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Arbitrage Opportunities in Indian Derivatives Markets

Binay Bhushan Chakrabarti
Retd. Professor, Indian Institute of Management Calcutta
D. H. Road, Joka, P.O. Kolkata 700 104
http://facultylive.iimcal.ac.in/workingpapers

Ananthula Rambabu, Swapnil Chaudhari, Tarun Sangishetty, Ramesh Naidu G.
Post Graduate Programme Students
Indian Institute of Management Bodh Gaya Turi Buzurg, Bihar 824234

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Retd. Prof. B.B.Chakrabarti, A. Rambabu, Swapnil Chaudhari, Tarun Sangishetty, Ramesh Naidu

Abstract:

Two portfolios with the same payoffs should be priced similarly if it doesn't happen, then there exists an arbitrage opportunity where the trader can make a profit, the trader can sell the higher priced portfolio and buy the cheaper portfolio. Arbitrage brings back prices of such portfolios to their fundamental price. According to Classical theories such arbitrage opportunities arise due to market inefficiencies and are taken care by the market consisting of rational investors and arbitrageurs. In reality these inefficiencies/opportunities do persist from time to time - due to information asymmetry and various other risks associated with performing the arbitrage. We have surveyed literature discussing the limitation to arbitrage and research related to arbitrage opportunities in financial markets. In this paper we find such arbitrage opportunities using the NIFTY 50 stocks. The paper is divided into two sections – the Spot-futures and Put-Call options. The mispricing in spot and futures markets have been found in stocks such as IDEA, ONGC, BPCL, COALINDIA, BHARTIARTL, INDUSINDBK, GAIL, YESBANK, KOTAKBANK, AUROPHARMA, BANKBARODA, TATAPOWER, MARUTI, HCLTECH, HEROMOTOCO, ICICIBANK. All the stocks are found to be in the normal backward markets. Some of the profits after all the transaction expenses are deducted are as follows: BPCL – Rs.3.08 per share; COALINDIA – Rs.1.48 per share; BHARTIARTL – Rs.1.25 per share; MARUTI – Rs.1.35 per share. The mispricing in spot and options market were also found in various stocks such as BHEL, BHARTIARTL (on the date:2/2/2107). The profits at different strike prices are shown in the results sections.

Keywords: Arbitrage, Spot-futures parity, Put-Call parity, market inefficiencies

JEL Classifications: G13, G14, G02

1.1. Introduction:

An arbitrage is the simultaneous purchase and sale of an asset to profit from a difference in the price. It is a trade that profits by exploiting the price differences of identical or similar financial instruments on different markets or in different forms. Arbitrage is described as risk free because participants are not speculating on market movements. Instead, they bet on the mispricing of a share/asset that has happened between two related markets. Therefore, Arbitrage exists as a result of market inefficiencies. Classical theories suggest that the market, assuming it has rational investors and arbitrageurs, take care of the mispricing and brings back the prices of the assets to their fundamental price. But in reality these mispricing do persist from time to time.

So, now the question arises – "Why do the inefficiencies persist?" The answer to this question can be understood from the learnings of the groundbreaking research papers: Shleifer and Vishny (1997) and Barberis and Thaler (2003). These papers discuss about the

real-world arbitrage and frictions that are associated with it, which make these inefficiencies to persist.

Theoretically if we have two securities giving the same payoffs in time, then the two securities must be priced same, this is also intuitively understood from the law of one pricing. Even the Efficient market hypothesis states the same – when there are anomalies in pricing of a security, i.e. the price of the security, if it moves away from its fundamental value then the rational investors and the arbitrageurs would come into picture and drive the misplaced price back to the fundamental value and hence eliminating the misplaced price. But in reality the inefficiencies or the misplaced pricings would still persist.

The persistence of these inefficiencies suggests that there are serious limitations to arbitrage. In practice, arbitrage strategies are risky and costly. There are various risks and the costs associated with the arbitrage.

1. **Fundamental risks**: Fundamental risks refer to the risk that new bad information may arrive to the market after you have purchased the security. In any arbitrage, a trader has to take a long position of the lower priced security, the trader takes a long position suspecting that the lower priced security would converge to its fundamental value and hence making him/her profit. But still this security is prone to fundamental risk i.e. its price may still go down. Theoretically this risk can be perfectly hedged by buying a closely related security. Unfortunately substitute securities are rarely perfect, making it impossible to remove all the fundamental risk.

2. **Noise trader risk**: Noise trader risk refers to the risk that the mispricing worsens in the short run because there is possibility that pessimistic traders become even more pessimistic about the future. Once a position is taken, noise traders may drive prices farther from fundamental value, and the arbitrageur may be forced to invest additional capital, which may not be available, forcing an early liquidation of the position.

