# Put-Call Parity: An Investigation into S&P CNX Nifty Index Options

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**Abstract**

*Put call parity is an important principle in the pricing of options. Based on the postulates of the Black Scholes model, a European call and a European put has to have a definite relationship as otherwise fairly risk free arbitrage opportunities will emerge. The literature on the subject has sought to examine the extent to which this theoretical model holds in the real world. In our paper, we have looked at the benchmark S&P CNX NIFTY index for a period of two years from January 2012 to December 2013 and specifically analysed at the money options and a few out of the money and in the money options for every trading day during the period. WE have compared the call prices and the present value of the strike prices on these days with the put prices and underlying prices for the same strike prices on the same days. Differences in the sums of these have been*

*analysed in absolute terms as well as taking a percentage of the difference on the underlying price.*

***Key words:*** *Put-call parity, European option, Volatility, Black-Scholes model*

## Introduction

The pricing of Options is based on certain no-arbitrage arguments. If disparities exist in prices alert dealers will buy and sell in the market in such a way that they reap risk-free profits. As more and more dealers exploit the disequilibrium, the prices adjust to their correct levels. Several principles have been laid down in this unit based upon these no arbitrage conditions. The intricate relationships between the expiry time in the asset price and option values result in a number of valid principles.

For a given call price there must be a corresponding put price on the same underlying asset with the same Exercise Price. This can again be established using the no arbitrage condition. This principle is called put-call parity. The Black Scholes model essentially calculates the value of a European call given the current stock price, the strike price we are interested in, the level of volatility in the market (which is supposed to remain steady for the whole duration of the contract), the risk free rate as well as the time remaining for the call to expire. Based on a no-arbitrage argument, it can be established that:

Call + Present value of the strike price = Put + stock

From this, we can derive:

Call = Put + Stock –Present value of strike

Put = Call +Present value of strike -stock

In the process, whatever price is arrived at by the Black-Scholes model for the European call can be used to arrive at the corresponding European put price. While the above principle applies essentially for a European option, with some modifications the principle can be extended to American options as well. It can be shown by using principles of time value of money that it is not optimal to exercise the American call earlier than maturity. Although, American calls carry this right it will be not worthwhile for the holder to exercise this right before maturity. However, in case of necessity the dealer can sell the American Option in the market. This principle does not hold for an American put because of the favourable time value of money. Here it is optimal to exercise the American put before maturity if it is sufficiently in the money.

The put call parity rule for American options is based on a range of possible prices and cannot be determined with the precision of a corresponding European option. The arguments regarding theoretical possibilities of early exercise make an American put more valuable than a European put on the same underlying and the same parameters; while the American call cannot have a greater perceived value than the corresponding European call. This principle is used in a no-arbitrage argument to arrive at the range of put call parity for American options as follows:

**(Stock – Exercise Price) < (American Call – American Put) < (Stock – PV of Strike)**

It is known that among the different inputs in the Black Scholes model the estimate of volatility is the most difficult. This entails an estimation of the extent to which the stock prices can change given the tenure. Being a right without an obligation, an option carries greater inherent value with greater volatility.

An estimation of volatility is fraught with differences in approach. Volatility could be estimated based on historical data, and here the implicit assumption would be that the near future will have volatility in the same direction and extent as the past. Assuming that this is taken as a valid assumption, the next issue would be as to how many months in the past do we have to dig for ascertaining the past volatility. Estimates of volatility could be greatly different if taken for say a three-year period compared to say a six-month period.

Academics use a slightly different technique for estimating volatility. Four of the inputs in the Black-Scholes model are known. By feeding in these and also the price prevalent in the market, the market's interpretation of volatility can be derived. The volatility that the market as a whole appears to be attributing to the stock at a given point of time (given the strike price, time to go and risk free rate) can be arrived at by studying the four clear inputs with the Option prices prevalent in the market. This trial and error estimation of dispersion results in what is called implied volatility.

