time series and cross-section analysis conducted.

Most often arbitrageurs used strategies based on PCP condition using spot values-PCP (Spot) and PCP condition using futures prices-PCP (Futures). These PCP conditions capture the cross-market efficiency of options market, futures market and cash market. Moreover, taking futures market in exploiting the arbitrage opportunities is a better alternative than cash market. A number of factors facilitate the arbitrage using futures market. First, futures market assist in doing away with the constraint of short-selling, as short position can easily be taken in futures contract. Second, both options and futures are traded in a single market with the same settlement mechanism and expiration dates. This helps in lowering the transaction costs and margin deposit to undertake the arbitrage transactions.

So far, in the context of PCP condition many empirical studies have been done, but most of these studies on market efficiency of options market are based on developed markets like, US, Europe, Australia, Canada, and Hong Kong. Studies on the emerging markets are very few, particularly the Indian derivatives market which is in the developing stage in terms of volume of trade and is scarcely investigated. The present study contributes to the literature by testing the market efficiency of S&P CNX Nifty index options traded on National Stock Exchange (NSE) India, by PCP condition using spot index values and futures prices. Further, a comprehensive sensitivity analysis of violations is done with different characteristics like, time to maturity, and moneyness and also, the magnitude of violations are scrutinized by incorporating transaction cost incurred during the execution of trading strategy.

The rest of the research paper is organized into five main sections. In section II, a review of literature on market efficiency by using PCP (Spot) and PCP (Futures) has been discussed. In section III, the objectives of the study have been presented. Section IV, follows the description of the data considered for the analysis and the procedure to test the market efficiency using PCP strategy. In section V, data analysis and empirical evidences are presented. Lastly, the paper ends with the concluding observations in section VI.

REVIEW OF LITERATURE & THEORETICAL FRAMEWORK

Stoll (1969) was the first to propose the Put-call Parity (PCP) Theory that developed into a central role in option pricing; later this theory was extended by Merton (1973). Stoll very first tested the PCP theory on the options trade on Put-Call Dealer Association (an OTC market in United States) using the conversion mechanism. The conversion mechanism converts a call (put) into a put (call) by taking long and short position in call, put and their underlying asset. The process of conversion resulted into a riskless hedged portfolio and is costless in the absence of transaction cost. The PCP condition is based on no-arbitrage argument and indicates an equilibrium price of call (put) option given the price of put (call) option having same characteristic in terms of strike price, trade date and maturity date. However, PCP condition holds even if call and put options are underpriced or overprice or correctly priced. Thus, PCP theory doesn't comment on the pricing efficiency of options and therefore, is a necessary condition but not a sufficient condition from pricing efficiency viewpoint.

The model-free approach of PCP efficiency test makes it of particular importance to investigate the efficiency of options market. Given the importance of PCP relationship, many studies have been conducted to test the market efficiency in various markets around the globe, including the U.S., U.K., German, Swiss, Australian, Italian, Canadian, and Hong Kong markets which reports frequent violations of PCP condition using spot options-PCP (Spot). Some of the studies that observed such violations were; Evnine and Rudd (1985), Finucane (1991), Kamara and Miller (1995), and Ofek, Richardson, and Whitelaw (2004) for the U.S. market. Brown and Easton (1992) for the Australian market, Chesney, Gibson, and Louberge (1994) for the Swiss market, Ackert and Tian (1998) for the Canadian market, Capelle-Blancard and Chaudhury (2001) for the French market, and Cassese and Guidolin (2004) for the Italian market also found such violations. However, there were few studies that did not find significant PCP violations using spot options, these were; Klemkosky and Resnick (1979), Blomeyer and Boyd (1995), and Ackert and Tian (2001) for the U.S. market, Mittnik and Rieken (2000) for the German market, and Brunetti and Torricelli (2005) for the Italian market. However, these violations represented potential profit opportunities disappeared when transactions costs were considered.

