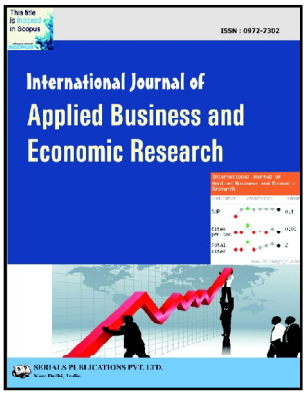

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A Test of Put Call Parity Relationship in Stock Options at National Stock Exchange

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Abstract: Recently there has been a spurt of interest in the stock options segment in India, as evidenced by the fast growth in volumes in this segment. The present study examines the put-call parity (PCP) in stock options. After applying a stringent sampling process, 16 stock options have been studied over a period of two years. The findings of the study indicate frequent violations of PCP, although the magnitude of the violations remains on the lower side. Non-parametric tests are applied to validate the findings statistically. The paper concludes with implications and limitations of the study along with the direction for future research.

Keywords: Put-Call Parity; Stock Options, National Stock Exchange; Derivatives; Options.

1. INTRODUCTION

India's tryst with exchange-traded derivatives commenced in the year 2000, with the introduction of index futures. There has been remarkable growth in the equity and index derivatives segments. . An important indicator of the development of such markets is the presence of pricing efficiency, which is measured in terms of market prices being consistent with intrinsic values.

If derivative securities are trading away from their intrinsic values, risk-free arbitrage opportunities arise. Therefore, the derivative instruments should be priced on the basis of tenets of financial theory, in the absence of which they would not be able to perform their functions of providing a platform for market participants to hedge their risk, and aiding in price discovery.

Initially, stock options could not gather volumes at Indian bourses. But with passage of time and investors gaining confidence, this segment has also grown considerably (Refer Table 1).

Table 1
Growth in Stock Options at National Stock Exchange of India

Year	*Notional Turnover (Rs. Crores)*	*Growth, YoY (%)*
2003-04	217,207	117%
2004-05	168,836	-22%
2005-06	180,253	7%
2006-07	193,795	8%
2007-08	359,137	85%
2008-09	229,227	-36%
2009-10	506,065	121%
2010-11	1,030,344	104%
2011-12	977,031	-5%
2012-13	2,000,427	105%
2013-14	2,409,489	20%
2014-15	3,282,552	36%
2015-16	3,488,174	6%

Source: Compiled from the website of National Stock Exchange (www.nseindia.com)

In the wake of this growth and given the importance of efficiency of financial markets, it becomes essential to investigate the empirically the notions of pricing efficiency in the thriving Indian derivatives market. The present study is an attempt to assess the pricing efficiency of Stock Options market in India using the Put-Call Parity relationship for the period January 2010 to December 2012.

The Put-Call Parity (PCP) approach was first identified by Stoll (1969). This approach is based on no-arbitrage argument; hence it completely sidesteps the limiting assumptions of model-based approaches. Recently, there has been a considerable interest in empirical examination of pricing efficiency of Options in Indian market. However most of the studies concentrate on Index options. The stock options remain unexplored. This paper attempts to fill this gap by examination of PCP for a sample of 16 stock options.

2. LITERATURE REVIEW

Stoll (1969) was the first to identify the Put-Call Parity (PCP) relationship. The study by Merton (1973) established the PCP for both European and American Options. Klemkosky & Resnick (1979) were the earliest to study the PCP on the exchange traded US market. The empirical results were found to be consistent with the established PCP relationship. A small degree of inefficiency was detected.

Evnine and Rudd (1985) studied the U.S. Market and reported that S&P 100 calls were underpriced, whereas the Major Market Index (MMI) call options were overpriced.

Loudon (1988) examined all the available options in Australian Markets during 1985 and determined that the magnitude of violations were insufficient to account for arbitrage opportunities considering transactions costs. The presence of transaction costs appeared to be most significant for mispricing behavior.

Lee and Nayar (1993), using various trading strategies, reviewed the existence of arbitrage between the S&P 500 Index Futures and Options market. They opined that since these derivatives are based on the same underlying, there pricing should also be interrelated with each other.

Wagner *et al.* (1996) studied the factors behind deviations in PCP for S&P 100 Index Options. The study reported substantial number of violations of PCP even after accounting for transaction costs contrary to Klemkosky & Resnick (1979), but in line with Evnine and Rudd (1985).

Berg *et al.* (1996) examined the Oslo Stock Exchange options in the Norwegian market. They reported a large number of PCP violations. The calls were relatively overpriced compared to puts.