Put call parity assumes in the typical Black-Scholes way that volatility once determined remains intact till expiry. For reasons given above, the estimates of volatility keep changing and consequently, put call parity also may not hold. In real life the put call parity does not hold absolutely. Several reasons are attributed for this. Trading though continuous may not involve a call and a put at concurrently the same time. Estimates of risk free rate interest keep changing. Volatility estimates and direction of markets also result in occasional disparity. In India, the key index based option – the S&P CNX NIFTY –option is European and has considerable volume. We seek to examine in this paper the extent to which put call parity holds in respect of these options over the stated period.

Literature Survey: As part of looking into the past research on put call parity, we have reviewed a few of the most pertinent papers to our paper.

Ben David Nissim and Tavor Tchahi (2011) attempted to examine if the put call parity holds valid in Israeli stock market. They took the data of Tel Aviv 25 Index as as the underlying asset for the period from 1 February 2010 to 31 March 2010 on daily basis. While we may argue that the data set may be too small to conclude, their findings are worth noting. Using economic estimation of put call parity, they concluded that there existed an arbitrage opportunity to profit. The findings of their study revealed that the profit rate for portfolio containing options at the money was very small and the standard deviation was very high. In fact our study also examines put call parity holding as percentage of the spot along with standard deviation and an additional element of risk i.e coefficient of variance.

Johannes Ruf (2013) showed how delta hedging could provide an optimal trading strategy in order to obtain minimal required capital and terminal pay-off. He has then attempted to prove modified put-call parity. He proved that under weak technical assumptions, there is no equivalent local martingale measure needed to find an optimal hedging strategy. His study by and large remained as theoretical and model development measure towards call options based portfolio and put call parity. While we have not looked at martingale measure, we have taken the inputs from his study in terms of understanding the relevance and importance of conducting research on put call parity.

Avraham Kamara and Thomas W. Miller, Jr. (1995) examined how much of the variations of the deviations of put-call parity and tried to reason out why and how put call parity deviated. Documenting the deviations from put call parity during 1986 to 1989 they found out that such deviations were less frequent and statistically insignificant. Having done the research on American options, they found that delay in execution was the main reason for lower profit and losses in options based portfolio and thus average profits became negative. Our study tests the similar situation, but with respect to European options.

In line with the above study, Cremers and Weinbaum (2010) found out that option prices are more likely to deviate from put-call parity when underlying asset face more information risk. Their results are consistent with mispricing of the underlying asset. Thus their study indicated there that there always existed information gap in the markets and that in turn results in market imperfections leading to volatility risk in options based portfolio. This paper is of use to us in terms of reinforcing the fact that markets are, most of the times, are imperfect and mispricing is an implied aspect of any asset and underlying asset.

Having examined the cross-market as put-call parity of Indian options and futures markets for European style Vipul (2008) observed frequent violations of put-call parity. His study revealed that such pu-call parity violations were primarily due to the restrictions on short sales. Looking into the existence of arbitrage opportunity, he found that put options were overpriced more often than call options. Also he traced out that there was a specific pattern in mispricing with respect to timing in the day, volatility and days to expiry. The mispricing was found to be more in the first and the last thirty minutes of trading on a day.  While we have not tested such timing aspects of parity, we have taken the daily trading activities and found on daily basis. Thus our research is also aimed at finding out the extent of profit from put-call parity.

Wen et.al (2008) investigated if put-call parity could be used as a mechanism to price discovery. They found out a dominant tendency for futures and a sub-ordinate non-trivial price discovery from options. The empirical evidence of their revealed that information contained in the put-call parity implied spot encompasses the information provided Black-Scholes. This study provides empirical evidence that put-call parity could be used to price discovery. This study helped us in understanding and appreciating the contribution made by stock index options to the process of price discovery. Thus there is a relevance of this paper to us in the sense that we have used index options instead of stock options. In fact it is needless to say that studying the index options would provide more reliable evidence.