3. **Information gap and financing issues**: Generally, the arbitrageurs are informed but wealth constrained and the investors are uninformed and wealthy. In a situation where noise trader risk rises and the mispricing worsens and the fund has to pay lot of margin calls to hold the position, the investors may panic and the arbitrageur might face financing issues to carry on with his arbitrage strategy. The investor might doubt arbitrageur's abilities and they might withdraw their precisely when the expected gain is at the maximum – lost opportunity which could have covered all the expenses incurred till now. This might make the arbitrageur to participate less in such similar trades in the future.

4. **Implied Volatility**: As implied volatility rises, the options prices will also rise (predicted by the Black-Scholes options pricing formula) this may affect the prices for the long positions adversely in some situations and decrease the overall expected profits. Also implied volatility is different from the historical volatility, it is the market's expectations of the stock's price volatility in the future. As this implied volatility rises, risk associated with the option raises so arbitrageurs expect more returns. Present market arbitrage value may not be as great as the expected returns of the arbitrageurs.

5. **Portfolio management issues**: arbitrage opportunities are short time and involves huge amount of money which has huge opportunity cost. Portfolio managers may not willing to disturb their portfolio for these short term profits.

6. **Liquidity**: Liquidity in the stock and futures segments or the options market contribute to the uncertainty, and therefore risk. In an arbitrage trade, when trader has to take long positions, if the liquidity is less then he may not find the securities to buy. In futures and options we buy in lots - and when we execute the contract we need to take delivery or buy few hundreds of stocks per lot, if liquidity is less, the trader may not be able to purchase the desired number of stocks at the given price. Also futures and options contracts usually get squared off at expiration date. The trader has to sell the stocks before the market closes on the expiration date. If for some reason, there isn't enough liquidity then the trader can't short the stocks and this may give rise to losses to the fund – since the entire profit can't be attained and the short position can't be taken over to the next month because of lack of opportunity.

7. **Implementation costs:** These refer to the transaction costs such as commissions, bid-ask spreads, premium payments and margin payments. Along with these costs there are other costs related to finding and learning about a mispricing, as well as the costs of the resources needed to exploit it – the state of the art technology and IT infrastructure that can trade at high-frequency speeds.

1.2. Literature survey:

This paper relates to the literature of the few research papers we have referred to study and understand the Arbitrage opportunities in various financial markets in the world.

In the paper, '*Arbitrage opportunities in the futures market: A study on NSE NIFTY 50*' by Dr.Dheeraj Mishra, Dr.R.Kannan, Dr.Sangeeta Mishra, the failure of the spot-futures parity was studied. The various factors such as time to maturity, rising or declining of markets, markets being in Contango or Normal Backwardation, were examined to check the parity. The paper finds that the parity fails in some stocks. It was found that the arbitrage profits were higher for far the month futures contracts than for near the month futures contracts.

In the paper '*DAX index futures: Mispricing and arbitrage in German markets*' by Wolfgang Buhler and Alexander Kempf we see that again the spot futures securities which are mispriced. The paper suggests an arbitrageur trade mainly in futures nearest to delivery. It also suggests that the risk associated with arbitrage trading is found to be very small so that the profits are nearly risk free.

In the paper '*Price discovery and arbitrage efficiency of Indian equity futures and cash markets*' by Dr.Balwinder singh, the author finds that strong and long run relationship exists between equity futures and cash markets. However, during short run significant

deviations have been observed. It was empirically found that price discovery happens in both the markets but the futures markets dominates the information transmission process.

Since mispricing happens in the derivatives markets, we reflect upon the paper '*Index Arbitrage between Futures and ETFs: Evidence on the limits to arbitrage from S&P 500 futures and SPDRs*' by Nivine Richie and Robert Daogler. The paper examines how long mispricing lasts and the impact of volatility on mispricing. It was found that the mispricing was far more frequent in high volatility months than in low volatility months. The duration of mispricing was found to be independent of the monthly level of volatility.

Having stated that the arbitrage opportunities exist from time to time, the purpose of this paper is to study the NIFTY 50 stocks to find out such opportunities in the India stock derivatives market. The paper is organized as follows: In the section 2.1 we explain the possibilities of any mispricing of the Spot and Futures contracts. We define the Spot-Futures parity. We suggest two scenarios how these mispricing happen. In section 2.2, the classification of the stocks into Contango and Normal backwardation is discussed and suitable arbitrage trading strategies are discussed. In section 2.2.1, the notations for the various inputs and their data sources to our model have been stated. In section 2.2.2, the risk free rate calculations have been discussed. In section 2.2.3, the arbitrage strategies applied in our approach have been stated. In section 2.2.4, the details regarding the transaction costs applicable to carry out the arbitrage trade have been stated. In section 2.3, the results consisting the profits after deducting the various expenses have been mentioned for the Spot-Futures markets. Section 2.4 consists of discussion about the results of the Spot-Futures markets.