Fung *et al.* (1997) studied the Hang Seng Index Options and futures market. The paper examined the Put-Call futures parity. The mispricing was evident in the markets on account of high number of violations before accounting for transaction costs. The results were in line with the findings of Lee and Nayar (1993).

Ackert and Tian (1999) examined the Standard and Poor's Depository Receipts (SPDRs). They deduced that there were significant violations, but the violations reduced after considering the transactions costs and commission.

Mittnik and Reiken (2000) studied the DAX index options in German market and opined that PCP did not hold. The market exhibited learning behavior in the sense that market efficiency improved in the last years of the sample period. Blancard and Choudhury (2001) studied the CAC 40 index in the French Options market. In the study the short PCP violations are more common than long PCP violations for the CAC 40 index options.

Draper and Fung (2002) used the Put call futures parity in the U.K for FTSE 100 futures and FTSE 100 options relationships. The study confirmed the efficiency of the market since there were relatively fewer number of arbitrage opportunities for the traders.

Shah (2003) studied the nascent derivatives market in India and reported that there were large deviations. However, the efficiency seemed to be improving.

Ahn *et al.* (2003) assessed the Korean market and deduced that there existed significant violations of Put-Call Parity conditions. The arbitrage opportunities remained intact even after considering transaction cost and replacing index price with index futures price.

Nilsson (2003) studied the Swedish market to examine the affect of short-sales restrictions on the violation of PCP. The research findings reported that that there was a significant difference in magnitude of violation of PCP between the period of short-sale constraints and no constraints.

Cassese and Guidolin (2004) examined the Italian Market for MIB 30 Stock Index options. The study indicated significant violations of no-arbitrage conditions including put-call parity at various moneyness levels and different maturities. However, like other studies, these violations decreased when market frictions were considered.

Ofek *et al.* (2004) examined PCP under short sales restrictions as measured by the rebate rate. The findings suggested statistically significant violations of PCP. The study reported clear relationship between arbitrage constraints and mispricing.

Misra and Misra (2005) investigated the Nifty options for Put-Call Parity. The study reported many instances for violations of PCP.

Li (2006) investigated the Osaka Securities Exchange (OSE), the largest derivatives exchange in Japan. The study did not find support for efficiency in the market. The violations of PCP were occasional, but the magnitude of profits led to arbitrage opportunities even after considering transactions costs.

Cremers and Weinbaum (2008) examined the put-call parity deviations to determine whether they contained information about the future stock prices. The stocks with relatively expensive calls outperform stocks with relatively expensive puts. Since the violations were both positive and negative, the authors deliberated that they cannot be attributed to short-sales restrictions alone.

Vipul (2008) tested the put–call–futures parity (PCFP) and put–call–index parity (PCIP) conditions for European style Nifty Index options, during January 2002 to Nov 2004. Frequent violations of both PCFP and PCIP were observed. Put options are overpriced more often than call options due to short selling restrictions.

Hoque *et al.* (2010) studied the foreign exchange options on Philadelphia Exchange for boundary conditions and Put-Call Parity with respect to impact of transaction costs. The PCP deviations for the conversion and reversal trades were 33.86% and 23.43%, respectively, for all currencies jointly.

Gupta & Jithendranathan (2010) investigated the Indian market over the period August 2001 to December 2006. The indicated that in 24% of the observations, there was violation of the put-call parity condition where the arbitrage required short-sales.

Nishiotis and Rompolis (2011) studied the PCP in the ban period in the U.S. markets. The study documented a significant increase in the magnitude of violations during the ban period relative to both the pre- and post-ban periods. The short-sales ban decoupled the options and the stock market and increased market inefficiencies. Similar to his study, Grundy *et al.* (2012) investigated the differences in market behavior before, during, and after the ban for stocks for which short sales were prohibited and for all other stock on which options were traded in the US market included in the S&P 500 Index. The results suggested that during the ban, there was a significantly greater reduction in the volume of trade in options on banned stocks relative to options on unbanned stocks.

Dixit *et al.* (2012) studied the PCP and PCP using futures prices for Nifty Index Options. They reported extremely high frequency of violations, which did not disappear to a large extent even after considering transaction costs.

From the above discussion on the literature, it can be summarized that literature in the area of PCP is divided whether PCP holds or not. Also, most of these studies were largely concentrated in the US markets in the early years. This could be because the US derivatives market preceded others in terms of development. In the recent years, there have been studies around the world, but still in Indian markets, they are scarce especially in stock options. A study of PCP in stock options will shed light on the pricing efficiency, which can further lead to hedging effectiveness.