Stephen L. Taylor (1990) tested the relative prices of exchange traded puts and calls. The put call parity violations were found particularly in the period immediately prior to the expiry of the options. He also found out that it was not that possible to exploit such violations to use as arbitrage and make profit due to transaction costs. His research made a contribution to the body of knowledge on put call parity and we also have attempted to make our own.

In line with Stephen L. Taylor (1990), Geoffrey (1988) found that the observed put call parity violations were not sufficient enough to conclude that there would be an arbitrage possibility to make economic gains. He evidenced that violations of lower boundary were significantly more frequent than those of upper boundary. He also found out that the institutional restrictions had the most significant impact on violations. Though we have not attempted to trace out the reasons for put call parity holding, this paper is of use to us in terms of understanding put call theory and its application to options based portfolios.

Investigating into German stock index (DAX) based European options, Stefan and Sascha (2000) found that ex-post profits diminish dramatically when the implementation of the arbitrage strategies is delayed after transaction costs are adjusted to. They evidenced that the prevailing restrictions on short selling in Germany could not allow arbitrage possibility and hence concluded that put call parity could not be used to make any significant economic profits. This study is of great significance to our study and the like in terms of understanding the conditions that would contribute to using put call parity as an arbitrage strategy.

Geoffrey Poitras (2009) took sample of 331 pairs of call and put options to explain put call parity and the arbitrage possibility. He found that call and put options with the same strike price and same time expiration there was possibility of early premiums for both the variants. He also found that such premiums strongly depended on interest rate differentials and time to expiration. The results of his study have some specific implications with respect to European option pricing models in valuing American options.

## Objectives and Methodology

The principal objective of the study is to examine the extent to which put call parity holds in the Indian stock market with particular reference to the key index S&P CNX NIFTY and options thereon. These options are European in nature. Being a benchmark index which is used for cross hedging by a number of portfolios, S&P CNX NIFTY is substantially efficient. The price discovery is transparent and the volumes are very high. At the money options are traded with great impact factor of correct prices. It is considered, therefore, that this underlying asset will provide a representative idea as to the extent of efficiency in the market when it comes to pricing as between calls and puts.

It is widely known that the implied volatility inherent in options change with strike prices as well as with time to maturity. The concepts of volatility smile would suggest that implied volatility is the lowest in at-the-money options and are higher for both the out-of-the-money and in-the-money options. Here we examine put call parity for at the money levels and a few levels out-of-the-money and in-the-money.

For the purposes of this paper, we have taken S&P CNX NIFTY for the period 1st January 2012 to 31st December 2013. For the dates in this period, one-month options (options expiring on the last Thursday of the same month) are analysed for ascertaining put call parity. Wherever trading did not take place in respect of certain exercise prices included in the original dates, the records have been excluded in the computations.

In respect of each of these dates, the call prices for several strike prices are ascertained. These call prices refer to the at-the-money level and several layers up and down from this level. The present value of exercise price discounted at the applicable risk free rate is the next part of the analysis. True to the put call parity rule the total of these is supposed to equal the total of the going price of the underlying NIFTY index and the value of a put on the same strike price.

We have sought to examine whether the put call parity principle holds absolutely and if not the extent of variation thereon. The extent of variation has been analysed in absolute terms as well as in terms of percentage on the stock price.

## Results and discussions

We have arranged the computations in tabular form followed by depiction in figures below. As the computations are by and large self-explanatory, we have made some important observations and implications in conclusion part.

*Table 1: Monthly statistics of put call parity holding and its percentage on spot of S&P CNX Nifty Index based call options for the period January 2012 through December 2013*