In section 3.1, we explain another parity condition between two portfolios – one containing the Put option on the stock and the stock itself and the second portfolio consisting of the Call option on the stock and a bond (or the cash to cover the purchase of the stock, i.e. to cover the call on the date of expiration). In section 3.2, we discuss the model used to describe the parity, the notations used for the various inputs used for our model have been stated in this section. We explain the arbitrage strategies that are used on the NIFTY 50 stocks. The viability of an easy arbitrage opportunity has been shown using a stock example. In section 3.2.1, the calculations related to the transaction expenses have been discussed. Further in the stock example, we arrive at the riskless profit that can be made. The methodology that has been used to explain the stock example has been implemented to calculate similar arbitrage opportunities. Finally, in section 3.3, we arrive at profits after deducting trade expenses for the NIFTY 50 stocks used in our research. Section 3.4 consists of discussion on results of the arbitrage opportunities in options market. Section 4 states the various assumptions of our study. Section 5 concludes the discussion.

Stock Futures Arbitrage

2.1. Problem description: Arbitrage opportunities in the Spot and Futures market

In normal market conditions, futures price would be greater than the spot price because of the effect of cost of carry and it moves in tandem with the price of the underlying asset. Thus, based on the cost of carry principle, if the spot price of a share on a given day is 'x' then, the futures price on that day would be 'x' + the interest for holding the spot to the duration of futures contract (minus) any dividend accrued on the spot.

So, to compute the cost of carry accurately a participant needs accurate information on interest rates and expected dividends. However, futures market is not so perfect where all the requisite information is readily available to all. Imperfections are common and that results in a mismatch between spot and futures price based on the cost of carry principle.

When this logic between spot and futures does not hold, the futures are incorrectly priced and that results in arbitrage opportunities.

Spot-futures parity:

It is a parity condition whereby, if an asset can be purchased today and held until the exercise of a futures contract, the value of the future should equate the current spot price adjusted for the cost of money, dividends, convenience yield and any carrying costs (such as storage). When the relationship between spot and futures does not hold, the futures are incorrectly priced and that results in arbitrage opportunities. The mathematical representation of the theoretical relationship between the spot and futures price can be put into the following equation:

Theoretical Futures price = Spot price (1 + risk-free interest rate – income yield – convenience yield)^t

If we assign a single 'r' to be the equivalent cost of carrying the asset (that is, the sum of interest, dividends, convenience and storage), then we can simply put this relation to be equivalent to:

$$\boldsymbol{F = S_0 e^{rt}} \quad \textbf{(1)}$$

NOTE: We use continuous compounding formula in equation (1), this is done for simplicity sake since the duration is small (less than a month), the above equation can be used for approximately similar results. The value of rate of interest for the above equation, adjusted for continuously compounding, can be described using the formula where

$$\boldsymbol{r_c = mln(1 + \frac{r_m}{m})} \quad \textbf{(2)}$$

Where, r_c is the continuous compounding rate of interest, r_m is therisk free rate (the duration till the expiry of the futures contracts) and m which is equal to (duration till expiry)/365.

The equation (1) describes that the futures contract should be for a strike price equivalent to F. When the futures price doesn't follow the parity condition described above, then there are two cases which can arise, they are as follows:

1. The actual futures price (F_0) is greater than the theoretical futures price F
2. The actual futures price (F_0) is less than the theoretical futures price F

In each case the arbitrageur has a risk less opportunity to make profit, the arbitrage strategy is discussed further in the following sections.

The research conducted in this thesis is done on the NIFTY 50 stocks. The spot prices and the one month future prices are recorded and the spot-futures parity is examined to check if the parity holds or not. Each of the stocks are examined individually and an Excel based model is created to run the calculations to find out the arbitrage profit that can be collected by the arbitrageur. The model has been described elaborately in the methodology section, which follows below. The methodology will categorize each case and delineate the arbitrage strategies that need to be used in a particular scenario. The data sources have been stated after the methodology section.