Likewise, a few studies tested the market efficiency with PCP condition using futures prices-PCP (Futures) on the same underlying asset instead of spot market values. The use of futures in PCP condition was first proposed by Lee and Nayar (1993) to test the efficiency of index options traded on Chicago Board Options Exchange (CBOE) and Chicago Mercantile Exchange (CME) of USA. It was seen that violations are much less in frequency and magnitude for PCP (Futures). The only study that found violations using this approach was done by Bharadwaj and Wiggins (2001) for the U.S. market. Other studies that did not accounted major violations include, Lee and Nayar (1993), Fung and Chan (1994), and Garay, Ordonez, and Gonzalez (2003) for the U.S. market, Draper and Fung (2002) for the U.K. market, and Fung, Cheng, and Chan (1997), Fung and Fung (1997), Fung and Mok (2001), and Lung and Marshall (2002) for the Hong Kong market.

The PCP condition using spot value after adjusting the effect of dividend yield following Fung and Fung (1997) and Li (2006) for European type index options contract is given in equation (1). The test of PCP condition using futures prices is shown in equation (2) which is in line with Lee and Nayar (1993), Fung and Chan (1994), and Fung and Mok (2001). It may be noted that in an efficient market, futures prices are expected to incorporate the effect of dividend yield and therefore dividend yield has not been included in equation (2) as the underlying asset used in the test is futures prices instead of spot values.

Using underlying spot index values

$$P_t = \{(C_t + K\, e^{-r(T-t)} - I_t\, e^{-\Delta(T-t)}) \pm TTC_t\} \quad \text{......................(1)}$$

Using index futures prices

$$P_t = \{(C_t + K\, e^{-r(T-t)} - F_t\, e^{-r(T-t)}) \pm TTC_t^{*}\} \quad \text{.....................(2)}$$

Where, I_t denotes spot market price of S&P CNX Nifty index at time t, C_t is market value of a European call options at time t, P_t is market value of a European put options at time t, F_t denotes the price of the S&P CNX Nifty futures (with similar expiration date as of the options considered) at time t, K is the strike price of the options contract, T is the expiration time of the options, r is continuously compounded annual risk-free rate of return, Δ is continuously compounded dividend yield, TTC_t is the total transaction costs relating to trading in options and spot market at time t and TTC_t^{*} is the total transaction costs relating to trading in options and futures contract at time t.

Under the PCP efficiency test the price of a portfolio of call and put options contracts is compared with the portfolio of the constituent stock index. If the call and put options price violates equation (1), then an arbitrage opportunity arises by selling the overpriced portfolio and buying the underpriced portfolio, and offsetting all the traded positions on the exercise date. A detailed description of arbitrage actions using spot index values is shown in Table-1(a) and (b).

Table 1(a): Arbitrage Transactions Using Spot Index Value for Put-Call Parity Condition Case: Overvalued Put Options

		Cash Flow at Expiration	
Transaction	**Current Date**	$I_T > K$	$I_T \leq K$
Buy a Call	$-C_t\ e^{(\Delta\tau)}$	$+(I_T - K)e^{(\Delta\tau)}$	-
Sell a Put	$+P_t\ e^{(\Delta\tau)}$	-	$-(K - I_T)e^{(\Delta\tau)}$
Sell a Stock	$+I_T$	$-I_T\ e^{(\Delta\tau)}$	$-I_T\ e^{(\Delta\tau)}$
Buy Bonds	$-K\ e^{(\Delta-r)\tau}$	$+K\ e^{(\Delta\tau)}$	$+K\ e^{(\Delta\tau)}$
	> 0	0	0

Note: 1. I_T denotes spot market price of S&P CNX Nifty on maturity T,
2. $\tau = (T - t)$, denotes time to expiration of the option at time t.

Table 1(b): Arbitrage Transactions Using Spot Index Value for Put-Call Parity Condition Case: Undervalued Put Options

		Cash Flow at Expiration	
Transaction	**Current Date**	$I_T \geq K$	$I_T < K$
Buy a Put	$-P_t\ e^{(\Delta\tau)}$	-	$+(K - I_T)\ e^{(\Delta\tau)}$
Sell a Call	$+C_t\ e^{(\Delta\tau)}$	$-(I_T - K)e^{(\Delta\tau)}$	-
Buy a Stock	$-I_T$	$+I_T\ e^{(\Delta\tau)}$	$+I_T\ e^{(\Delta\tau)}$
Borrow	$+K\ e^{(\Delta-r)\tau}$	$-K\ e^{(\Delta\tau)}$	$-K\ e^{(\Delta\tau)}$
	> 0	0	0

Note: 1. I_T denotes spot market price of S&P CNX Nifty on maturity T, 2. $\tau = (T - t)$, denotes time to expiration of the option at time t.