3. THEORETICAL BACKGROUND

Put Call Parity defines the parity that must exist between European call options and European put options, which have the same expiration and strike price and the underlying. This implies that the price of the call options can be determined from the price of the put options and vice-versa.

The Put-Call Parity for European Options can be explained as follows:

If there are two portfolios,

- Portfolio A: European call on the underlying+ Present Value (PV) of the strike price in cash
- Portfolio B: European put on the Index + the underlying

Both are worth max (S_T, K) at the maturity of the options

They must therefore be worth the same today. This means that

$$c + Ke^{-rT} = p + S_0 \qquad \text{Equation 1.1}$$

Where,

c = call option price

Ke^{-rT} = Present value of Strike Price K, continuously compounded at the risk free interest rate, r, for the time period T

p = put option price

S_0=Spot price of the underlying

If the above relationship is violated, there is a possibility of arbitrage. A careful arbitrager can buy the underpriced portfolio and sell the overpriced portfolio thereby making riskless profits.

In equation 1.1, adjustment for dividends needs to be made. Dividends cause stock prices to reduce on the ex-dividend date by the amount of dividend payment (Hull and Basu, 2010). To make such an adjustment, the approach is to treat the payment of dividends as discrete, i.e. payments made at discrete time. The dividend is counted as being during the life of the option only if its ex-dividend date occurs during the life of the option (Hull and Basu, 2010). It can be expressed as (Chance and Brooks, 2008):

$S_0 *= S_0 - (De^{-rT})$

Where, $S_0 *$ is the adjusted spot price after incorporating dividends

S_0 is the spot price before adjustment of dividends

D is the dividend per share

T is the time to expiry in years on/after the ex-dividend date

$S_0 *$ is used in Equation 1.1 to arrive at PCP relationship.

4. DATA AND METHODOLOGY

The primary objective of the study is to assess the PCP relationship in stock options. The sample period is January 2011 to December 2012. The criteria for selection of stock sample and its procedure are laid down as follows:

(a) The stock options should have sufficient liquidity. If options contract lack sufficient trading, it is prone to mispricing due to lack of demand and supply. Therefore only those stock options, which were highly liquid, were to be chosen in the sample. From the website of NSE (*www.nseindia.com*), the top 10 most liquid futures and options were downloaded for every month

of the sample period. Further check was made regarding sufficient liquidity for these companies. If the daily average number of contracts was less than 500, for any company, in either of the two years studied, it was removed from the sample.

(b) In an efficient options market, predictable increases stock return volatility should be incorporated into the option price at the split announcement date for options expiring after the split ex-date (Deng and Julio, 2005). Thus, each of the companies was checked for stock splits, for the sample period and at 30 days preceding the beginning of sample period. Companies where the stock was split were removed from the sample. Additionally, the companies' where rights/bonus issues were declared were also removed from the sample, since they may affect option pricing.

(c) The stock option should have been continuously traded throughout the sample period; i.e. the stock option shouldn't have been banned or withdrawn for any trading day by the regulatory body or the NSE.

After applying the above- mentioned methodology the total number of companies left in the sample are 16, and observations for the study are 43,841.

The present study is based on secondary sources of data. All data like strike price, the transaction date, expiry date and number of contracts traded, option price, underlying price, dividend yield and 30-day MIBOR (as a proxy to risk-free interest rate) have been obtained from the official website of NSE, *www.nseindia.com.* Only near-term expiry options contracts have been taken up for the study.

In most empirical studies, error estimates are used to evaluate the performance of the competing models for forecasting. The following notations are used:

Y_{mod} = The theoretical price of the option as determined by PCP

Y_{obs} = Observed market price of the option

N = Number of observations

(a) Mean Error (ME)

$$ME = \frac{1}{N}\sum_{t=1}^{n}\left(Y_{obs} - Y_{\text{mod}}\right)$$

(b) Mean Absolute Error

$$MAE = \frac{1}{N}\sum_{t=1}^{n}\left|\, Y_{obs} - Y_{\text{mod}} \,\right|$$

(c) Root Mean Squared Error

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{n}\left(Y_{obs} - Y_{\text{mod}}\right)^2}$$

(d) Percentage Mean Error (PME)

$$PME = \frac{1}{N}\sum_{t=1}^{n}\left[\frac{(Y_{obs} - Y_{\text{mod}})}{Y_{\text{mod}}}\right]$$