| Month | Put Call Parity Holding | | | | | Put Call Parity as % of Spot | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | Average | Standard Deviation | Coefficient of Variance | Minimum | Maximum | Average | Standard Deviation | Coefficient of Variance |
| Jan-12 | -26.13 | 18.44 | -1.92 | 7.43 | -3.86 | -0.54 | 0.38 | -0.04 | 0.15 | -3.80 |
| Feb-12 | -23.84 | 27.69 | 5.81 | 11.28 | 1.94 | -0.45 | 0.50 | 0.11 | 0.21 | 1.99 |
| Mar-12 | -9.47 | 29.01 | 11.21 | 8.55 | 0.76 | -0.18 | 0.54 | 0.21 | 0.16 | 0.76 |
| Apr-12 | -13.35 | 25.47 | 4.30 | 8.70 | 2.02 | -0.26 | 0.48 | 0.08 | 0.16 | 2.03 |
| May-12 | -29.62 | 7.43 | -16.79 | 6.44 | -0.38 | -0.61 | 0.15 | -0.34 | 0.13 | -0.39 |
| Jun-12 | -29.09 | 22.99 | -5.54 | 9.61 | -1.73 | -0.60 | 0.45 | -0.11 | 0.19 | -1.73 |
| Jul-12 | -19.45 | 23.45 | -1.26 | 6.58 | -5.22 | -0.37 | 0.44 | -0.02 | 0.12 | -5.35 |
| Aug-12 | -21.87 | 17.56 | 2.02 | 9.35 | 4.62 | -0.42 | 0.33 | 0.04 | 0.18 | 4.77 |
| Sep-12 | -17.30 | 22.33 | 1.74 | 7.11 | 4.09 | -0.32 | 0.40 | 0.03 | 0.13 | 4.18 |
| Oct-12 | -13.82 | 21.51 | 5.03 | 7.28 | 1.45 | -0.24 | 0.38 | 0.09 | 0.13 | 1.45 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nov-12 | -25.00 | 20.86 | 4.40 | 7.23 | 1.64 | -0.43 | 0.36 | 0.08 | 0.13 | 1.65 |
| Dec-12 | -3.71 | 29.90 | 13.04 | 7.46 | 0.57 | -0.06 | 0.51 | 0.22 | 0.13 | 0.57 |
| Jan-13 | -25.82 | 27.43 | 2.97 | 8.61 | 2.90 | -0.43 | 0.46 | 0.05 | 0.14 | 2.88 |
| Feb-13 | -23.61 | 27.41 | -2.44 | 7.90 | -3.24 | -0.40 | 0.46 | -0.04 | 0.13 | -3.24 |
| Mar-13 | -28.11 | 20.79 | 0.21 | 10.02 | 47.01 | -0.49 | 0.35 | 0.00 | 0.17 | 50.99 |
| Apr-13 | -26.07 | 9.67 | -6.54 | 6.35 | -0.97 | -0.47 | 0.17 | -0.12 | 0.11 | -0.97 |
| May-13 | -29.90 | 18.77 | -10.42 | 9.43 | -0.90 | -0.50 | 0.31 | -0.17 | 0.16 | -0.91 |
| Jun-13 | -27.30 | 17.65 | -10.69 | 6.29 | -0.59 | -0.47 | 0.31 | -0.18 | 0.11 | -0.59 |
| Jul-13 | -29.62 | 21.43 | -7.47 | 12.53 | -1.68 | -0.51 | 0.36 | -0.13 | 0.21 | -1.66 |
| Aug-13 | -29.80 | 29.52 | -5.37 | 10.86 | -2.02 | -0.54 | 0.53 | -0.10 | 0.20 | -2.01 |
| Sep-13 | -29.60 | 29.76 | 2.29 | 17.27 | 7.53 | -0.55 | 0.51 | 0.03 | 0.30 | 9.47 |
| Oct-13 | -29.16 | 29.90 | 6.25 | 9.25 | 1.48 | -0.47 | 0.51 | 0.10 | 0.15 | 1.48 |
| Nov-13 | -6.82 | 29.87 | 14.30 | 6.78 | 0.47 | -0.11 | 0.49 | 0.23 | 0.11 | 0.48 |
| Dec-13 | -17.89 | 28.07 | 12.73 | 8.13 | 0.64 | -0.29 | 0.45 | 0.20 | 0.13 | 0.64 |