A similar PCP arbitrage action can be established by using the futures contracts based on the same underlying asset with lower transaction costs, which is shown in Table-2(a) and (b).

Table 2(a): Arbitrage Transactions Using Index Futures for Put-Call Parity Condition Case: Overvalued Put Options

		Cash Flow at Expiration	
Transaction	**Current Date**	$I_T > K$	$I_T \leq K$
Buy a Call	$-C_t$	$+(I_T - K)$	-
Sell a Put	$+P_t$	-	$-(K - I_T)$
Sell a Future	0	$-(I_T - F_t)$	$+(F_t - I_T)$
Borrow	$+(C_t - P_t)$	$-(C_t - P_t)\ e^{(r\tau)}$	$-(C_t - P_t)\ e^{(r\tau)}$
	0	$F_t - K - (C_t - P_t)\ e^{(r\tau)} > 0$	$F_t - K - (C_t - P_t)\ e^{(r\tau)} > 0$

Note: 1. I_T denotes spot market price of S&P CNX Nifty on maturity T, 2. $\tau = (T - t)$, denotes time to expiration of the option at time t.

Table 2(b): Arbitrage Transactions Using Index Futures for Put-Call Parity Condition Case: Undervalued Put Options

		Cash Flow at Expiration	
Transaction	**Current Date**	$I_T \geq K$	$I_T < K$
Buy a Put	$-P_t$	-	$+(K - I_T)$
Sell a Call	$+C_t$	$-(I_T - K)$	-
Buy a Future	0	$+(I_T - F_t)$	$-(F_t - I_T)$
Borrow Bonds	$-(C_t - P_t)$	$+(C_t - P_t)\, e^{(r\tau)}$	$+(C_t - P_t)\, e^{(r\tau)}$
	0	$K - F_t + (C_t - P_t)\, e^{(r\tau)} > 0$	$K - F_t + (C_t - P_t)\, e^{(r\tau)} > 0$

Note: 1. I_T denotes spot market price of S&P CNX Nifty on maturity T, 2. $\tau = (T - t)$, denotes time to expiration of the option at time t.

OBJECTIVES OF THE STUDY

From the review of literature, it gives the impression that the abnormal profit opportunities did exist in these options market. However, these abnormal profits were completely eradicated when transaction costs were considered. Thus, the hypothesis that markets were efficient cannot be rejected. But this conclusion of past literature does not rule out the need for further research particularly in developing markets. Keane (1983) emphasised the importance of regular investigation of financial markets in terms of efficiency. According to Keane (1983) regular scrutiny serves two purposes, firstly, it provides a continuous attestation of efficiency of financial market and secondly, it keeps a watch on the process so that any violations could be quickly identified and eliminated.

Thus, the present research attempts to investigate the cross-market efficiency of Indian index options market by Put-Call Parity (PCP) condition using spot index values and futures prices. Thus, the primary objective of the study is; to examine the cross-market efficiency of S&P CNX Nifty index options traded on National Stock Exchange (NSE) India by the Put-Call Parity (PCP) condition using spot index values and futures prices on daily closing observations of call and put options from April 01, 2008 to March 31, 2012.

Further, a sensitivity analysis has been done with respect to time to maturity and moneyness for investigating the exploitability of the violations obtained from PCP condition. Here, the moneyness is defined as the ratio of current index price to strike price.

DATA & METHODOLOGY

Over a period from April 01, 2008 to March 31, 2012, the daily closing prices of nifty index options contracts, spot values and futures contracts have been used in this research. As a substitute for risk-free interest rate, yield on 91-day Treasury bills has been taken for the same period to test the PCP condition. From the National Stock Index (NSE) website, the daily closing prices of nifty index options, spot values and futures contracts have been obtained. The short term risk free rate (i.e., yield on 91-day Treasury bills) has been obtained from the website of Reserve Bank of India, then after these short term yields are transformed into continuously compounded annual rate of return.