2.2. Methodology:

This section discusses the methodology to conduct the arbitrage in the two cases that can occur. The two possible scenarios for a market resulting into arbitrage opportunities have been named as Contango markets and Normal Backward markets. They are explained as follows:

Case 1: Contango market: **if the spot futures price (F_0) is greater than the theoretical futures price (S_0e^{rt}) as suggested by the parity equation, in this scenario the trader can BUY STOCK and SELL FUTURES** (Assuming the trader operates in India and also assuming that the arbitrageur already possesses the futures)

Case 2: Normal Backward market: **if the spot futures price (F_0) is less than the theoretical futures price (S_0e^{rt}) as suggested by the parity equation then the trader can SELL STOCK and BUY FUTURES** (Assuming the trader operates in India and also assuming that the arbitrageur already possesses the stock)

These are the only two strategies that any arbitrageur can use to see if he/she makes any profit by taking a long position in one market and a short position in another. Having stated the two strategies that an arbitrageur can use, we will first categorize any stock into two cases which are stated below. For any stock we have its respective spot futures price & its spot price.

For any arbitrage strategy applied, as discussed above, we have a long position and a short position. In the long position we will be dealing with the ask price of the asset and in

the short position we will be dealing with the bid price of the asset. In futures contract we must pay margin amount to the exchange so we need to consider the interest we lost on the margin amount to calculate the net value of arbitrage opportunity.

NOTE: In our research we have taken the one month futures contracts which is going to expire in coming 19 days, therefore the risk free interest rate is also for 19 days duration.
Notations mentioned below are used in further calculations.

r is Risk free interest rate, *t* is Time duration (19 days), S_{0a} is the Ask price of the stock in spot market, S_{0b} is the Bid price of the stock in Spot market, F_{0a} is Ask price in future market, F_{0b} is the Bid price in future market, F^1 is the theoretical spot futures price

2.2.1 Data sources:

1. **NSE India**[1] - NIFTY 50 stocks are chosen to form the underlying asset in the arbitrage trades. The appropriate data regarding the stock spot and futures prices are collected from the NSE website
2. **RBI**[2] **–** The data for the call money rate and 91 day T-bill rate used for the risk free rate calculations were taken the RBI website.
3. **Zerodha**[3] –The data used for calculating the transaction charges is taken from this website

2.2.2 Risk free rate calculation:

The above data have been collected on 9th January, 2017. The Call money rate as on 9th January 2017 was 6.12%. The 91 days T-bill rate was 6.19%. The number of days for the futures contract expiration is 19 days.

The risk free rate is 6.12% + (6.19%-6.12%)*19/90.

Therefore, the interpolated risk free rate = 6.13%. This rate of interest is used in equation (1).

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1. THE NATIONAL STOCK EXCHANGE OF INDIA LIMITED IS THE LEADING STOCK EXCHANGE OF INDIA, LOCATED IN MUMBAI. NSE WAS ESTABLISHED IN 1992 AS THE FIRST DEMUTUALIZED ELECTRONIC EXCHANGE IN THE COUNTRY - HTTPS://WWW.NSEINDIA.COM/

2. RBI.ORG
3. ZERODHA IS AN INDIAN FINANCIAL SERVICES COMPANY THAT OFFERS BROKERAGE-FREE EQUITY INVESTMENTS, RETAIL AND INSTITUTIONAL BROKING, AND CURRENCIES AND COMMODITIES TRADING. HTTPS://ZERODHA.COM/CHARGES

2.2.3 Arbitrage Strategies:

Table 1: Arbitrage Strategy in Case 1

If $F^1 < F_0$: BUY STOCK SELL FUTURES		
Time	Action	Cash flow
Now	Borrow Spot price and Margin money to buy Short Futures contract @ Risk free rate	$(S_{0a}$ +Margin%* $F_{0b})$*lot size
	Buy stock at Spot price and buy Short futures contract	$-(S_{0a}$+Margin%*$F_{0b})$*lot size
At t:	Deliver on Future (sell stock @ F_{0b}) and receive margin money back	F_{0b}*lot size + margin money paid before
	Pay back the loan with interest	$-((S_{0a}$+margin%*$F_{0b})$*lot size $)*(1+r)^t$ = say $A(1+r)^t$
		NCF = F_{0b}*lot size +margin money - $A(1+r)^t$

Table 2: Arbitrage Strategy in Case 2

If $F^1 > F_0$: SELL STOCK BUY FUTURES		
Time	Action:	Cash flow
Now	Sell Stock at Spot price and buy Long futures contract	$(S_{0b} - F_{0a}$*margin%)* lot size = say B
	Lend money @ risk free rate	B
At t:	Collect money on loan with interest	Be^{rt}
	Buy stock @ F_a	F_{0a}*lot size
	Receive margin back	F_{0a}*margin%*lot size
		NCF = $(B(1+r)^t$ + Margin money) – F_{0a}*lot size

2.2.4 Transaction expenses:

In the above analysis the Net cash flows from each of the arbitrage strategies is given, but in a real scenario we also have other expenses that go into the transactions mentioned above. These are as follows: Brokerage charges, SEBI Charges, Stamp charges, Securities transaction tax, NSE Transaction charges & Service Tax.

