Arbitrage Opportunities in the Futures Market: A Study of NSE Nifty Futures

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ABSTRACT

This paper aims at finding out whether there is a violation of spot-futures parity theorem in case of NSE Nifty futures and to find out different factors behind this violation. The different factors which have been considered as the determinants of arbitrage profits are: time to maturity; whether violation is more in rising markets or in declining markets; whether violation is more when theoretical futures price exceeds actual futures price or when actual futures price exceeds theoretical futures price; number of contracts traded; and change in open interest. The results indicate that there is a violation of spot-futures parity relationship for many futures of NSE Nifty. The results further indicate that arbitrage profits are more: for far the month futures contracts than for near the month futures contracts; for undervalued futures market (relative to the spot market) than for overvalued futures market (relative to the spot market); for high liquid futures than for less liquid futures; when new contracts are added than when outstanding contracts are settled. The results do not indicate anything whether the arbitrage profits are higher in declining markets or in rising markets.

Futures today constitutes the most important segment of the Indian Derivatives market since the inception of derivatives trading in June 2000. In June 2000, Securities and Exchange Board of India (SEBI) permitted two stock exchanges, viz., National Stock Exchange (NSE) and Bombay Stock Exchange (BSE), and their clearing houses to commence derivatives trading with the introduction of index futures contracts based on S&P NSE Nifty index and BSE-30 (Sensex) index. This was followed by the introduction of trading in options based on these two indices, options on individual securities and futures on individual securities. Inspite of the fact that it is less than six years since derivatives trading was introduced in the Indian stock market, there has been spectacular growth in the Indian derivatives market. The futures and options (F&O) segment of NSE reported a total turnover of Rs. 2,547,053 crores during 2004-05 as against Rs. 2,130,649 crores during 2003-04, Rs. 439,863 crores during 2002-03, Rs. 101,925 crores during 2001-02 and only Rs. 2365 crores in 2000-01. The turnover in the first ten months (April – January) of 2005-06 was Rs. 3,596,669 crores. Although futures on individual securities are more popular than those on indices, even then there has been massive growth in the turnover of index futures. The F&O segment of NSE reported an index futures turnover of Rs. 772,174 crores during 2004-05 as against Rs. 554.462 crores, Rs. 43,951 crores, Rs. 21,482 crores and only Rs. 2365 crores during 2003-04, 2002-03, 2001-02 and 2000-01 respectively. The index futures turnover in the first ten months (April-January) of 2005-06 was Rs. 1,165,355 crores.

Futures contract is one of the variants of derivative contracts. Futures contract is an agreement between two parties to buy or sell an asset at a certain time in the future for a certain agreed price. The certain agreed price is called futures price. Unlike forward contracts, futures contracts are traded on an exchange. To make trading possible, the exchange specifies certain standardized features of the contract. As the two parties to the contract do not know each other, the exchange provides a mechanism that gives the two parties confidence that the contract will be honoured. One of the parties to a futures contract assumes a long position and agrees to buy the underlying asset on a certain specified future date for a certain agreed price. The other party assumes a short position and agrees to sell the asset on the same date for the same price. Long futures gives the profit to the trader if the value of the underlying asset on the maturity date is

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more than the futures price. Short futures gives the profit to the trader if the value of the underlying asset on the maturity of the futures contract is less than the futures price. The underlying asset may be individual stock, stock market index, foreign currency, commodities, gold, silver, fixed-income securities. The profit to the trader acquiring long position in the futures contract is the value of the underlying asset at expiration minus futures price. The profit to the trader acquiring short position in the futures contract is futures price minus value of the underlying asset at expiration.

In the Indian stock market (NSE), the underlying assets are 3 stock market indices and 116 individual securities. As far as the present study is concerned, the underlying asset is broad stock market index based on NSE. Thus, for the present study the underlying asset is S&P CNX NSE Nifty.

There exists a deterministic relationship between spot and futures prices, irrespective of the investor demand for the futures. The theoretical spot-futures relationship can be developed to determine a futures price for a given spot price and other relevant information (risk-free rate, dividend yield and time to maturity). If the actual futures price differs from the theoretical price, there exists an arbitrage opportunity and an arbitrageur can set up a risk-less position and earn more than the risk-free rate of return.