Now in order to identify arbitrage opportunities, the PCP condition using spot and futures index values depicted in equation (1) and (2) have to be restructured. The testable forms are give in equations (3), (4), (5) and (6) for identifying overpriced and underpriced put options relative to the corresponding call options with same contract specifications.

$$\lambda_t^{Overpriced} = [P_t^{Market} - \{(C_t^{Market} + K\, e^{-r(T-t)} - I_t\, e^{-\Delta(T-t)}) + TTC_t\}] \text{ ....(3)}$$

$$\lambda_t^{Underpriced} = [C_t^{Market} - \{(P_t^{Market} - K\, e^{-r(T-t)} + I_t\, e^{-\Delta(T-t)}) - TTC_t\}] \text{ ....(4)}$$

$$\lambda_t^{Overpriced} = [P_t^{Market} - \{(C_t^{Market} + K\, e^{-r(T-t)} - F_t\, e^{-r(T-t)}) + TTC_t^*\}] \text{ ....(5)}$$

$$\lambda_t^{Underpriced} = [C_t^{Market} - \{(P_t^{Market} - K\, e^{-r(T-t)} + F_t\, e^{-r(T-t)}) - TTC_t^*\}] \text{ ....(6)}$$

Where, $\lambda_t^{Overpriced}$ and $\lambda_t^{Underpriced}$ signify the absolute magnitude of violations. If, $\lambda_t^{Overpriced} > 0$ and $\lambda_t^{Underpriced} > 0$ are found then positive magnitude of violations of PCP is recorded.

Transaction Costs

Phillips and Smith (1980) empirically showed that the abnormal returns resulted from the violations of equilibrium prices turned negative when transaction costs are considered. Thus, the absolute profits resulted from the violations of equilibrium prices are computed in order to verify, whether there are abnormal profits persist after transaction costs (Ofek, Richardson and Whitelaw, 2004). In the present research, the transaction costs incorporated have been defined only as, brokerage, service tax on the brokerage and securities transactions tax STT (effective from 1st October, 2004). The statutory STT cost is applicable only on the short side of the derivative contracts (STT charged in derivative markets is 0.125%) and on both legs in spot equity transactions (STT charged inequity market is 0.125%).

However, the most challenging task in computing the transaction costs is the estimation of brokerage charges, as it varies over time, brokering firms and on particular trading strategy. Further, it has been found that the arbitrageurs are categorized into retail investors and institutional investors based on the differential transaction costs. Thus, in order to estimate the brokerage charges, opinions have been taken from executives of brokerage firms. The estimated brokerage charges for retail investor and institutional investor is 0.05 percent and 0.03 percent respectively, in derivatives contracts. For options contracts, the brokerage charge is applicable on the strike price and the option premium together and in case of futures contracts, it is applicable to the futures prices only. In case of spot equities brokerage charge is 0.20 percent and 0.10 percent for general and institutional investors respectively. These estimations of the brokerage charges are similar to the estimates of earlier studies done by Dixit, Yadav and Jain (2009, 2011) and Vipul (2008).

DATA ANALYSIS AND EMPIRICAL EVIDENCES

The key consideration after the data collection process for the preparation for efficiency tests is the filtration of data on the basis of liquidity and maturity. Only liquid contracts (at least one contract traded) and near the month (NTM), next the month (NXTM) and far the month (FTM) contracts are considered.

To identify the mispricing for arbitrage with PCP strategy, all possible pairs of call and put options on nifty index are made in such a way that for each pair, the strike price and expiration date of call and put options are matched. Next, for each pair of call and put options, a futures contract is identified with identical expiration date as of call and put options. Finally, a total of 33888 triplets of call, put, and spot index values are identified for PCP strategy using spot index values and with a similar approach, a total of 33888 triplets of call, put, and futures contracts are made for PCP strategy using futures contract. For matching up the triplets, call transactions are taken as the preparatory point to ensure that a large sample size to be achieved for the investigation, as call options are more frequent than put.

