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ASSESSMENT OF ARBITRAGE OPPORTUNITIES IN OPTIONS MARKETS USING PUT-CALL FUTURES PARITY: EVIDENCE FROM INDIA

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Put-Call Future Parity, Market Efficiency, European Options, NSE India, S&P CNX Nifty, Bid-Ask Quotes.

Abstract

This paper aims at assessing the arbitrage opportunities in the Indian options market by using the best bid-ask quotes of European options premiums and futures prices in put-call parity theorem, covering the time period from July, 2015 to October, 2015.The opportunities are assessed for 61970 Put- Cheaper portfolios and 68225 Call-Cheaper portfolios. The underlying asset chosen for the current study is NSE Nifty index. The empirical results of the study show that in the absence of transaction costs, the put-call parity is violated in few cases and the frequency of arbitrage profits is higher in case of call-cheaper portfolios and the intensity of arbitrage profits is higher in case of put-cheaper portfolios. However after the incorporation of transaction costs, the arbitrage opportunities in the Indian options market are negligible and thus the results suggest that Indian options market are efficient to a great extent.

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1. Introduction

Put-call parity relationship using spot price of the underlying asset and European call and put options, which was originally developed by Stoll (1969, 1973) and later on extended and modified by Merton (1973) and Gould and Galai (1974), is generally used to test the efficiency of any options market. However, if the underlying asset is not traded in the spot market and/or there are short selling restrictions in the spot market of the underlying asset, an arbitrageur may not be able to exploit arbitrage opportunities even if it exists. If the underlying asset is not traded in the spot market and/or there are short selling restrictions in the spot market of the underlying asset, one can use the futures price instead of the spot price of the underlying asset in put-call parity theorem to assess arbitrage opportunities. Generally, we observe that if in any market options are traded on some underlying asset, the futures are also traded on the same underlying asset. The main objective of this paper is to assess the existence of arbitrage opportunities in the Indian options market using futures price and European options in put-call futures paritytheorem(PCFP). The underlying asset chosen for the current study is NSE Nifty index of National Stock Exchange of India (NSE).

Put-call parity theorem using futures price of the underlying asset can be derived by using the following two portfolios. Portfolio A comprises of buying one European put option on the underlying asset with an exercise price K and time to maturity T and buying one futures (the current futures price is F_0) on the same underlying asset with time to maturity T. Portfolio B comprises of buying one call option with an exercise price K and time to maturity T and lending [borrowing] $(K - F_0)e^{-rT}[(F_0 - K)e^{-rT}]$ in [from] risk-free market if $K > F_0[K < F_0]$ for the time period T.

Payoff of Portfolio A = Payoff of Portfolio B = $Ma(K - F_0, S_T - F_0)$

In case of no transaction costs, if the two portfolios have the same payoff, they must have the same cost to establish. Thus, the put-call parity relationship (assuming no transaction costs) using futures price of the underlying asset may be written as:

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

Whenever, there is a violation of put-call parity theorem and there are no transaction costs, one can earn risk-less arbitrage profit by buying relatively cheaper portfolio and selling relatively costlier portfolio. Thus, one will earn arbitrage profit if the absolute value of cash flow of the costlier portfolio is more than the absolute value of the cheaper portfolio at the time of constructing these portfolios. Thus, if portfolio A is relatively cheaper than portfolio B, one can earn riskless arbitrage profit by buying portfolio A and selling portfolio B.

If by using futures price, one observes that portfolio involving put and futures is cheaper than the portfolio involving call and risk-free asset, the risk-less arbitrage profit (assuming no transaction costs) will exist only if

$$P_0^A + F_0^A e^{-rT} < C_0^B + Ke^{-rT}$$

Where,

P_0^A: Put premium at time 0 at which one can buy a European put option on the underlying asset with an exercise price K and time to maturity T.

F_0^A: Futures price of the underlying asset at time 0 at which one can buy a futures on the underlying asset with time to maturity T.

C_0^B: Call premium at time 0 at which one can sell a European call option on the underlying asset with an exercise price K and time to maturity T.

r: Risk-free rate of interest with continuous compounding at which an arbitrageur can borrow from or lend in the risk-free market for the time to maturity T.