(e) Mean Absolute Percentage Error (MAPE)

$$MAPE = \frac{1}{N}\sum_{t=1}^{n}\left|\frac{(Y_{obs} - Y_{\text{mod}})}{Y_{\text{mod}}}\right|$$

(f) Theil's U Statistic

$$Theil's\ U = \frac{\frac{1}{N}\Sigma_{t=1}^{n}(Y_{obs} - Y_{\text{mod}})^2}{\sqrt{\left[\frac{1}{N}\Sigma_{t=1}^{n}(Y_{obs})^2\right]} + \sqrt{\left[\frac{1}{N}\Sigma_{t=1}^{n}(Y_{\text{mod}})^2\right]}}$$

The PME, MAPE and Theil's U Statistic are scale-independent measures.

Financial time series data are known to be non-normal. The Jarque-Bera (JB) Test is used to check the assumption of normality of data. Table 2 demonstrates that the Mean Error series does not follow the normal distribution for any of the year/ sub-period of the study. Therefore, non-parametric tests are applied for further analysis.

Table 2
Descriptive Statistics and Jarque-Bera Test for Mean Error for Stock options using PCP

	No. of observations	*Mean*	*Standard deviation*	*Skewness*	*Kurtosis*	*JB (Observed value)*
Axis Bank	3159	-3.32	10.96	1.26	31.58	132101.36*
Bharti Airtel	1795	-0.15	2.03	-1.01	24.31	44504.60*
DLF	2670	-0.74	2.22	-1.53	23.75	63795.74*
HDIL	2398	-0.07	1.25	-1.38	49.86	249129.60*
Hindalco	2096	0.10	1.41	-0.41	18.58	30224.35*
ICICI Bank	3533	-1.00	7.22	-0.64	7.08	7612.71*
Infosys	3441	-4.20	17.12	0.32	47.73	326729.09*
Jaypee	2276	-0.10	0.95	-0.78	38.27	139086.14*
LT	2902	-0.97	11.73	-0.89	19.04	44222.41*
Rcom	2444	0.02	0.86	-0.69	30.63	95734.82*
RelCap	2376	0.34	5.34	2.44	26.10	69784.59*
Reliance	3649	0.27	5.43	0.92	21.70	72101.15*
SBI	4452	-3.89	19.38	-1.92	43.12	347675.17*
Tata Steel	2672	-1.05	5.21	-1.06	16.71	31572.16*
TCS	2152	-0.82	7.04	-0.22	6.47	3771.15*
Unitech	1826	-0.02	0.50	-6.18	125.68	1213411.1*

*Denotes significant at 5%

In the present study, Wilcoxon Signed Rank Test is used to study whether there is any significant difference between the market price of options and the theoretical price as calculated by PCP.

5. FINDINGS AND ANALYSIS

It can be observed from the Table 3 that the Put-Call Parity is violated for the sampled stock options, although the quantum remains low. The Mean Error (ME) is negative for most of the stock options indicating that the call options are underpriced. For precisely 50% of the stock options the magnitude of violation improved from 2011 to 2012 looking at ME. These observations are in line with the previous studies like Vipul (2008) and Dixit *et al* (2012).