Table 3: Violations of Put-Call Parity Conditions

	PCP (Spot)		
Particulars	**Underpriced put option**	**Overpriced put options**	**Total**
Total number of ex-post violations observed	33888	33888	33888
Total number of ex-post violations observed before transaction cost	10120 (30)	23768 (70)	33888 (100)
Total number of ex-post violations observed after transaction cost (for retail investors)	2134 (06)	10162 (30)	12296 (36)
Total number of ex-post violations observed after transaction cost (for institutional investors)	3476 (10)	13816 (40)	17292 (51)
	PCP (Futures)		
Particulars	Underpriced put option	Overpriced put options	Total
Total number of ex-post violations observed	33888	33888	33888
Total number of ex-post violations observed before transaction cost	14531 (43)	19356 (57)	33887 (99)
Total number of ex-post violations observed after transaction cost (for retail investors)	4848 (14)	6258 (18)	11106 (33)
Total number of ex-post violations observed after transaction cost (for institutional investors)	6686 (20)	9066 (27)	15752 (46)

Note: Figures in parenthesis show percentage

The summary of overall results related to the mispricing of PCP condition using spot index values and futures contracts are reported in Table 3. It can be observed that number of violations are equal as of number of observations i.e., 100 percent frequency of violations are recorded in case of PCP (Spot) and more than 99 percent frequency of violations out of the total observations are recorded in PCP (Futures). However, there is a drastic decline in the frequency of violations when transaction cost with respect to retail and institutional investor is incorporated in case of both PCP (Spot) and PCP (Futures). About 36 percent and 51 percent violations are identified in PCP (Spot) after considering transaction cost for retail and institutional investor point of view respectively, whereas about 33 percent and 46 percent violations are recorded in PCP (Futures) after considering transaction cost for retail and institutional investor respectively. Moreover, it is interesting to note that majority of the violations have been observed in overpriced put options i.e. about 70 percent and 57 percent violations out of total frequency of violations are recorded under overpriced put option category in PCP (Spot) and PCP (Futures) respectively.

The occurrence of violations before the transaction cost for PCP (Spot) and PCP (Futures) are further investigated to identify the pattern of occurrence in the mispricing. The pattern of violations is examined with respect to different levels of maturity and the moneyness of the options. The sensitivity analysis of violations is important in a sense that only frequency and magnitude of violations are insufficient to comment upon the efficiency of the market. One needs to understand whether these mispricing falls under exploitable category. Thus, to investigate from the perspective of the sensitivity analysis, the time to maturity has been categorized as follows; (i) 0 to 7 days, (ii) 8 to 30 days, (iii) 31 to 60 days, and 61 to 90 days to maturity. According to Rubinstein (1985), the moneyness is categorized as; (i) DOTM-Deep-out-of-money (0.75-0.85), (ii) OTM-Out-of-money (0.85-0.95), (iii) ATM-At-the-money (0.95-1.05), (iv) ITM-In-the-money (1.05-1.15), (v) DITM-Deep-in-the-money (1.15-1.25).

Table 4: Violations of Put-Call Parity Conditions Relating to the Maturity of Options Contract

Time to maturity	PCP (Spot)	PCP (Futures)
0 to 7 days	4838 (14)	4837 (14)
8 to 30 days	12317 (36)	12317 (36)
31 to 60 days	11062 (33)	11062 (33)
61 to 90 days	5671 (17)	5671 (17)
Total	33888	33887

Note: Figures in parenthesis show percentage

The Table-4 summarizes the pattern of violations with respect to different levels of maturity. From the results it is that noted the relationship of violations with respect to maturity is similar in case of both PCP (Spot) and PCP (Futures) and majority of violations i.e. about 50 percent of the total violations are found between 0 to 30 days to maturity. The high concentration of the violations in NTM contracts is similar to the findings of Bhattacharya (1983). From the analysis, it can be seen that the number of mispricing shows a deceasing pattern with an increase in time to maturity for both PCP (Spot) and PCP (Futures), this shows the lack of exploitability of the violations and thus, supports the Dixit's above proposition.

The Tables-5 shows the pattern of frequency of violations with respect to different level of moneyness. It is important to note that the different level of moneyness is depicted from the viewpoint of call option. From the results it can be observed that maximum instances of violations (29%) are identified for "at the money" ATM options. Some occurrences of violations about 22 percent and 18 percent are also found for "out of the money" OTM and "in in-the-money" ITM options respectively. However, "deep out of the money" DOTM and "deep in the money" DITM options provide limited instances of mispricing i.e., about 13 percent and 19 percent respectively. In general, there is enough liquidity found in ATM options contracts and therefore these violations do not lack exploitability, however the liquidity of options contract decreases as the options are more into the money and therefore violations found in "nearer the money" contracts (i.e. OTM and ITM contracts) and "far-from-the-money" options (i.e. DOTM and DITM contracts) are left unexploited. Further it is also observed that the relationship of violations with respect to moneyness is similar in case of both PCP (Spot) and PCP (futures).