Similarly if by using futures price of the underlying asset, one observes that portfolio involving put and futures is costlier than portfolio involving call and risk-free asset, he or she can earn risk-less arbitrage profit (assuming no transaction costs) only if

$$P_0^B + F_0^B e^{-rT} > C_0^A + Ke^{-rT}$$

Where,

P_0^B: Put premium at time 0 at which one can sell a European put option on the underlying asset with an exercise price K and time to maturity T.

F_0^B: Futures price of the underlying asset at time 0 at which one can sell a futures on the underlying asset with time to maturity T.

C_0^A: Call premium at time 0 at which one can buys a European call option on the underlying asset with an exercise price K and time to maturity T.

There are many studies which have investigated the arbitrage opportunities using put-call parity theorem. Ofek, Richardson and Whitelaw (2004), Manohar (2013), Cremers and Weinbaum(2010), Envine and Rudd (1985), Finucane (1991), Blomeyer and Boyd (1995), Bharadwaj and Wiggin (2001), Ackert and Tian (2001), Kamara and Miller (1995), Klemkosky and Resnick (1979) and Lee and Nayar (1993) investigated the arbitrage opportunities using put-call parity theorem for the US market. Alpert (2009), Taylor (1990) and Brown and Easton (1992) used put- call parity relationship to assess arbitrage opportunities for the Australian market. The other studies which have used the put-call parity theorem to investigate arbitrage opportunities are Draper and Fung (2002) for the UK market, Mittnik and Rieken (2000) for the German market, Crapelle-Blancard and Chaudhury (2001) and Deville and Riva (2007) for the French market, Cassesse and Guidolin (2004) for the Italian market, Chesney, Gibson and Louberge (1995) for the Swiss market, Ackert and Tian (1998) for the Canadian market, Nissim and Tchahi (2011) for Israel market, Vipul (2008) for the Indian market, Zhang and Lai (2006), Fung and Mok(2001), Fung, Cheng and Chan (1997), Fung and Fung (1997) and Lung and Marshall (2002) for the Hong Kongmarket.

The frequency and intensity of arbitrage profits are more when the spot price of the underlying asset is used in put-call parity theorem to investigate the existence of the arbitrage opportunities in the options markets [Nissim and Tchahi (2011); Ofek, Richardson and Whitelaw (2004); Cassesse and Guidolin (2004); Crapelle-Blancard and Chaudhury (2001); Ackert and Tian (1998); Kamara and Miller (1995); Chesney, Gibson and Louberge (1995); Brown and Easton (1992); Finucane (1991); Envine and Rudd (1985)]. These violations of put-call parity theorem may be on account of assessing of arbitrage opportunities using American options, short selling restriction in the spot market of the underlying assets, usage of traded prices (instead of bid-ask quotes) to assess arbitrage opportunities in the options markets, and the portfolio comprising of put and the underlying asset being costlier than the portfolio comprising of call and risk-freeasset (which requires short position in the underlying asset but there may be short selling restrictions in the spot market of the underlying asset). Kamara and Miller (1995) assessed arbitrage opportunities for American market using European options in put-call parity theorem and reported that frequency and intensity of arbitrage profits are much smaller than using American options.

When futures price of the underlying asset is used in put-call parity theorem to assess arbitrage opportunities, the frequency and magnitude of arbitrage profits are much smaller than when the spot price of the underlying asset is used in used in put-call parity theorem. This may because there are no short selling restrictions in the futures market. Garay, Ordonej and Gonzalez (2003); Lung and Marshall (2002); Draper and Fung (2002); Fung and Mok (2001); Fung and Fung (1997); Fung, Cheng and Chan (1997); and Lee and Nayar (1993) used futures price of the underlying asset to assess arbitrage opportunities in options markets and did not report significant arbitrage opportunities in their studies. However, Vipul (2008) and Bharadwaj and Wiggins (2001) showed significant violations of put-call parity theorem for the Indian and the American markets respectively while using futures price of the underlying asset in put-call parity theorem.

The empirical results of these studies on the existence of arbitrage opportunities in the options market are mixed. The results of some of these studies show that arbitrage opportunities exist in the options markets. However, the results of many of these studies show that after taking into account the transaction costs arbitrage opportunities are negligible in the options markets.