Table 3
Error Estimates using Put-Call Parity for Stock Options

	Years	*Mean Mkt Price*	*Mean Call Price*	*ME*	*MAE*	*PME*	*MAPE*	*RMSE*	*Theil's U*
Axis Bank	2011	39.3239	41.7768	-2.4529	6.6808	0.0010	1.9429	9.1618	0.0827
	2012	54.5113	58.3150	-3.8037	7.9400	0.2819	1.0566	12.5415	0.0837
	All	**49.0931**	**52.4149**	**-3.3218**	**7.4907**	**0.1817**	**1.3728**	**11.4508**	**0.0834**
Bharti Airtel	2011	14.9464	15.4071	-0.4607	1.4636	-0.0045	1.0525	2.2115	0.0536
	2012	11.7780	11.6882	0.0898	1.1273	0.3066	1.8337	1.8892	0.0540
	All	**13.1389**	**13.2856**	**-0.1467**	**1.2717**	**0.1730**	**1.4981**	**2.0339**	**0.0538**
DLF	2011	12.2986	13.4997	-1.2011	1.9200	-0.0322	1.8963	2.8101	0.0774
	2012	11.8359	12.0904	-0.2546	1.0882	0.2734	1.0931	1.7171	0.0508
	All	**12.0719**	**12.8093**	**-0.7374**	**1.5125**	**0.1175**	**1.5028**	**2.3394**	**0.0666**
HDIL	2011	7.3201	7.3535	-0.0334	0.9847	0.4867	2.0003	1.6768	0.0774
	2012	6.8079	6.5667	0.2412	0.6289	0.9872	1.9405	1.0540	0.0519
	All	**7.0721**	**6.9725**	**0.0996**	**0.8124**	**0.7291**	**1.9714**	**1.4100**	**0.0671**
Hindalco	2011	32.0926	32.3344	-0.2418	4.7045	0.4241	1.7238	7.4041	0.0820
	2012	41.9837	43.6172	-1.6335	4.6346	0.2222	1.6426	7.1946	0.0618
	All	**37.4791**	**38.4788**	**-0.9997**	**4.6664**	**0.3142**	**1.6796**	**7.2907**	**0.0692**
ICICIBank	2011	32.0926	32.3344	-0.2418	4.7045	0.4241	1.7238	7.4041	0.0820
	2012	41.9837	43.6172	-1.6335	4.6346	0.2222	1.6426	7.1946	0.0618
	All	**37.4791**	**38.4788**	**-0.9997**	**4.6664**	**0.3142**	**1.6796**	**7.2907**	**0.0692**
Infosys	2011	79.2884	84.2182	-4.9298	11.4164	0.0389	2.5865	19.2829	0.0833
	2012	72.7239	76.3085	-3.5846	10.7871	0.9972	3.4703	16.1024	0.0755
	All	**75.7305**	**79.9312**	**-4.2007**	**11.0754**	**0.5583**	**3.0655**	**17.6304**	**0.0795**
Jaypee	2011	3.9554	3.9702	-0.0148	0.5154	0.4007	2.1686	1.0949	0.0935
	2012	5.3685	5.5527	-0.1842	0.5110	0.2280	0.9442	0.8089	0.0526
	All	**4.6986**	**4.8025**	**-0.1039**	**0.5131**	**0.3099**	**1.5247**	**0.9552**	**0.0694**
LT	2011	49.4317	51.1564	-1.7247	7.9584	1.7421	4.3656	13.6167	0.0940
	2012	77.4095	77.8079	-0.3984	6.4184	1.2197	1.6649	10.1379	0.0475
	All	**65.2813**	**66.2546**	**-0.9733**	**7.0860**	**1.4461**	**2.8356**	**11.7729**	**0.0630**

contd. table 3

	Years	*Mean Mkt Price*	*Mean Call Price*	*ME*	*MAE*	*PME*	*MAPE*	*RMSE*	*Theil's U*
RCom	2011	5.5530	5.5643	-0.0114	0.5294	0.1358	1.1230	0.9361	0.0578
	2012	4.4771	4.4254	0.0517	0.3949	0.2045	1.4053	0.7868	0.0603
	All	**5.0032**	**4.9823**	**0.0209**	**0.4607**	**0.1709**	**1.2673**	**0.8630**	**0.0589**
RelCap	2011	24.4200	24.2218	0.1982	3.5105	0.6364	2.5275	6.3415	0.0901
	2012	26.8994	26.4358	0.4636	2.6139	0.9846	1.4433	4.2390	0.0582
	All	**25.7140**	**25.3773**	**0.3367**	**3.0426**	**0.8181**	**1.9617**	**5.3483**	**0.0746**
Reliance	2011	25.9616	25.2506	0.7109	3.6970	1.6508	3.3012	6.3296	0.0826
	2012	27.0375	27.3142	-0.2767	2.7388	-0.7040	2.1192	4.0442	0.0518
	All	**26.4387**	**26.1657**	**0.2730**	**3.2721**	**0.6066**	**2.7771**	**5.4361**	**0.0703**
SBI	2011	71.9943	75.2940	-3.2997	11.7640	2.7413	5.7487	20.5765	0.0937
	2012	108.5234	112.9437	-4.4203	12.0407	1.1008	3.5491	19.0230	0.0591
	All	**91.3830**	**95.2775**	**-3.8945**	**11.9109**	**1.8706**	**4.5812**	**19.7672**	**0.0709**
TataSteel	2011	17.8019	18.9618	-1.1599	3.7439	-0.1487	3.1194	5.9262	0.1083
	2012	21.0360	21.9833	-0.9473	2.6666	0.9413	2.7471	4.6369	0.0723
	All	**19.4443**	**20.4963**	**-1.0519**	**3.1968**	**0.4049**	**2.9303**	**5.3106**	**0.0890**
TCS	2011	40.4528	42.2358	-1.7831	4.7496	-0.4713	1.4196	6.8174	0.0616
	2012	46.1630	45.8898	0.2732	4.9802	0.5435	1.1870	7.3885	0.0582
	All	**43.1275**	**43.9474**	**-0.8199**	**4.8576**	**0.0041**	**1.3107**	**7.0906**	**0.0598**
Unitech	2011	2.3104	2.3441	-0.0337	0.2633	0.0754	1.0936	0.5821	0.0823
	2012	2.2001	2.1955	0.0045	0.1692	0.0827	0.3630	0.3690	0.0605
	All	**2.2610**	**2.2776**	**-0.0166**	**0.2212**	**0.0787**	**0.7667**	**0.4981**	**0.0748**