The put-call parity relationship was originally developed by Cornell and French (1983). There are many studies which have empirically tested the spot-futures parity theorem. The major studies are: Bhatt and Cakici (1990); Cornell and French (1983); Figlewski (1984); Chung (1991); Modest and Sundaresan (1983); Mackinlay and Ramaswamy (1988); Yadav and Pope (1994); Brenner, Subrahmanyam and Uno (1989); Neal (1990); Brailsford and Hodgson (1997); Lai and Marshall (2002); Stoll and Whaley (1997); Vipul (2005); Klemkosky and Lee (1991); Butterworth and Holmes (2000); Garrett and Taylor (2001); Puttonen (1983); Hodgson, Kendig and Tahir (1993); Brennan and Schwartz (1990); Miller, Muthuswamy and Whaley (1994). Regarding the empirical verification of spot-futures parity relationship, the response is mixed. There are some studies which are in support of the spot-futures parity relationship and there are some which do not support the spot-futures parity theorem.

There are three kinds of participants in the index futures market: speculator, hedger and arbitrageur. Hedgers use index futures to eliminate the price risk associated with an underlying asset. Speculators use index futures to bet on future movement in the price of the underlying asset. Arbitrageurs use index futures to take advantage of mispricing. This paper has been analysed from the point of view of arbitrageurs. The objective of this paper is to find out whether the spot-futures parity relationship holds in case of index futures in the Indian stock market. The index which has been chosen as the underlying asset is NSE Nifty. This paper further aims at finding out different factors responsible for the violation of spot-futures parity relationship, if any.

This paper is divided into five sections. Section 1 deals with the theoretical framework. Sections 2 and 3 deal with the empirical model and the data base of the study respectively, section 4 discusses the empirical results and section 5 gives the summary and conclusion.

1. THEORETICAL FRAMEWORK:

In futures contract, there are two parties involved – one of the parties to a futures contract assumes a long position and agrees to buy the underlying asset on a certain specified future date for a certain agreed price. The other party assumes a short position and agrees to sell the asset on the same date for the same price. The buyer of futures contract believes that the asset prices will increase in the future. The seller of futures contract believes that the asset prices will decline in the future. In the discussion in the present section, stock has been assumed as the underlying asset.. The profits of the sellers (short futures) and buyers (long futures) in the futures market are as follows:

Profit from the long futures = $S_T – F_0$
Profit from the short futures = $F_0 - S_T$
Where:
S_T: the market price of the underlying asset on the maturity of the futures
F_0: current market price of the underlying asset in the futures market

There exists a theoretical relationship between spot price, futures price and other relevant variables such dividend yield, risk-free rate and time to maturity. If risk-free rate, dividend and time to maturity are given to us, for a given spot price, there will exist a unique theoretical futures price. If actual futures price is different from theoretical futures price, there will exist a pure arbitrage opportunity and the investor will be able to earn the cash flow that will yield him more than the risk-free rate of return.

Consider a portfolio consisting of selling a futures contract with time to maturity of T and investment in the underlying asset in the spot market.
The value of this portfolio at time T, when the futures expires is:

Value of short futures	$F_0 - S_T$
Value of underlying asset	$S_T + D$

Total	$F_0 + D$

Where r is the risk-free rate with continuous compounding and D is the dividend per share (if any) the stock is expected to pay on or before the maturity.
The portfolio mentioned above has a certain payoff on maturity.
Cost of establishing the portfolio = S_0
The portfolio which has deterministic payoff is expected to earn only the risk-free rate.

$$F_0 + D = S_0e^{rT}$$
$$F_0 = S_0e^{rT} – D$$
$$F_0 = S_0e^{(r-q)T}$$

Where:
S_0 is the current value of underlying asset;
F_0 is the current futures price of the underlying asset; and
q is the dividend yield with continuous compounding.

If the stock (underlying asset) is not expected to pay any dividend before the maturity of the option (i.e. D = 0), the above relationship can be written as:

$$F_0 = S_0e^{rT}$$

The above relationship is called as spot-futures parity theorem because it represents the proper relationship between spot and futures prices. The futures price derived from the above formulation is called theoretical futures price. If this relationship is ever violated, an arbitrage opportunity arises. If the above relationship is violated it indicates mispricing. To exploit mispricing, one should buy the relatively cheap portfolio and sell the relatively expensive portfolio to earn arbitrage profits. If actual futures price is greater than theoretical futures price, one can earn arbitrage profits by selling futures, borrowing S_0 from the risk-free market and buying the stock from the spot market. The value of profit on the maturity of futures contract is:

$S_T + (F_{0,A} – S_T) - S_0e^{rT}$

$F_{0,A} – F_{0,Th} = á$

Where:

$F_{0,A}$ is the actual futures price; and

$F_{0,Th}$ is the theoretical futures price

If theoretical futures price is more than actual futures price, one can earn arbitrage profits by buying futures, lending S_0 in risk-free market and acquiring a short position in the stock. The value of profit from this position on maturity of futures contracts is:

$-S_T + (S_T - F_{0,A}) + S_0e^{rT}$

$F_{0,Th} – F_{0,A} = â$

There will not be any arbitrage opportunity if á = â = 0

The above put-call parity relationship was originally developed by Cornell and French (1983). As spot-futures parity theorem, there are similar ways to determine the proper relationship among futures prices for contracts of different maturity dates. Assume $F(T_1)$ is the current futures price for delivery at date T_1, and $F(T_2)$ the futures price for delivery at T_2. Let q be the dividend yield (with continuous compounding) of the stock. We know from the spot-futures parity theorem that

$F(T_1)= S_0e^{(r-q)T_1}$

$F(T_2)= S_0e^{(r-q)T_2}$

$F(T_2)/F(T_1) = S_0e^{(r-q)(T_2 - T_1)}$

Thus, the basic parity relationship for spreads is:

$F_0 = S_0e^{(r-q)T}$

$F(T_2) = F(T_1)e^{(r-q)(T_2 - T_1)}$

The above relationship is called as basic parity for spreads because it represents the proper relationship between futures prices of contracts of two different maturity dates. For a given futures price with time to maturity of T_1, one can compute the theoretical futures price with time to maturity of T_2. If this relationship is ever violated, an arbitrage opportunity arises. If the above relationship is violated it indicates mispricing. To exploit mispricing, one should buy the relatively cheap portfolio and sell the relatively expensive portfolio to earn arbitrage profits. If actual futures price with time to maturity of T_2 is greater than theoretical futures price with time to maturity of T_2, one can earn arbitrage profits by:

a. entering a long futures position with maturity date T_1 and futures price $F(T_1)$;
b. entering a short futures position with maturity date T_2 and futures price $F(T_2)$;
c. by buying the asset and borrowing $F(T_1)$ from the risk-free market at time T_1 (when the first contract expires) ; and
d. paying back the loan with interest at time T_2.

Similarly, if actual futures price with time to maturity of T_2 is less than theoretical futures price with time to maturity of T_2, one can earn arbitrage profits by:

e. entering a short futures position with maturity date T_1 and futures price $F(T_1)$;
f. entering a long futures position with maturity date T_2 and futures price $F(T_2)$;
g. selling the asset and lending $F(T_1)$ in the risk-free market at time T_1 (when the first contract expires) ; and
h. receiving back the loan with interest at time T_2.

Thus the model given by Cornell and French can be applied in case of NSE Nifty options to exploit arbitrage profit arising out of violation of spot-futures parity theorem. The present study aims at finding out whether there exists an arbitrage profit due to violation of spot-futures parity theorem in case of NSE Nifty options and if there is a violation, then what are the factors responsible for the violation of this relationship. The different factors considered are: time to maturity; whether violation is more in rising markets or in declining markets; whether violation is more when theoretical futures price exceeds actual futures price or when actual futures price exceeds theoretical futures price; number of contracts traded; and change in open interest. A discussion on these factors follows in the following sections.

2. MODEL:

As mentioned earlier, the objective of this paper is to find out whether spot-futures parity theorem holds in case of NSE Nifty options and if it does not hold then what are the factors responsible for this violation. To verify the spot-futures relationship, theoretical put price is computed for a given value of NSE Nifty, risk-free rate and time to maturity. As far as the present study is concerned, the risk-free rate has been assumed as 5% with continuous compounding. The theoretical futures price has been computed as follows:

$F_{Th,\,t} = S_{A,\,t}\, e^{rT}$

Where:

$F_{Th,\,t}$: theoretical futures price for NSE Nifty with time to maturity of T on day t.

$S_{A,\,t}$: actual value NSE Nifty on day t.

r: risk-free rate per annum with continuous compounding.

T: time to maturity of the futures on day t.

After computing the theoretical futures price of day t for a given Nifty value, risk-free rate and time to maturity, this theoretical futures price is compared with actual futures price of day t with the same time to maturity. This is done by subtracting theoretical futures price from actual futures price with the same time to maturity. That is,

$A = F_{A,\,t} - F_{Th,\,t}$

$F_{A,\,t}$: actual futures for NSE Nifty with time to maturity of T on day t.

$|A|$: arbitrage Profit.