Source: www.nseindia.com and computations by the authors

Table 1 above captures the details pertaining to put call parity holding and its percentage on spot of S&P CNX Nifty index based call options. As far as holding is concerned it was as minimum as -29.9 as maximum as 29.9 in May 2013 and December 2012 and October 2013 respectively. While we observe carefully, we notice that there was significant variation in the movement of put call parity holding. This is aptly demonstrated by standard devistion and co-efficient of variance. However, co-efficient variance indicates that per unit standard deviation of holding was extremely high of 47.01 in March 2013. Barring this outlier, the risk involved in put call parity holding was almost similar during the observed period. On the other hand put call parity as percentage of spot was maximum of 0.54% in March 2012 and minimum of -0.61 May 2012. While the standard deviation was almost similar in most of the months, co-efficient of variance reveals that there the risk in terms of per unit basis significantly varied during the observed period. This implies that there was assessing the  performance of put call parity as percentage of spot was exposed to greater risk when compared to that of put call parity holding. Thus the returns from put call parity holding and as percentage of spot indicate varied significantly over the period January 2012 through December 2013.

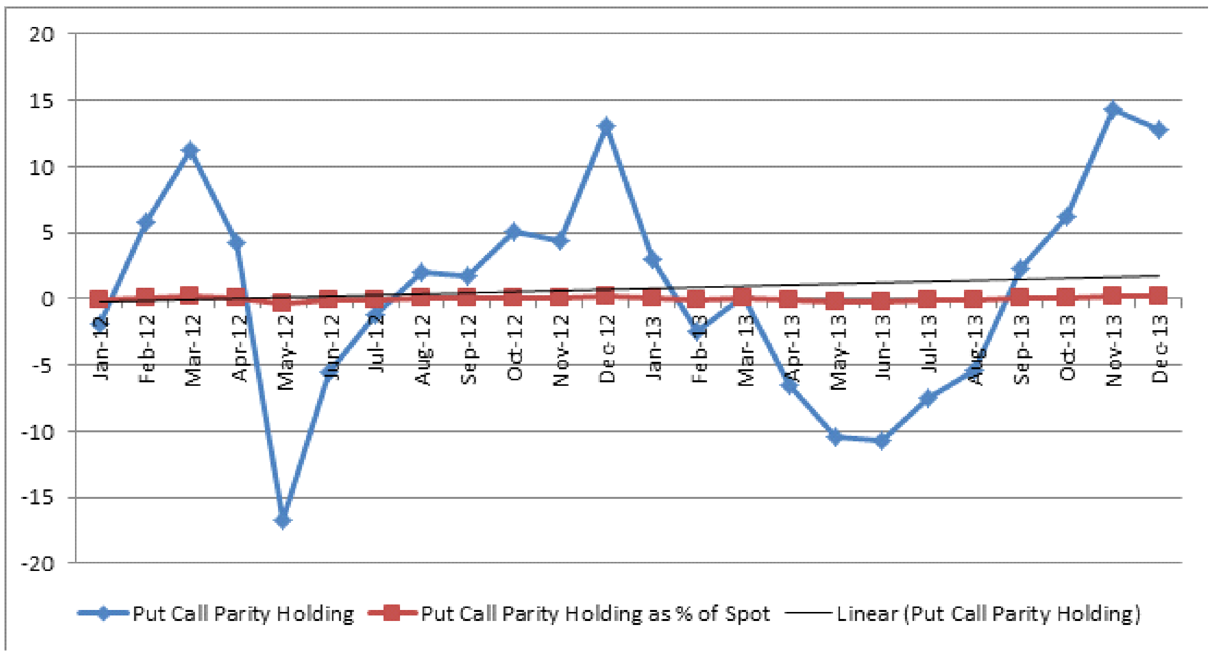


***Figure 1:*** *Comparison of monthly average put call parity holding and its percentage on spot of S&P CNX Nifty Index based call options for the period January 2012 through December 2013*

We have compared monthly average put call parity holding and its percentage on spot through a line chart in figure 1. As we can observe put call parity holding varied significantly from put call parity holding as percentage of spot during the observed period. In fact only in few months was there similarity between holding and as percentage of spot. This implies that assessing the performance of these variants of derivatives in terms of only holding does not make sense rather it makes sense to assess in terms of its percentage on spot. Therefore, looking at these two dimensions of performance metrics will also avoid bias wrong interpretations.