In the context of developed countries like US there are sufficient studies which have assessed the efficiency of options market by using put-call parity theorem. However, in the context of emerging economies like India there are not sufficient studies which have investigated the efficiency of options market. Vipul (2008); Vipul (2009); Girish and Rastogi (2013) showed that there are quite frequent arbitrage opportunities in the Indian Option Market. With the existence of around 18 years of the Indian Derivative Market, we believe that investigating the market efficiency of Indian option market is very important. The other motivation to write this paper is that the existing studies showing frequent arbitrage opportunities in Indian option market are based on the traded data (high frequency) and thus have methodologicalissues.

A study (Vipul, 2008) which has been conducted to assess the arbitrage opportunities in the Indian context, using put-call parity theorem, has the problem of data structure and methodology. Vipul (2008) used high frequency traded prices to assess arbitrage opportunities in the Indian options market. However, the current study has used bid-ask quotes of futures and options to assess arbitrage opportunities in the Indian options market using Put-Call Futures Parity. These bid-ask quotes of each element of the two portfolios were prevailing at the same moment oftime. An arbitrageur should always use bid-ask quotes (rather than traded prices) to judge whether there exists arbitrage opportunities or not.The traded prices may be ex-ante bid price or ex-ante ask price. Many times, the traded prices may indicate the existence of arbitrage opportunities but actually there may not be any arbitrage opportunities according to bid-ask quotes. For example, if in the put-call parity relationship the portfolio involving call and risk-free asset is cheaper than the portfolio involving put and futures, then to assess arbitrage opportunities one should use the best sell price of call, the best buy price of futures, and the best buy price of put, however if one uses traded price of price of call (which was not ex-ante best sell price quote but it wasex-antebest buy price quote), it may show arbitrage profit using the best buy price as traded price, but under this situation, an arbitrageur may actually incur losses as he or she has not bought the call option but has sold the call option. Thus, the traded prices may not be the indicator of the existence of arbitrage opportunities especially if the bid-ask spread is too high and/or if one uses the traded prices of different elements of portfolio (call, put and underlying asset) of different time period.

This study has an important contributions to make in the sense that this study suggests better data structure and methodology to judge the efficiency of options markets in general and of the Indian option market in particular.

This paper is further divided into three sections. Section 2 describes the data structure and methodology of the study. Section 3 describes the empirical results and section 4 deals with the concluding remarks.

2. Data Structure andMethodology

This section will describe about the data structure and methodology that have been used in the current study to assess the arbitrage opportunities in the Indian options market. One can exploit the existence of risk-less arbitrage opportunities only if all the elements of portfolios A and B (as described in the last section) are bought (sold) and sold (bought) at the same time. To analyze whether arbitrage opportunities existed in the past or not, one should not use the past traded prices of different elements of the portfolios but he or she should use the past bid-ask quotes of the these elements of the portfolios. The bid-ask quotes of different elements of the portfolios of the put-call parity theorem should be exactly of the same time.

If the portfolio involving put and futures (Portfolio A) is cheaper than the portfolio involving call and risk-free asset (portfolio B), the arbitrage profit before transaction costs is computed using the following expression.

$$BTC^{PC} = C_0^B + Ke^{-rT} - P_0^A - F_0^A e^{-rT}$$

Where,

BTC^{PC} : Arbitrage profit before transaction costs in case of put-cheaper portfolio.

If $BTC^{PC} > 0$, it means that an arbitrageur can earn risk-less arbitrage profit (in the absence of transaction costs) by buying the portfolio involving put and futures and selling the portfolio involving call and risk-free asset. However, if $BTC^{PC} \leq 0$, it means that risk-less arbitrage profit does not exist by buying portfolio A and selling portfolio B. Only those cases have been considered to assess arbitrage opportunities after the transaction costs where ever risk-less positive arbitrage profit exists ($BTC^{PC} > 0$).

Similarly, if the portfolio involving call and risk-free asset (Portfolio B) is cheaper than the portfolio involving put and futures (portfolio A), the arbitrage profit before the transactioncosts is computed using the followingexpression.

$$BTC^{CC} = P_0^B + F_0^B e^{-rT} - C_0^B - Ke^{-rT}$$

Where,

BTC^{CC} : Arbitrage profit before transaction costs in case of call-cheaper portfolio.