We also deduct these charges which are applicable accordingly. After deducting these charges we arrive at the final arbitrage profits that the arbitrageur could actually receive.

Table 3: Zerodha Charge sheet

Zerodha charges	**Equity delivery**	**Equity futures**
Brokerage	Zero Brokerage	0.01% or Rs. 20/trade whichever is lower
STT/CTT	0.1% on buy & sell	0.01% on sell side
Transaction charges	NSE: 0.00325% BSE: 0.00275% MCX-SX: 0.002%	NSE: 0.0021% BSE: 0.0007% MCX-SX: 0.0014%
Service tax	15% on (brokerage + transaction charges)	15% on (brokerage + transaction charges)
Sebi charges	□20 / crore*	□20 / crore*

2.3. Results:

Positive Arbitrage profits are found for stocks: IDEA, ONGC, BPCL, COALINDIA, BHARTIARTL, INDUSINDBK, GAIL, YESBANK, KOTAKBANK, AUROPHARMA, BANKBARODA, TATAPOWER, MARUTI, HCLTECH, HEROMOTOCO, ICICIBANK. Assuming the trader would have certain cut-offs regarding the profits per share (say Rs 1.20 per share minimum), we recommend the following stocks:

Table 4: Results from Stock – Futures Arbitrage

COMPANY	MARKET TYPE	ARBITRAGE PROFIT (RS)	Profit per share
BPCL	NORMAL BACKWARD	3694.95	3.08
COALINDIA	NORMAL BACKWARD	2521.66	1.48
BHARTIARTL	NORMAL BACKWARD	2131.62	1.25
MARUTI	NORMAL BACKWARD	202.47	1.35

2.4 Analysis of results:

The above section shows that there exist arbitrage profits that can be made using the spot and futures markets. We observe that the recommended stocks have their futures contracts in the normal backward market. Since a trader would have to short the stock and buy futures, the trader has to have the stock in his/her possession. He would either own the stock or borrow it from some lender, in each case the rate of returns would vary.

Let's take the stock BPCL, it can be seen that the profits made by trading on single lot of stock is Rs.3694.95 – which is realized in the normal backward market. Now, if the trader

doesn't own the stock then he/she would have to borrow the stock, assuming he/she borrows under the SLB mechanism. Say the trader borrows single lot of stock, so for BPCL it is 1200 shares, and then under the SLB mechanism the trader has to pay a margin to the intermediary like ILFS (Infrastructure leasing and financial services Ltd.), the margin for a borrower is 125% of the stock value (worth Rs.664.25*1200*1.25). In this case, it would be equal to roughly Rs.9.96 lakhs. Also the margin for single lot of futures contracts is around Rs.1.1 lakhs. Hence for the trader, total money blocked is around Rs.11 lakhs. So the return on blocking Rs.11 lakh is (3694.95/1100000) roughly 0.33%. Assuming, the trader has to pay for interest costs of borrowing the asset from the lender, the rate of return would further decrease. We should notice that this return is for 19 days, and also that the return is lesser than the return he would get if he/she invested the same Rs.11 lakh worth of amount in a fixed deposit.

Same goes with the trader who owns the stock, even he/she would face almost the scenario except that the trader here would sell stock, receive cash, pay margin money for futures, invest remaining amount in a bank till the contract expiry date, take out money, and buy the stock at expiry of futures at strike price. Therefore, in either of the case i.e. the trader owns the stock or borrows it, the trader would have a meager rate of return which is not worth the complex actions that need to be taken. This can be one of the reasons that the mispricing continues to persist in the financial markets - since the trade is not worth the expected profits. In today's technologically advanced era these trades of spot and futures arbitrages are done using super computers in hedge funds where the asking rate of return would be higher than the rate of return we would actually receive, therefore, few such opportunities do persist longer.