*Table 2: Quarterly statistics of put call parity holding and its percentage on spot of S&P CNX Nifty Index based call options for the period January 2012 through December 2013*

| Quarter | Put Call Parity Holding | | | | | Put Call Parity Holding as % of Spot | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | Average | Standard Deviation | Coefficient of Variance | Minimum | Maximum | Average | Standard Deviation | Coefficient of Variance |
| Q1, 2012 | -26.13 | 29.01 | 6.06 | 8.77 | 1.45 | -0.14 | 0.54 | 0.11 | 0.16 | 1.44 |
| Q2, 2012 | -29.62 | 25.47 | -6.20 | 12.18 | -1.97 | -0.33 | 0.35 | -0.02 | 0.12 | -5.56 |
| Q3, 2012 | -21.87 | 23.45 | 0.84 | 7.96 | 9.44 | -0.42 | 0.44 | 0.01 | 0.15 | 9.94 |
| Q4, 2012 | -25.00 | 29.90 | 7.35 | 8.29 | 1.13 | -0.43 | 0.51 | 0.13 | 0.14 | 1.13 |
| Q1, 2013 | -28.11 | 27.43 | 0.43 | 9.15 | 21.25 | -0.49 | 0.46 | 0.01 | 0.16 | 22.06 |
| Q2, 2013 | -29.90 | 18.77 | -9.32 | 7.85 | -0.84 | -0.50 | 0.31 | -0.16 | 0.13 | -0.84 |
| Q3, 2013 | -29.80 | 29.76 | -3.83 | 14.20 | -3.71 | -0.55 | 0.53 | -0.07 | 0.25 | -3.52 |
| Q4, 2013 | -29.16 | 29.90 | 10.33 | 9.06 | 0.88 | -0.47 | 0.51 | 0.17 | 0.15 | 0.88 |
| Source: www.nseindia.com and computations by the authors | | | | | | | | | | |

As we stated earlier, we have analysed quarterly performance of put call parity holding and its percentage on spot and relevant details are captured in table 2. If we compare the details in table 1 and table 2, we notice that there was no much of variation in the way holding and its percentage on spot during the observed period. Thus we conclude that even if we regress the data on quarterly basis there is no significant difference in put call parity performance.

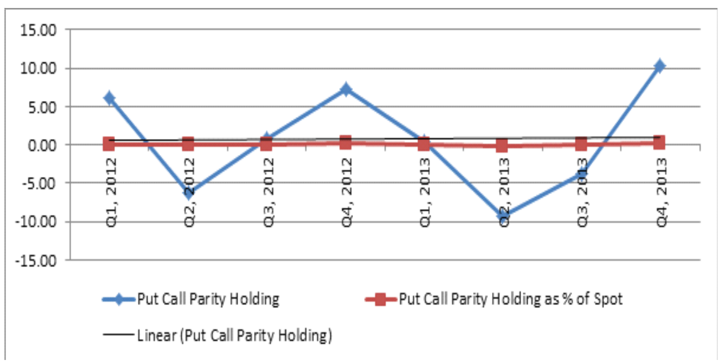


***Figure 2:*** *Comparison of quarterly average put call parity holding and its percentage on spot of S&P CNX Nifty Index based call options for the period January 2012 through December 2013*

Like in the case of monthly data, as depicted in figure 2 above, even in case of quarterly observation, put call parity holding varied significantly from its percentage on spot. However in third quarter of 2012 and first quarter of 2013 was there similarity between the two. Otherwise it implies that holding and its percentage on spot matters a lot while assessing the performance of put call parity.