If $BTC^{CC} > 0$, it means that an arbitrageur can earn risk-less arbitrage profit (in the absence of transaction costs) by buying the portfolio involving call and risk-free asset and selling the portfolio involving put and futures. However, if $BTC^{CC} \leq 0$, it means that risk-less arbitrage profit does not exist by buying portfolio B and selling portfolio A. Only those cases have been considered to assess arbitrage opportunities after the transaction costs where ever risk-less positive arbitrage profit exists ($BTC^{CC} > 0$).

To exploit the arbitrage opportunities in the Indian market, an arbitrageur is required to incur the transaction costs on buying and/or selling the different elements of the portfolios of put-call parity theorem. An investor who trades in futures and options segment of the Indian stock exchanges is required to incur the transaction costs. The transaction costs details of different element of portfolio are given below.

Put-Cheaper:

- Average brokerage of 0.05% of the purchase price of futures at the time of constructing theportfolio.

- Average brokerage of Rs. 1.60 for every put optionpurchased.
- Average brokerage of Rs. 1.60 for every call optionwritten.
- Average brokerage of 0.05% of the settlement futures price at the time of settlementof futurescontract.
- Service tax @14% on the total value ofbrokerage.
- Security transaction tax @0.01% of the settlement futures price at the time ofsettlement of the futurescontract.
- Security transaction tax @0.017% of call premium and 0.125% of settlement value of put option where put option isexercised.
- SEBI turnover charges @0.0002% of the sum of purchase price of futures andsettlement price offutures.
- SEBI turnover charges @0.0002% of the sum of call premium, put premium andtwice the exerciseprice.
- Transaction charges @0.0018% of the sum of purchase price of futures and the settlement price of futures plus service tax over and above the transactioncharges.
- Transaction charges @0.05% of the sum of call premium, put premium and twicethe exercise price plus service tax over and above the transactioncharges.
- Applicable state wise stamp duty on the sum of purchase price of futures and the settlement price offutures.
- Applicable stamp duty on the sum of call premium, put premium and twice the sum of exercisepremium.

Call-Cheaper:

- Average brokerage of 0.05% of the sale price of futures at the time of constructingthe portfolio.
- Average brokerage of Rs. 1.60 for every put optionwritten.
- Average brokerage of Rs. 1.60 for every call optionpurchased.

- Average brokerage of 0.05% of the settlement futures price at the time of settlementof futurescontract.
- Service tax @14% on the total value ofbrokerage.
- Security transaction tax @0.01% of the sale price of futures at the time ofconstructing theportfolio.
- Security transaction tax @0.017% of put premium and 0.125% of settlement value ofcall option where call option isexercised.
- SEBI turnover charges @0.0002% of the sum of sale price of futures and settlementprice offutures.
- SEBI turnover charges @0.0002% of the sum of call premium, put premium andtwice the exerciseprice.
- Transaction charges @0.0018% of the sum of sale price of futures and thesettlement price of futures plus service tax over and above the transactioncharges.
- Transaction charges @0.05% of the sum of call premium, put premium and twicethe exercise price plus service tax over and above the transactioncharges.
- Applicable state wise stamp duty on the sum of sale price of futures and thesettlement price offutures.
- Applicable stamp duty on the sum of call premium, put premium and twice the sum of exercisepremium.

The arbitrage profit after the transaction costs has been computed using the following two expressions.

ATC^{PC}= $BTC^{PC} - TC^{PC}$, BTC^{PC}>0

ATC^{CC}= BTC^{CC}− TC^{CC}, BTC^{CC}> 0

Where,

$ATC^{PC}$is the arbitrage profit after transaction costs in case of the put-cheaperportfolio.

$ATC^{CC}$is the arbitrage profit after transaction costs in case of the call-cheaper portfolio.

$TC^{PC}$is the transaction costs incurred in case of the put-cheaper portfolio.

$TC^{CC}$is the transaction costs incurred in case of the call-cheaperportfolio.

The risk-less positive arbitrage profit after the transaction costs exists if ATC^{PC}> 0 in case of put-cheaper portfolio and if ATC^{CC}> 0 in case of call-cheaper portfolio.