StdDev: Standard Deviation, ME: Mean Error, PME: Percentage Mean Error, MAE: Mean Absolute Error, MAPE: Mean Absolute Percentage Error, RMSE: Root Mean Square Error

Theil's U Statistic: The *U* statistic is bounded between 0 and 1, with values closer to 0 indicating greater forecasting accuracy

The Mean Absolute Error (MAE) also indicates violations of PCP. The magnitude of the violation is on the higher side for the stocks Infosys, LT and SBI. This may result in riskless arbitrage opportunities. For all the other stock options, the violations would be unexploitable in the presence of transaction costs and bid-ask spread.

The scaled measures of Mean Absolute Percentage Error (MAPE) present a totally different picture. The violation of PCP is very high looking at these error estimates. The explanation of this may lie in the fact that MAPE generates very high values when the denominator (Observed Market Price of the call options) is very low. This leads to higher variability and therefore higher values.

Theil's U statistic describes good accuracy of forecasts using PCP. Since Theils' U value is closer to zero in most of the cases, the pricing efficiency is high.

Therefore it may be concluded that although the PCP is violated for the stock options yet the arbitrage opportunities are minimum leading to higher efficiency in the market as denoted by Theil's U statistic.

To validate these results statistically, firstly normality tests are conducted along with analyses of descriptive statistics. The results are presented in Table 2.

The Mean Error series exhibit leptokurtic properties. This indicates non-normality of the data. This is confirmed with high JB statistic, which is significant at 5% level. Therefore, non-parametric tests are used to validate our findings stated above statistically. The results of Wilcoxon-Signed rank tests are presented in Table 4 below:

Table 4
Wilcoxon Signed Rank Tests for differences between Market Price and Put-Call Parity Price for Stock options for the Period 2011-2012

		N	*Mean Rank*	*Z*[a]	*Asymp. Sig. (2-tailed)*
Axis Bank	Negative Ranks	2030	1712.10	-19.115[b]	0
	Positive Ranks	1129	1342.49		
	Total	3159			
Bharti Airtel	Negative Ranks	956	921.07	-3.396[b]	0.001
	Positive Ranks	839	871.71		
	Total	1795			
DLF	Negative Ranks	1727	1475.36	-19.204[b]	0
	Positive Ranks	943	1079.36		
	Total	2670			
HDIL	Negative Ranks	1264	1243.45	-3.938[b]	0
	Positive Ranks	1134	1150.51		
	Total	2398			
Hindalco	Negative Ranks	926	1048.37	-4.621[c]	0
	Positive Ranks	1170	1048.61		
	Total	2096			
ICICI Bank	Negative Ranks	1831	1920.57	-6.517[b]	0
	Positive Ranks	1702	1601.79		
	Total	3533			
Infosys	Negative Ranks	2042	1895.42	-15.605[b]	0
	Positive Ranks	1399	1466.42		
	Total	3441			
Jaypee	Negative Ranks	1185	1218.70	-4.738[b]	0
	Positive Ranks	1091	1051.39		
	Total	2276			
LT	Negative Ranks	1535	1517.99	-4.962[b]	0
	Positive Ranks	1367	1376.84		
	Total	2902			

contd. table 4

		N	*Mean Rank*	*Z*[a]	*Asymp. Sig. (2-tailed)*
RCom	Negative Ranks	1123	1216.64	-3.657[c]	0
	Positive Ranks	1321	1227.48		
	Total	2444			
RelCap	Negative Ranks	1135	1185.16	-1.997[b]	0.046
	Positive Ranks	1241	1191.56		
	Total	2376			
Reliance	Negative Ranks	1653	1877.11	-3.564[b]	0
	Positive Ranks	1996	1781.85		
	Total	3649			
SBI	Negative Ranks	2719	2420.56	-18.951[b]	0
	Positive Ranks	1733	1922.03		
	Total	4452			
TCS	Negative Ranks	1708	1445.57	-17.137[b]	0
	Positive Ranks	964	1143.26		
	Total	2672			
Tata Steel	Negative Ranks	1212	1108.92	-6.441[c]	0
	Positive Ranks	940	1034.70		
	Total	2152			
Unitech	Negative Ranks	923	915.70	-.495[b]	0.62
	Positive Ranks	903	911.25		
	Total	1826			