If A is significant and greater than zero, it means that futures price is too high relative to spot price and an arbitrageur can exploit this situation by earning arbitrage profit. In this scenario, he should short NSE Nifty futures, buy NSE Nifty from the spot market and borrow from the risk-free market. By acquiring this position, he will be able to generate sufficient cash flow that will yield him more than the risk-free rate of return.

If A is significant and less than zero, it means futures price is too low relative to spot price and an arbitrageur can exploit this situation by buying NSE Nifty futures, acquiring short position in NSE Nifty and lending in the risk-free market.

That is, if the value of A comes out to be significant (either positive or negative), arbitrageur can set up a position where he will be able to generate good amount of arbitrage profit.

The next objective of this paper is to find out if there is a violation of spot-futures parity theorem, what are the different factors responsible for this violation. This analysis has been conducted by using the regression technique. The variables which have been considered as the determinants of this violation are:

a. Time to maturity of the options. That is, number of days after which the options will expire.

b. Whether the violation is more when NSE Nifty value declines or when it increases. This has been measured by introducing dummy variable:

D_1 = 0, if NSE Nifty value decreases
D_1 = 1, if NSE Nifty value increases

c. Whether the violation is more when actual futures price is more than theoretical futures price or when actual futures price is less than theoretical futures price. This has been measured by introducing another dummy variable:

D_2 = 0, if $F_A < F_{Th}$
D_2 = 1, if F_A F_{Th}

d. Number of contracts. In case of NSE Nifty options, 100 index options is equal to one contract.

e. Change in open interest.

Thus the final model which has been considered for the present study is:

| $F_{A,\,t}$ – $F_{Th,,\,t}$ | = á + âT_t + ãD_1 + äD_2 + èNOC_t + ìOI_t + U

Where:

| $F_{A,\,t}$ – $F_{Th,\,t}$ |	:	Absolute difference between actual futures price and theoretical futures price on day t time to maturity of T_t.
T_t	:	Time to maturity of the option on day t.
D_1	:	Dummy variable D_1 = 1, if NSE Nifty value increases on day t D_1 = 0, if NSE Nifty value decreases on day t
D_2	:	Dummy variable D_2 = 1, if $F_{A,\,t}$ $F_{Th,\,t}$ D_2 = 1, if $F_{A,\,t} < F_{Th,\,t}$
NOC_t	:	Number of NSE Nifty futures contracts traded on day t.
OI_t	:	Change in open interest on day t.
U	:	Random disturbance term.

If estimated â is positive and significant it means that arbitrage profits are more for far the month futures contracts than for near the months futures contracts. If estimated â is negative and significant, it means that near the month futures contracts generate higher arbitrage profits than far the month futures contracts.

If estimator of ã is positive and significant, it means that arbitrage profits are more in rising markets than is there in the declining markets.

Positive and significant estimator of ä will indicate that the arbitrage profits are more when actual futures price is more than theoretical futures price than when actual futures price is less than theoretical futures price.

If estimated è is positive and significant, it means that futures which are more liquid generate more arbitrage profits than futures which are less liquid. Negative estimated è will indicate that less liquid futures generate more arbitrage profits than more liquid futures.

The model discussed above has been tested for NSE Nifty futures. This follows in the following sections.

3. Data:

The basic data for this study have been collected from www.nseindia.com, an official website of National Stock Exchange. The spot-futures parity relationship has been verified using daily data on value of NSE Nifty; time to maturity for different futures contracts available for trading; and number of contracts traded for different futures contracts.

To verify the spot-futures parity relationship, the sample carrying one year time period from 1^{st} November 2004 to 31^{st} October 2005 has been chosen. From 1^{st} November 2004 to 31^{st} October 2005, there were total 253 days available for trading and the number of observations for which trading was available with different time to maturity were 756. There were 3 observations per day for which trading was available for different time to maturity.

At any point of time, there were only three contracts available with 1 month, 2 months and 3 months to expiry. The expiry date for these contracts is last Thursday of expiry month and these contracts have a maximum of three months expiration cycle. A new contract is introduced on the next trading day following the expiry of the near month contract.

4. EMPIRICAL RESULTS:

The model described above has been tested for the NSE Nifty futures. At any point of time, there are three contracts available for trading with one month, two months and three months to expiry. If today is 15^{th} January 2005, three contracts are available for trading: January futures, February futures and March futures. January futures will expire on last Thursday of January. A new contact (April option) will be introduced on the next trading day following the expiry of January futures (near month contract).. The first objective of this study is to find out whether there is a violation of spot-futures parity theorem in case of NSE Nifty futures and if there is a violation what amount of arbitrage profits can be earned due to this violation. In the present study, arbitrage profits have been computed for different ranges of number of contracts traded and for different ranges of time to maturity.