In addition to above, an arbitrageur also incurs the cost in terms of interest foregone on the margin deposit. The current margin deposit in case of Nifty futures is around 8% of the value of the futures contract and the margin deposit in case of Nifty options is equal to margin deposit applicable for Nifty futures plus the extent of amount to which the option is out of money.

Arbitrage profit after transaction costs and interest foregone on margin deposit has been computed using the following two expressions.

$ATCM^{P} = ATC^{PC} - M^{PC}$, ATC^{PC}>0

$ATCM^{C} = ATC^{CC} - M^{CC}$, ATC^{CC}>0

Where,

$ATCM^{PC}$is the arbitrage profit after transaction costs and interest foregone on margin deposit in case of the put-cheaperportfolio.

$ATCM^{CC}$is the arbitrage profit after transaction costs and interest foregone on margin deposit in case of the call-cheaperportfolio.

$M^{PC}$is the interest foregone on margin deposit in case of the put-cheaperportfolio.

$M^{CC}$is the interest foregone on margin deposit in case of the call-cheaperportfolio.

The risk-less positive arbitrage profit after the transaction costs and interest foregone on margin deposit exists if $ATCM^{PC} > 0$ in case of put-cheaper portfolio and if $ATCM^{CC} > 0$ in case of call-cheaper portfolio.

The basic data for the current study has been taken from National Stock Exchange of India covering the time period from July 2015 to October 2015. The underlying asset for the current study is NSE Nifty index. The options on NSE Nifty index are of European style. NSE provides the data on bid-ask quotes on NSE Nifty index at five different points of time on each day, that is, 11 AM, 12 Noon, 1 PM, 2PM and 3 PM. NSE prepares the order book in which the trader canenter the order indicating underlying asset, maximum price (for buy order) or minimum price (for sell order), quantity, exercise price, expiration date, buy or sell, type of order (day order, good till cancelled order, good till day/date order, fill/kill order etc.). The snapshot directory of Futures and Options segment captures the order placed by different traders along with above details. For the current study, the best buy price and the best sell price have been used to assess the arbitrage opportunities in NSE Nifty options. Since NSE Nifty index is not traded in thespot market, the best buy futures price and the best sell futures price of the NSE Nifty index have been used to judge the efficiency of the Indian options market while using put-call parity theorem. The best buy price at each point of time has been computed by taking the maximum of all the buy prices available in the snapshot directory of F&O segment at that moment oftime.Similarly, the best sell price at each point of time has been computed by taking the minimum of all the sell prices available in the snapshot directory of F&O segment at that moment oftime.The 91-days treasury bills rate has been taken as a proxy for the risk-free rate for the current study. The data on average Treasury bill rates from July 2015 to October 2015 has been taken from the official website of Reserve Bank of India.

On an average at each point of time on each day, 6407 buy orders on futures with different expiration dates, 5249 sell orders on futures with different expiration date, 13166 buy orders on options (call and put together) with different exercise prices and expiration dates and 13307 sell orders on options (call and put together) with different exercise prices and expiration dates were existing (see Table 1). Out of the total 6407 buy orders on futures 5990 (93%), 309 (5%) and 108 (2%) orders were available for near the month, not so near the month and far the month respectively. Out of the total 5249 sell orders on futures, 4994 (95%), 172 (3%) and 83 (2%) sell orders were existing for near the month, not so near the month and far the month respectively.

Out of the total 13,166 buy orders on options with different exercise prices and expiration dates, 10707 (81%), 1269 (10%) and 1190 (9%) buy orders were available for near the month, not so near the month and far the month respectively. Out of the total 13,307 sell orders on options with different exercise prices and expiration dates, 11,379 (85%), 1153 (9%) and 775 (6%) sell orders were available for near the month, not so near the month and far the month respectively.At any point of time on any day, maximum number of buy order which were available with any exercise price for near the month, not so near the month and far the month options contracts were 1305, 87 and 86 respectively. At any point of time on any day, maximum number of sell orders which were available with any exercise price for near the month, not so near the month and far the month options contracts were 1760, 91 and 69 respectively. At any expiration date and any point of time on any day, average number of exercise prices for which at least one of the four quotes (put bid, call bid, put ask, call ask) were available were 81.