Negative Ranks: When Market Price < PCP Price
Positive Ranks: When Market Price > PCP Price
a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

It can be observed from the above that the differences between the observed price and the theoretical price as estimated with the Put-Call Parity is significant for all stock options except for Unitech, for the period 2011-2012 at 5% alpha level.

CONCLUSIONS AND SCOPE FOR FUTURE RESEARCH

This paper is an attempt to assess the pricing efficiency of selected Stock Options using the put-call parity relationship. The study has been taken up for a 2-year period from 2011 to 2012, when stock options were introduced, for 16 stock options, using a number of measures, to establish the robustness of the pricing mechanism.

The Mean Error (ME) is found to be negative for most of the stock options, indicating thereby that the call options are underpriced. Statistically significant differences are found to exist between the observed

prices and PCP prices. The magnitude of the violation is on the higher side for the stocks Infosys, LT and SBI.

While instances of mispricing are found, Theil's U statistic indicates good accuracy of forecasts using PCP since the value is closer to zero than one in most of the stock options. This indicates that the magnitude of mispricing on average remains low, and may be accounted for if market imperfections like transaction costs are taken into consideration.

The study suffers from the limitations that transactions costs are not taken into account. The results therefore, need to be interpreted with caution. Also, the study period is small owing to the newness of the instrument. A longer time horizon may shed different light on the PCP relationship. The closing prices are taken for call and put options which may lead to errors due to non-synchronism of data.

The implications of the study are manifold. The Indian derivatives markets exhibit encouraging prospects. The growth in the volumes can be deemed as an enhancement in investor interest, and can instigate further participation in the segment. The quantum of mispricing remains low. This indicates that hedging can be carried out more effectively, with market efficiency evidenced by the study.

The present study can be extended in many possible ways. Most importantly, the affect of variables like Moneyness, Time to Expiry and Liquidity on mispricing can be studied. Similar research can be taken up, with other class of options. A comparative study can be made using different approaches of assessing pricing efficiency like, Black-Scholes Model, Box-Spreads, Butterfly Spreads etc. The causal effect between variables & violations of PCP can be examined.

REFERENCES

Ackert, L. F., & Tian, Y. S. (1999), Efficiency in Index Options Markets and Trading in Stock Baskets. *Federal Reserve Bank of Atlanta Working Paper 99-5* .

Ahn, C. Y., Byoun, S., & Park, H. Y. (2003, December), Put-Call Parity: The Case of KOSPI 200 Options in Korea. *Working Paper*, Retrieved April 21, 2013, from http://business.baylor.edu/Soku_Byoun/wp/kospi_jfm.pdf

Berg, E., Brevik, T., & Saettem, F. (1996), An Examination of the Oslo Stock Exchange Options Market. *Applied Financial Economics*, *6* (2), 103-113.

Blancard, G. C., & Chaudhury, M. (2001), Efficiency tests of the French Index (CAC 40) Options Market. *McGill Finance Research Centre Working Paper*.

Cassese, G., & Guidolin, M. (2004), Pricing and Informational Efficiency of the MIB30 Index Options Market. An Analysis with High-frequency Data. *Economic notes by Banca Monte dei Paschi di Siena Spa,*, 275-321.

Chance, D. M., & Brooks, R. (2008), *Derivatives and Risk Management* (1st ed.). Ceneage Learning India Pvt Ltd.

Cremers, M., & Weinbaum, D. (2008), Deviations from Put-Call Parity and Stock Return Predictability.

Deng, Q., & Julio, B. (2005, September), The Informational Content of Implied Volatility Around Stock Splits. *Available at SSRN 831144*.

Dixit, A., Yadav, S. S., & Jain, P. K. (2012), A test of Put-Call Parity Relationship on S&P CNX Nifty Index Options Market. In A. Dixit, S. S. Yadav, & P. K. Jain, *Derivative Markets in India: Trading, Pricing, and Risk Management* (pp. 63-96). Tata McGraw Hill.