*Table 3: Half-yearly, yearly and overall statistics of put call parity holding and its percentage on spot of S&P CNX Nifty Index based call options for the period January 2012 through December 2013*

| Frequency | Put Call Parity Holding | | | | | Put Call Parity Holding as % of Spot | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Minimum** | **Maximum** | **Average** | **Standard Deviation** | **Coefficient of Variance** | **Minimum** | **Maximum** | **Average** | **Standard Deviation** | **Coefficient of Variance** |
| H1, 2012 | -29.62 | 29.01 | -0.08 | 12.72 | -165.16 | -0.61 | 0.54 | -0.01 | 0.25 | -33.08 |
| H2, 2012 | -25.00 | 29.90 | 3.97 | 8.75 | 2.20 | -0.43 | 0.51 | 0.07 | 0.16 | 2.28 |
| H1, 2013 | -29.90 | 27.43 | -4.21 | 9.84 | -2.34 | -0.50 | 0.46 | -0.07 | 0.17 | -2.32 |
| H2, 2013 | -29.80 | 29.90 | 2.51 | 14.06 | 5.59 | -0.55 | 0.53 | 0.04 | 0.24 | 6.47 |
| Jan 2012 – Dec 2012 | -29.62 | 29.90 | 2.01 | 11.04 | 5.49 | -0.61 | 0.54 | 0.03 | 0.21 | 6.57 |
| Jan 2013 – Dec 2013 | -29.90 | 29.90 | -1.26 | 12.34 | -9.77 | -0.55 | 0.53 | -0.02 | 0.21 | -8.66 |
| Jan 2012 – Dec 2013 | -29.90 | 29.90 | 0.39 | 11.81 | 30.24 | -0.61 | 0.54 | 0.00 | 0.21 | 52.05 |

Source: www.nseindia.com and computations by the authors

Lastly we have further regressed the data on half yearly basis to find out if our observations monthly and quarterly basis still hold good when compared to half yearly basis. Thus by and large we notice no much difference in the results. However co-efficient of variance out lied in first half of the year 2012 both in case of put call parity holding and its percentage on spot. The key observation in half yearly analysis is that minimum and maximum figures are highly similar during the observed period. The average figures are however slightly varying but again not significantly.

## Conclusion

From the above tables, as is to be expected, it has been observed from our analysis of the sample data that put call parity does not hold absolutely. The deviations have been analysed with special reference to maximum, minimum and average deviations. Separate analysis has been made for the deviations in absolute terms and as a percentage of the stock price. To make the analysis complete we have also computed the coefficient of variation for the summary data. The arbitrage argument for a call given a put price will involve selling the call if it is overpriced, lending at the risk free rate and concurrently buying the put and the stock. If the stock ends up greater than the strike price, the call will be exercised against the trader but the stock is there for protection. The risk free loan can be repaid from out of the proceeds of the sale. The excess price that the call commands will then be the clean profits. Conversely, if the call is under-priced with reference to the put, then the call can be bought and an investment made in risk free securities to grow to the strike price on maturity.

Concurrently, the put is sold and stock is sold as well. The difference is pocketed as profits. At maturity if the stock price exceeds the strike price, the call is exercised and the stock bought back. The put would then expire out of the money.

The above argument does not take into account the transaction costs involved and any regulatory margins and restrictions. If the put call parity rule does not hold with a large difference then it would be possible to have the above arbitrage done. If the difference is small as is the case in the sample data analysed, an arbitrage might prove to be too much of trouble.

Further, throughout our analysis we have taken the final prices of the calls and puts for analysis. These may not have been concurrently traded and so the parity has no reason to hold. This factor is not high in the sample on account of the fact that NIFTY options have a great deal of volume. The counter argument would be that highest volumes occur on the at the money levels, and not on other levels. Our summary data above takes the “at the money”, “out of the money” and “in the money levels for analysis. To this extent the results are not conclusive. While we have tried our level best to bring out a few new dimensions to the performance of put call parity, the observations could strengthened by doing further analysis with larger data inputs which we could not do due time limitation. Also this sort of analysis could be carried out on individual stock options instead of index based options. Thus we invite the interested researcher to take this study further in a meaningful manner.

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