Table 5: Violations of Put-Call Parity Conditions Relating to the Five Levels of Moneyness

Moneyness	PCP (Spot)	PCP (Futures)
DOTM (< 0.85)	4315 (13)	4315 (13)
OTM (0.85-0.95)	7347 (22)	7346 (22)
ATM (0.95-1.05)	9705 (29)	9705 (29)
ITM (1.05-1.15)	6058 (18)	6058 (18)
DITM (1.15 <)	6463 (19)	6463 (19)
Total	33888	33887

Note: Figures in parenthesis show percentage

From the above results in can be indicated that majority of frequency of violations before transaction cost are exploitable in terms of maturity and moneyness. However, before making a comment about the inefficiency, the

Table 6: Descriptive Statistics of the Absolute Amount of the Violations Across the Specified Levels of Maturity

Maturity	Mean		Standard deviation		Minimum		Maximum	
	PCP (Spot)	PCP (Futures)	PCP (Spot)	PCP (Futures)	PCP (Spot)	PCP (Futures)	PCP (Spot)	PCP (Futures)
0 to 7 days	12.33	9.97	19.00	19.55	0.00	0.00	356.31	366.64
8 to 30 days	16.79	10.17	21.77	20.64	0.01	0.00	647.69	648.62
31 to 60 days	25.72	13.60	35.39	33.69	0.00	0.00	1787.92	1759.75
61 to 90 days	34.71	17.03	35.51	33.37	0.06	0.00	1050.17	1048.02

Table 7: Descriptive Statistics of the Absolute Amount of the Violations Across the Specified Levels of Moneyness

Moneyness	Mean		Standard deviation		Minimum		Maximum	
	PCP (Spot)	PCP (Futures)	PCP (Spot)	PCP (Futures)	PCP (Spot)	PCP (Futures)	PCP (Spot)	PCP (Futures)
DOTM (< 0.85)	28.96	22.68	51.14	50.69	0.01	0.01	1787.92	1759.75
OTM (0.85-0.95)	22.77	12.36	24.71	21.50	0.00	0.00	476.27	514.62
ATM (0.95-1.05)	20.92	6.08	20.51	12.68	0.00	0.00	424.68	451.19
ITM (1.05-1.15)	21.28	10.11	21.14	17.31	0.00	0.00	376.69	388.24
DITM (1.15 <)	22.34	17.26	34.38	33.63	0.00	0.00	1050.17	1048.02

sensitivity analysis of the magnitude of the violations before transaction costs needs to be analyzed, which is shown in the Table-6 and 7 with respect to maturity and moneyness respectively.

From the mean results obtained from Tables-6, it can be suggested that the absolute amount of violations increases with the increase in days to maturity for both PCP (Spot) and PCP (Futures). However, as the volume traded in the NTM contracts are much higher than the NXTM and FTM contracts, therefore the larger absolute amount of violations are difficult to get exploited. Thus, it infers that the magnitude of profit declines as the liquidity of the contract increases and thus majority of mispricing are un-exploitable under highly traded contract.

Table-7 results shows the magnitude of mispricing is the highest for "far-from-the-money" options and the lowest for "at the money" options. This entails that an arbitrageur can earn higher absolute profits when the current spot price of the options are far from their strike prices. However, such arbitrage opportunities are less frequent as shown in Table-5. These results are in line with the results of Kamara and Miller (1995), Ackert and Tian (1999), and Draper and Fung (2002) for the U.S. and U.K. markets.

Jensen in 1978, defined "market efficiency" in terms of economic profits, according to Jensen, risk adjusted economic profits net all transaction costs are zero from trading. This implies that no trader can consistently generate abnormal returns after incorporating all transaction costs. Phillips and Smith (1980) empirically showed that above normal returns resulted from violations of equilibrium prices turned negative when transaction costs are considered. Thus, the absolute profits after transaction costs are computed in order to verify whether there are abnormal profits persist after transaction costs.