Draper, P., & Fung, J. K. (2002), A Study of Arbitrage Efficiency Between the FTSE 100 Index Futures and Options Contracts. *Journal of Futures Markets*, *22* (1), 31-58.

Evnine, J., & Rudd, A. (1985), Index Options: the Early Evidence. *Journal of Finance*, *40* (3), 743-756.

Fung, J. K., Cheng, L. T., & Chan, K. C. (1997), The Intraday Pricing Efficiency of Hong Kong Hang Seng Index Options and Futures Markets. *Journal of Futures Market*, *17* (7), 797-815.

Grundy, B. D., Lim, B., & Verwijmeren, P. (2012), Do Option Markets Undo Restrictions on Short Sales? Evidence from the 2008 Short-Sale Ban. *Journal of Financial Economics, 106* (2), 331-348.

Gupta, R., & Jithendranathan, T. (2010), Short-sales Restrictions and Efficiency of Emerging Option Market: A Study of Indian Stock Index Options. *International Research Journal of Finance and Economics* (46), 99-109.

Hoque, A., Manzur, M., & Poitras, G. (2010), Put-call parity, transactions costs and PHLX currency options: intra-daily tests. *In Proceedings of the 59th Midwest Finance Association Annual Conference (MFA 2010),* 1-25.

Hull, J. C., & Basu, S. (2010), *Options, Futures and Other Derivatives.* Pearson Education, Inc.

Klemkosky, R. C., & Resnik, B. G. (1979), Put Call Parity and Market Effieciency. *Journal of Finance*, *34* (5), 1141-1155.

Lee, J. H., & Nayar, N. (1993), A Transactions Data Analysis of Arbitrage Between Index Options and Index Futures. *The Journal of Futures Markets*, *13* (8), 889-902.

Li, S. (2006, November), The Arbitrage Efficiency of the Nikkei 225 Options Market: A Put Call Parity Analysis. *Institute for Monetary and Economic Studies*. Bank of Japan.

Loudon, G. F. (1988), Put Call Parity: The Evidence from the Big Australian. *Australian Journal of Management*, *13* (1), 53-67.

Merton, R. C. (1973), The Relationship Between Put and Call Option Prices: Comment. *Journal of Finance*, *28* (1), 183-184.

Misra, D., & Misra, S. (2005, February 15-16), Determinants of Violation of Put-Call Parity Theorem: A Study of NSE Nifty Options. *Written for and presented at 7th GCA* . Retrieved on March 7, 2011 from http://www.actuariesindia.org/downloads/gcadata/7thGCA/DVPCPT_Dheeraj%20&%20Sangeeta%20Misra.PDF

Mittnik, S., & Reiken, S. (2000), Put-call parity and the Informational Efficiency of the German DAX-Index Options Market. *International Review of Financial Analysis*, *9* (3), 259-279.

Nilsson, R. (2003, June 23), The Effects of Short Sale Constraints on Derivative Prices. Retrieved on December 20, 2012 from https://secure.northernfinance.org/nfa2003/papiers/Roland%20Nilsson.pdf

Nishiotis, G. P., & Rompolis, L. S. (2011), Put-call Parity Violations and Return Predictability: Evidence from the 2008 Short Sale Ban. *Available at SSRN.com* .

www.nseindia.com. (n.d.). Retrieved January 15, 2013, from http://www.nseindia.com/products/content/derivatives/equities/historical_fo.htm

Ofek, E., Richardson, M., & Whitelaw, R. F. (2004), Limited Arbitrage and Short Sales Restrictions: Evidence from the Options Markets. Journal of Financial Economics, 74.

Shah, A. (2003), *Market Efficiency on the Indian Equity Derivatives Market.* Retrieved September 11, 2011, from http://www.researchgate.net/publication/228799429_Market_efficiency_on_the_Indian_equity_derivatives_market/file/3deec5208d54631b0c.pdf

Stoll, H. R. (1969), The Relationship Between Put and Call Option Prices. *Journal of FInance*, *XXIV* (5), 802-824.

Vipul. (2008), Cross-market efficiency in the Indian derivatives market: A test of put-call parity. *The Journal of Futures Markets, 28* (9), 889-910.

Wagner, D., Ellis, D. M., & Dubofsky, D. A. (1996), The Factors Behind Put Call Parity Violations of S&P 100 Index Options. *The Financial Review*, *31* (3), 535-552.