Table 1: Average Number of Orders Available at Each Point of Time on Each Day

Contract	**Futures**		**Options**	
	Buy	**Sell**	**Buy**	**Sell**
Near the Month	5990	4994	10707	11379
Next Month	309	172	1269	1153
Far the Month	108	83	1190	775
Total	6407	5249	13166	13307

The total number of cases for which the best buy and the best sell quotes for at least one of the elements of the portfolios of put-call parity were available with different exercise price and expiration date is 98,224 (see Table 2).

Table 2: Number of Cases for Which the Best Buy and/or the Best Sell Quotes of Atleast One Element of the Portfolio was Available

Put-Cheaper	Call-Cheaper
98,224	98,224

Out of these the best buy and the best sell quotes (shown in Table 2), the total number of cases for which the quotes of all the elements of the portfolios (with different exercise prices and expiration dates) of put-cheaper and call-cheaper portfolios which were available for the period from July 2015 to October 2015 is 61,970 and 68,225 respectively (see Table 3). Thus, the opportunities are assessed for these numbers of cases for different portfolios which seem to be adequate.

Table 3: Number of Cases for Which the Best Buy and/or the Best Sell Quote of Allthe Elements of the Portfolio were Available

Put-Cheaper	Call-Cheaper
61,970	68,225

3. EmpiricalResults

Out of the total number of cases for which it was possible to assess arbitrage opportunities (as shown in Table 4), the total number of cases which show positive arbitrage profits (without transaction costs) for put cheaper and call-cheaper portfolios of put-call parity theorem is 7336 and 9800 respectively. When we incorporate transaction costs (except interest foregone on margin requirements), the total number of cases which show arbitrage profits for put-cheaper, and call-cheaper is 138 and23 respectively. If we include the interest foregone on margin requirement also as part of transaction costs, we observe the arbitrage profit does not exist even in single case.

Table 4: Positive Arbitrage Profit (Number of Cases)

Put-Cheaper			Call Cheaper		
BTC	ATC	ATCM	BTC	ATC	ATCM
7336	138	0	9800	23	0

BTC: Arbitrage Profit before transaction costs; ATC: Arbitrage Profit after transaction costs but before interest foregone on margin deposit; ATCM: Arbitrage Profit after transaction costs and interest foregone on margin deposit.

Table 5 shows the analysis of arbitrage profits according to time to maturity of the options. When we analyze arbitrage profits (before transaction costs) according to time to maturity of the options contracts, we observe that for both put-cheaper and call-cheaper portfolio, the frequency of arbitrage profits is the highest in case of near the month contracts and the lowest in case of far the month contracts. The intensity of arbitrage profits is the highest in case of far the month contract for both the portfolios (put-cheaper and call cheaper) of put-call parity relationship.

Table 5: Descriptive Statistics (Time to Maturity)

Portfolio	Time to Maturity	Mean		Standard Deviation		Maximum		Minimum		Count	
		BTC	ATC	BTC	ATC	BTC	ATC	BTC	ATC	BTC	ATC
Put-Cheaper	0-30 Days	5.33	1.91	3.17	1.55	19.94	6.30	0.003	0.01	5099	64
	31-60 Days	5.13	2.02	3.65	2.70	26.96	12.29	0.001	0.07	1889	26
	>60 Days	7.09	5.32	6.46	4.53	37.25	22.26	0.04	0.20	348	48
	Overall	5.36	3.12	3.54	3.48	37.25	22.26	0.01	0.01	7336	138
Call-Cheaper	0-30 Days	3.86	1.19	2.40	0.60	15.98	1.98	0.00	0.62	6131	4
	31-60 Days	4.00	1.40	2.69	1.55	17.87	4.01	0.001	0.22	2670	7
	>60 Days	4.38	4.50	3.35	3.54	27.52	12.22	0.01	0.31	999	12
	Overall	3.95	2.98	2.59	3.10	27.52	12.22	0.00	0.22	9800	23

Table 6 shows the analysis of arbitrage profits according to moneyness of the options. The analysis of arbitrage profits according to the moneyness of the options show that the frequency of arbitrage profits is the highest in case of in-the-money put options for put-cheaper portfolio. For call-cheaper portfolios, the frequency of arbitrage profits is the highest in case of in-the-money call options. The intensity of arbitrage profits is the highest in case deeply in-the-money put options for put-cheaper portfolios and deeply in-the-money call options in case of call cheaper portfolios.