From the Table-8, it can be observed that the average magnitude of profit before transaction cost is 22.07 and 12.41 for PCP (Spot) and PCP (Futures) respectively However, the average magnitude of violations increases for both retail and institutional investor after accounting for transaction costs. The average absolute amount of violations is 23.74 and 21.74 for PCP (Spot) and PCP (Futures) respectively for retail investor and the average absolute amount of violations 22.64 and 17.91 for PCP (Spot) and PCP (Futures) respectively for institutional investor.

The increase in the size of the absolute profit does not make the arbitrage more fruitful as the percentage of violations falls from 100 percent to about 36 percent in case of PCP (Spot) and the percentage of violation falls from 99 percent to about 33 percent for PCP (Futures) after

Table 8: Descriptive Statistics of the Absolute Amount of the Violations

Descriptive Statistics	Before Transaction Cost		Retail Investors		Institutional Investors	
	PCP (Spot)	PCP (Futures)	PCP (Spot)	PCP (Futures)	PCP (Spot)	PCP (Futures)
Mean	22.07	12.41	23.74	21.74	22.64	17.91
SD	29.97	27.80	40.42	43.14	36.19	37.76
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	1787.92	1759.75	1772.38	1750.78	1777.62	1754.00

Table 9: Descriptive Statistics Including Kolmogorov-Smirnov Statistics

Descriptive Statistics		PCP (Spot)	PCP (Futures)
Mean		22.07	12.41
95% Confidence Interval for Mean	Lower Bound	21.75	12.11
	Upper Bound	22.39	12.70
Median		14.93	5.25
Variance		898.48	772.86
Std. Deviation		29.97	27.80
Skewness		14.04	17.88
Kurtosis		534.86	722.02
Kolmogorov-Smirnova		0.23	0.33
Sig.		0.00	0.00

transaction costs have been incorporated.

From the above records it can be identified that the mean magnitude of the violations for PCP (Spot) is greater than PCP (Futures) before transaction cost. Also, the mean magnitude of violations increases with increase in days to maturity for both PCP (Spot) and PCP (Futures). Further, the magnitude of mispricing is the highest for "far-from-the-money" options and the lowest for "at the money" options. Now in order to statistically validate these deviations, we first apply Kolmogorov-Smirnov test (K-S test) to test the normality of the magnitude of the violations. From the p-value of K-S test shown in Table-6, we reject the null hypothesis of Kolmogorov-Smirnov test (K-S test). Therefore, it is concluded that the data has not been drawn from the normally distributed population and thus, non parametric tests like; Mann-Whitney-U test and Kruskal-Wallis test will be applied.

Now in order to statically validate the deviation between the mean magnitude of the violations in PCP (Spot) and PCP (Futures) before transaction cost, hypothesis has been formulated and tested by a non parametric tests-Mann-Whitney-U test. The hypothesis and summary of Mann-Whitney-U test are as follows,

H_0: There is no significant difference among the mean sizes of absolute violations in PCP (Spot) and PCP (Futures) before transaction cost.

From the p-value of Mann-Whitney-U test for PCP violations shown in Table-10, we can reject the null hypothesis. Therefore, it can be concluded that mean size of absolute amount of violation (22.07) in PCP (spot) is statistically greater than mean size (12.41) of violation for PCP (Futures).

Further, to statically validate that the mean magnitude of violations increases with the increase in days to maturity and magnitude of mispricing is the highest for "far-from-the-money" options and the lowest for "at the money" options, hypotheses has been formulated and tested by a non parametric tests-Kruskal-Wallis test as shown in Table-11.