Stock options arbitrage opportunities in Indian financial markets

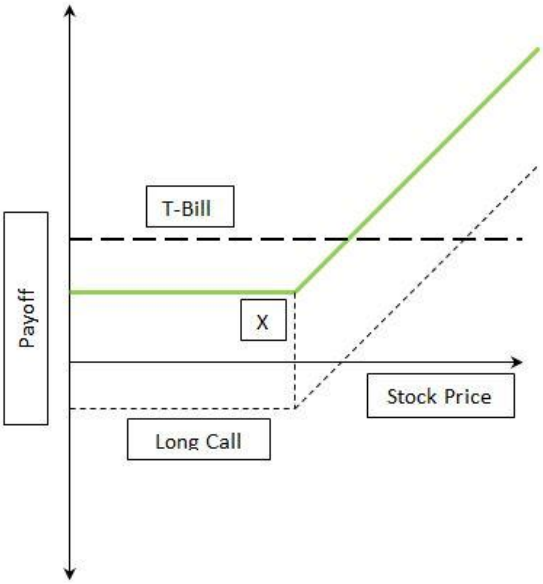
3.1 Problem Statement:

PUT-CALL parity:

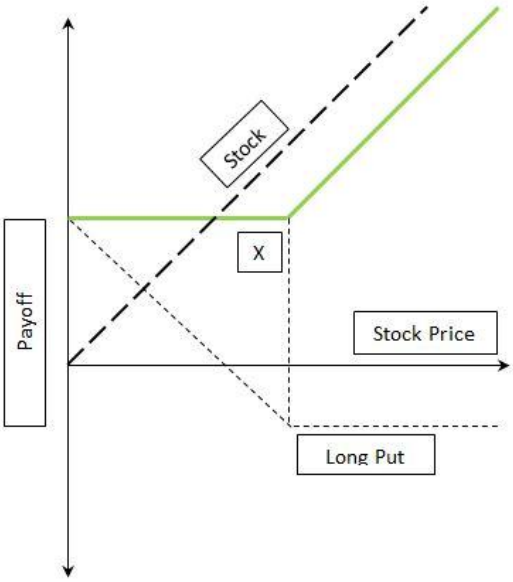
If a trader has two portfolios consisting of a Stock A and a put option on the stock (at strike price: X) and another portfolio with a Bond which at maturity gives X (strike price) worth of money and a Call option on the stock with a strike price of X again. Considering both the call and put options have the same date as the maturity date, then we can say that the two portfolios will have the same payoffs whatever be the price of the stock in the future on the maturity date. This can be understood using the payoff graphs for each of the portfolio.

Fig. payoff diagrams for PUT + STOCK and CALL + BOND portfolios

CALL + BOND:



PUT + STOCK:



The two portfolios at maturity will give the same payoff value so if the total price of each of the portfolio doesn't happen to be same now, then we have an arbitrage opportunity. A trader can then buy the cheaper portfolio and short the costlier portfolio to make a risk less profit.

3.2 Methodology:

Our research is based on the NIFTY 50 stocks. We have taken two portfolios consisting of a PUT + STOCK and another with the CALL + BOND (T-Bill). Both the options have the same strike prices and the same maturity dates. The Bond matures at a risk free rate. The risk free rate calculations are mentioned below:

The risk free rate is interpolated using the call money rate and the 91 T-bill rate.

Risk free rate for required number of days = Call money rate + (91 day T-bill rate – Call money rate)*number of days /365. We then find the rate adjusted for continuous

compounding suing the equation (2), then substitute in the equation (3) The PUT-CALL parity is denoted as follows:

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

Where, *P* is price of PUT option, *C* is Price of CALL option, S_0 is the current Stock Price, *X* is the Strike price of option contract, and *r* is the Risk free rate.

When the above equation doesn't hold, then there exists an arbitrage opportunity and the trader can make a riskless profit. There arise two cases:

Case 1: PUT + STOCK portfolio is priced more, CALL + BOND is priced less. In this situation we **sell the PUT + STOCK** portfolio and **buy the CALL + BOND** portfolio, take a **LONG CALL** at **Ask price + LONG BOND** and carry a **SHORT PUT** at **Bid price+ SHORT STOCK** at **Bid price**

CASE 2: CALL + BOND portfolio is priced more, and the PUT + STOCK is priced less. In this situation we **sell the CALL + BOND** portfolio and **buy the PUT +STOCK** portfolio take a **LONG PUT** at **Ask price + LONG STOCK at Ask price** and carry a **SHORT CALL at Bid price + SHORT BOND**

The calculations have been done using an excel model and the methodology has been discussed below using a real stock example.