Table 6: Descriptive Statistics (Moneyness)

Month	Moneyness	Mean		Standard Deviation		Maximum		Minimum		Count	
	F/K	BTC	ATC	BTC	ATC	BTC	ATC	BTC	ATC	BTC	ATC
	<0.85	6.83	3.90	4.74	3.97	37.27	22.26	0.02	0.10	1186	88
Put-Cheaper	0.85-0.95	6.16	1.76	3.09	1.72	21.45	7.47	0.01	0.01	4003	47
	0.95-1.05	3.06	0.94	2.21	0.22	15.07	1.09	0.003	0.77	2136	2
	1.05-1.15	2.06	-	2.27	-	6.41	-	0.03	-	8	0
	>1.15	5.76	2.05	9.04	-	16.18	2.05	0.12	2.05	3	1
	Overall	5.36	3.12	3.54	3.48	37.25	22.26	0.01	0.01	7336	138
Call-Cheaper	<0.85	-	-	-	-	-	-	-	-	0	0
	0.85-0.95	1.25	-	0.86	-	2.87	-	0.08	-	16	0
	0.95-1.05	2.91	2.01	1.98	1.97	16.67	3.40	0.00	0.62	3728	2
	1.05-1.15	4.37	0.97	2.45	0.97	16.31	3.17	0.01	0.28	3670	8
	>1.15	4.95	4.37	3.04	3.44	27.52	12.22	0.00	0.22	2386	13
	Overall	3.95	2.98	2.59	3.10	27.52	12.22	0	0.22	9800	23

Our results are not consistent with Vipul (2008). Vipul (2008) show that there are huge arbitrage opportunities even after taking into account the transaction costs. The main reason for this inconsistency is that Vipul (2008) had used traded prices (high frequency) to assess arbitrage opportunities where as the current study used bid-ask quotes to judge the efficiency of the Indian options market. We believe that the using traded prices to assess arbitrage opportunities is notthe right approach as the traded prices may be ex-ante bid price or ex-ante ask price. More specifically, if in the put-call parity relationship the portfolio involving put and futures is cheaper than the portfolio involving call and risk-free asset, then to assess arbitrage opportunities one should use the best sell price of put, the best sell price of futures, and the best buy price of call, however if one uses traded price of price of put (which was not ex-ante best sell price quote but it was ex-ante best price quote), it may show arbitrage profit using the best buy price but under this situation, an arbitrageur may actually incur losses as he or she is not buying the put option but selling the put option.

4. Conclusion:

The main objective of this study is to assess the arbitrage opportunities in the Indian options market by using European options and futures prices in put-call parity theorem. The current study also describes the data structure and methodology that should be used to assess theefficiency of the options markets. The study suggest that to assess the arbitrage opportunities in the options market, one should use the bid-ask quotes instead of traded prices.

The existence of arbitrage opportunities has been empirically tested for the Indian optionsmarket using the best buy price and the best sell price, covering the time period of from July, 2015 to October, 2015. The underlying asset chosen for the current study is NSE Nifty index. The empirical results show that call-cheaper portfolio generates arbitrage profit (before transaction cost) in more number of cases than put-cheaper portfolio. The magnitude of arbitrage profit (before transaction costs) is also higher in case of put-cheaper portfolio than in case of call-cheaper portfolio. When we incorporate transactions costs (before interest foregone on margin amount), the results show that arbitrage opportunities arbitrage opportunities exists in a few cases. In the presence of transaction costs (before interest foregone on margin deposits), the frequency and intensity of arbitrage profits are higher in cases of put-cheaper portfolios than in cases of call cheaper portfolios. Finally, when we incorporate interest foregone on margin amount as also part of transaction costs, we observe that arbitrage opportunities do not exist even in a single case. This shows that Indian options market is efficient. Our results are not consistent with the earlier studies in the Indian context. The main reason for this inconsistency is that the earlier studies had used traded prices instead of bid-ask quotes to assess the arbitrage opportunities which we believe is not the rightapproach.

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