From the p-value of Kruskal Wallis Test for specified level of maturity shown in Table-11, we can reject the null hypothesis (i.e. H_0: There is no significant difference among the mean sizes of absolute violations in both PCP (Spot) and PCP (Futures) under specified level of maturity). Thus, it can be concluded that the mean size of the absolute magnitude of violations increases with increase in days to maturity. Further, from the p-value of Kruskal Wallis Test for specified level of moneyness shown in Table-11, one can reject the null hypothesis (i.e. H_0: There is no significant difference among the mean sizes of absolute violations in both

Table 10: Summary of Mann-Whitney U Statistics

PCP Violation				Test Statistics	
	N	Mean Rank	Sum of Ranks		
PCP (Spot)	33888	40713.0795	1379684838	Mann-Whitney U	342900000.00
PCP (Futures)	33887	27062.7191	917074362	Wilcoxon W	917100000.00
Total	67775			Z	-90.82
				Asymp. Sig. (2-tailed)	0.00

Table 11: Summary of Kruskal-Wallis test Statistics across Specified Level of Maturity and Moneyness

Specified level of maturity and moneyness	Test Statistics of Kruskal Wallis Test		
	Chi-Square	df	Asymp. Sig.
PCP (Spot) with specified level of maturity	4930	3	0
PCP (Futures) with specified level of maturity	949.771	3	0
PCP (Spot) with specified level of moneyness	155.096	4	0
PCP (Futures) with specified level of moneyness	3196	4	0

PCP (Spot) and PCP (Futures) under specified level of moneyness). Thus, Kruskal Wallis Test statistically support the findings that the magnitude of mispricing is the highest for "far-from-the-money" options and the lowest for "at the money" options.

CONCLUSIONS

The present research attempts to test the efficiency of S&P CNX Nifty index options traded on National Stock Exchange (NSE), India by empirically testing the Put-Call Parity (PCP) condition using spot and futures prices. Over a period from April 01, 2008 to March 31, 2012, the daily closing prices of nifty index options contracts, spot values and futures contracts have been used in this research.

The study reveals frequent violations of PCP condition i.e., 100 percent frequency of violations are recorded in case of PCP (Spot) and more than 99 percent frequency of violations out of the total observations are recorded in PCP (Futures). However, there is a drastic decline in the frequency of violations when transaction cost with respect to retail and institutional investor is incorporated in case of both PCP (Spot) and PCP (Futures). About 36 percent and 51 percent violations are identified in PCP (Spot) after considering transaction cost for retail and institutional investor point of view respectively, whereas about 33 percent and 46 percent violations are recorded in PCP (Futures) after considering transaction cost for retail and institutional investor respectively. Moreover, it is interesting to note that majority of the violations have been observed in overpriced put options i.e. about 70 percent and 57 percent violations out of total frequency of violations are recorded under overpriced put option category in PCP (Spot) and PCP (Futures) respectively. These violations can mainly be attributed to the short selling restrictions in the cash market, and thus tend to overprice the put options.

The sensitivity analysis with respect to time to maturity and moneyness further validates the efficiency of Nifty index options market, and indicates that the Nifty index options market has the similar organized patterns of PCP violations as U.S and other European index options markets. Firstly, the number of mispricing shows a deceasing pattern with an increase in time to maturity for both PCP (Spot) and PCP (Futures). Secondly, the maximum instances of violations are identified for "at the money" ATM options, with some occurrences of violations found in "nearer the money" contracts (i.e. OTM and ITM contracts) and limited instances of mispricing are recorded in "far-from-the-money" options (i.e. DOTM and DITM contracts). These results are consistent with results from Ackert and Tian (1999) for the S&P 500 options market. Thus, the findings of the PCP condition tests shows that the Indian options market was adequately efficient during the period of study and most of the mispricing are un-exploitable because of illiquidity in such contracts.

The efficiency of the index options market is further supported by incorporation of transaction cost, which shows that despite the increase in the size of the absolute profit, the percentage of violations falls from 100 percent to about 36 percent in case of PCP (Spot) and the percentage of violation falls from 99 percent to about 33 percent for PCP (Futures) after transaction costs have been incorporated.

The present study is very important for National Stock Exchange (NSE), Securities and Exchange Board of India (SEBI), brokerage houses and institutional investors, as the study suggest that Indian index options market is efficient as majority of violations are un-exploitable after incorporating transaction cost. However, un-exploitability of violations does not deny the fact that the mispricing exists in the market and this brings out few notable implications. Firstly, the deviation of option prices from its equilibrium prices might impede the price discovery process. Secondly, mispricing will impede the overall hedging mechanism as the advanced hedging techniques might turn out to be ineffective. Lastly, the study attempts to contribute to the literature on market efficiency of index options particularly in the case of Indian index options.

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