Name of the stock: BHARTIARTL (Bharti Airtel)

Lot size: 1700, ASK price: 349.85, BID price: 349.75
Let's take the **strike price of the stock option X =360**
The put and call ask-bid prices are given below:

Table 5: Bid-Ask Prices of Call & Put for BHARTI AIRTEL

CALL		PUT	
BID	ASK	BID	ASK
3.8	3.95	25.85	29.35

CASE 1: LONG CALL + LONG BOND and SHORT PUT + SHORT STOCK

Ask price CALL + PV of Bond = 644640
Bid Price PUT + BID price of STOCK = 618460

Opportunity doesn't exist

CASE 2: LONG PUT + LONG STOCK and SHORT CALL + LONG BOND

Ask price PUT + Ask price of STOCK = 638520
Bid price CALL + PV of BOND = 618715

Opportunity = 638520-618715 = 19805 riskless profit can be made

Now keeping this real stock example in picture we need to deduct other expenses that we have incurred to execute this arbitrage strategy.

3.2.1. Transaction expenses:

There are various expenses that need to be mentioned, they are as follows: Interest lost on margin payments, Interest expenses on the borrowed money, Brokerage charges, SEBI Charges, Stamp charges, Securities transaction tax, NSE Transaction charges, Service tax

The table below lists the appropriate transaction charges and taxes associated with the equity and equity options:

Table 6: Zerodha Charge Sheet

Zerodha charges						
	Brokerage	STT	Transaction charges	Service Tax	SEBI charges	Stamp charges
Equity delivery	Zero Brokerage	0.1% on buy & sell	NSE: 0.00325%	15% on (brokerage + transaction charges)	□20 / crore *(on turnover)	0.01% - Max 50
options	Flat Rs. 20 per trade	0.05% on sell side (on premium)	NSE: 0.053%			

In the above discussed example, we have an arbitrage opportunity in the case 2: LONG PUT + LONG STOCK and SHORT CALL + SHORT BOND, the taxes that need to be deducted are shown in the table below:

Taxes for long (P+S), short (C+B)						
Brokerage	STT	Transaction charges	SEBI charges	Service Tax	Stamp charges	TOTAL
40	597.98	49.19736	13.3796	1.3022	50	751.8541669

In this example we need to deduct the interest expenses also, the respective interest payment calculations are shown below:

In the example above, we have arbitrage in case 2: LONG PUT +LONG STOCK and SHORT CALL+ SHORT BOND. When doing a long put we need to pay the premium hence we lose the interest on this amount since it is stuck with the exchange. Also when we do a short call we need to pay a margin, hence the interest is also lost on this amount.

TOTAL expenses = taxes + transaction costs + interest expenses

TOTAL expenses = 751.85 + 256.25

Therefore, the final arbitrage profit = 19805 – 1008.1 = 18796.9

3.3. Results:

The table below shows the various arbitrage opportunities and the profits after deducting transaction expenses for the strategies applied.

The various parameters used for the calculations have been mentioned below as well.

Exhibit 1 – Details of Trading

Today	2/7/2017
Option expiration date	2/23/2017
Number of days	16
Call Money rate (%)	5.97
91 day rate (%)	6.23
Required rate (%)	5.98

Name of Stock	BHEL
ASK price	147.95
BID price	148.00
Lot size	5000

Exhibit 2 – Arbitrage profit opportunities at each strike price

Strike Price	Net Arbitrage Profits	Profits per share
	Short(P+S) Long (C+B)	
110.00	42448.30	8.49
115.00	42959.41	8.59
120.00	44719.94	8.94
125.00	45477.08	9.10
130.00	46230.11	9.25
135.00	45978.10	9.20
140.00	45721.16	9.14
145.00	44708.91	8.94
150.00	44692.26	8.94
155.00	43673.03	8.73
160.00	41652.85	8.33
165.00	42627.30	8.53
170.00	39355.23	7.87
175.00	41826.38	8.37

Profits per share for BHEL stock options arbitrage have been displayed in the above. We see that there are multiple opportunities at different strike prices for a trader to exploit, assumingly if the trader has a cut-off of Rs 9 per share then in the above shown results for BHEL stock, we would have strike prices – Rs 125,130,135 and Rs 140. Similar results have been found in the case of other stocks.

These arbitrage profits show that the inefficiencies do persist and if we apply an appropriate strategy we can make sizeable profits as shown above. We find similar arbitrage opportunities for other stocks at different strike prices. The table below shows few other stocks and their respective strike prices at which a positive arbitrage profit can be realized.

NOTE: All the ask and bid prices are taken as per the dates mentioned above Exhibit 1

Exhibit 2 – Arbitrage profit opportunities at different strike prices for various stocks

Name of Stock	Strike prices at which arbitrage opportunities exist
Tech Mahindra (Current Ask and Bid prices are around Rs.477.45-.50)	At strike prices greater than Rs.420 and lesser than Rs.560, i.e. both in the money and out of money scenarios
Tata Power (Rs.81.55-.60)	Rs.72.50 to Rs.87.5 (both in the money and out of money)
Sun Pharma (Rs.673.00-15)	Rs.560 to Rs.700
Larsen (Rs.1480.00-.50)	Rs.1260 to Rs.1680
ITC (Rs.278.65-.80)	Rs.215 to Rs.310
IndusInd Bank (Rs.1314.00-.05)	Rs.1100 to Rs.1420
Idea Cellular (Rs.107.60-.65)	Rs.60 to Rs.107.50
ICICI Bank (Rs.289.20-.30)	Rs.210 to Rs.320
Hero Motocorp (Rs.3242.75-.3243.35)	Rs.2600 to Rs.3800
HDFC Bank (Rs.1309.30-.80)	Rs.1080 to Rs.1440
HDFC (Rs.1396.55-.75)	Rs.1220 to Rs.1520
GAIL (Rs.483.20-.40)	Rs.400 to Rs.550
Coal India (Rs.322.70-.75)	Rs.285 to Rs.360
Cipla (Rs.600.55-.65)	Rs.510 to Rs.710
BHEL (Rs.147.95 – Rs.148)	Rs.110 to Rs.175
Bharti Airtel (Rs.354.90-.95)	Rs.260 to Rs.440 except Rs.300
Bank of Baroda (Rs.184.60-.70)	Rs.130 to Rs.210
Axis Bank (Rs.495.10-.35)	Rs.400 to Rs.650
Asian paints (Rs.1001.90 – Rs.1002.00)	Rs.880 to Rs.1100
Ambuja Cements (Rs.237.15-.30)	Rs.200 to Rs.270
Adani ports (Rs.306.70-.80)	Rs.240 to Rs.340
ACC (Rs.1458.80-.85)	Rs.1200 to Rs.1560

3.4. Discussion on results:

In the previous section, we have explained the Put-Call parity and also explained that the failure to adhere to this parity would create an arbitrage opportunity. But the query that remains is again – why do these opportunities persist rather than disappear quickly. Similar to the Spot-futures arbitrage, the Put-Call arbitrage also has trade related to shorting stock or buying stock. If we recollect the discussion done in the Results analysis of the spot-futures markets we can explain this dilemma stating the similar reasons - that the rate of return on such trades are meager and the return is not worth the complexity of the trade.

Apart from the rate of return, volatility played vital role in existence of arbitrage for longer duration in case of Bharti Airtel. Various factors such as implementation costs,

information asymmetry, and liquidity impact the expected profitability from the existing arbitrage opportunities.

4. Limitations & Assumptions:

1. Data collected from the NSE website is delayed by a few minutes. This limits the practical implementation of the model in market because of arbitrage opportunities appear for short window.
2. To simplify our model we consider only one time margin (span margin + exposure margin) but margin calls are not included.
3. In options, margin percentages are calculated on mark to market basis which is not feasible in our model so we have considered margins remain constant at initial value.
4. As our model is applicable for short durations we have assumed that dividends are not paid in this duration.
5. Assumption is trader can borrow or lend at risk free rate, this may not be the scenario in real time.

5. Conclusion:

From the above discussions, we find that there exist arbitrage opportunities. Arbitrageurs utilize these opportunities to make risk-less profits and in this process the mispricing of the asset are corrected to their fundamental value but in some cases these opportunities are associated with certain risk. In this paper, we have analyzed two Indian derivative markets – Futures and Options using NIFTY 50 stocks as the underlying asset. In both the markets, we have seen that there exist scope for profit making using arbitrage. We have noticed that these mispricing due to market inefficiencies persist from time to time. This happens due to various factors such as fundamental risks, noise trader risk, information gap, financing issues, higher implied volatility, portfolio management problems, lesser liquidity of the markets and implementation costs that are accompanied by doing these trades.

6. References:

1. Buhler W., A. Kempf,(1994), "*DAX index futures: Mispricing and arbitrage in German markets*", Journal of futures markets, Volume 15, issue 7, pages 833-859
2. Mishra D., R. Kannan , S. Mishra, (2006), "*Arbitrage opportunities in the futures market: a study on NSE NIFTY 50 futures*"
3. Singh B.,(2003), "*Price discovery and arbitrage efficiency of Indian equity futures and cash markets*"
4. Roll R., E. Schwartz, A. Subrahmanyam, (2005), "*Liquidity and the law of one price: The case of futures/cash basis.*", Journal of Finance, Volume 62, issue 5, pages 2201-2234
5. Rosch D., (2013), "*The impact of arbitrageurs on market liquidity*"