The arbitrage profits for different ranges of number of contracts and for different ranges of time to maturity have been shown in tables 4.1 and 4.2 respectively.

Table 4.1: Arbitrage Profits and Number of Contracts Traded

Number of Contracts	Arbitrage Profits Per Contract (Rupees)			
	Mean	Maximum	Minimum	Standard Deviation
1000	3367	8069	245	1757
1001-5000	3151	6570	383	1460
5001-10000	2450	4812	705	1156
> 10000	1327	5458	5	1135
Overall	2422	8069	5	1748

Table 4.2: Arbitrage Profits and Time to Maturity

Time to Maturity	Arbitrage Profits Per Contract (Rupees)			
	Mean	Maximum	Minimum	Standard Deviation
30	1069	3628	5	884
31-59	2555	7306	33	1413
>60	3785	8069	833	1661

The arbitrage profits for different ranges of number contracts traded have been shown in Table 4.1. The results in Table 4.1 show that arbitrage profits are more for less liquid futures. For number of contracts traded between 1 to 1000, the mean arbitrage profit is Rs. 3367 per contract as against Rs. 3152, Rs. 2450 and Rs.1327 for number of contracts traded between 1001-5000, 5001-10000 and greater than 10000 respectively. The results further show that there is the largest variation in the arbitrage profits for the number of contracts traded between 1 to 1000. The standard deviation of the arbitrage profits for the number of contracts traded between 1-1000 is Rs. 1757 as against around Rs. 1200 for the number of contracts traded more than 1000.

Table 4.2 shows the amount of arbitrage profits earned for different time to maturity. The results indicate that larger the time to maturity, higher the mean arbitrage profit. Thus, far the month futures contracts generate more arbitrage profit than near the month futures contracts.

Another objective of this paper is to analyse the different factors responsible for the violation of spot-futures parity theorem. The model specified in section 2 has been used to find out different variables responsible for this violation. The independent variables which have been chosen as the determinants of violation of spot-futures parity theorem are: time to maturity of the futures contract; dummy variable indicating whether violation is more in rising markets or in declining markets; dummy variable indicating whether violation is more when theoretical futures price exceeds actual futures price or when actual futures price exceeds theoretical futures price; number of contracts traded; and change in open interest. The estimated regression model has been shown in Table 4.3.

Table 4.3: Regression Model

$|F_{A,t} - F_{Th,t}| = á + âT_t + ãD_1 + äD_2 + èNOC_t + ìOI_t + U$

á	Â	ã	ä	è	ì	R^2	Number of Observations
2.48 (1.42)	0.46 (17.36)*	0.93 (0.96)	-4.65 (2.00)**	1.83×10^{-5} (2.10)**	7.9×10^{-7} (1.98)**	0.45	756

Figures in parentheses show t-values
* significant at 1% level.
** significant at 5% level.
*** significant 1t 10% level.

The results of the estimated regression model show that all the coefficients have come out to be significant except the dummy variable one (D_1). Thus, on the basis of the estimated coefficients shown in Table 4.3, the overall results can be summarized as follows:

a. Arbitrage profits are higher for far the month futures contracts than for near the month futures contracts.
b. The results do not indicate anything whether the arbitrage profits are higher in declining markets or in rising markets..
c. Arbitrage profits are more for undervalued futures market (relative to the spot market) than for overvalued futures market (relative to the spot market).
d. High liquid futures generate higher arbitrage profits than less liquid futures.
e. Higher the change in open interest, higher the arbitrage profits. That is, arbitrage profits are higher when new contracts are added than when outstanding contracts are settled by reversing the position.

5. Conclusion:

Futures have constituted an important segment of the Indian derivatives market. In the Indian securities market, trading in index option commenced in June 2000. Even though it is less than six years since index futures trading was introduced in the Indian stock market, there has been spectacular growth in the turnover of index futures. The index futures turnover increased from Rs. 2365 crores during 2000-01 to Rs 1,165,355 crores during the first ten months of 2005-06. There are three kinds of participants in the index futures market: speculator, hedger and arbitrageur. Hedgers use index futures to eliminate the price risk associated with an underlying asset. Speculators use index futures to bet on future movement in the price of the underlying asset. Arbitrageurs use index futures to take advantage of mispricing. There exists a deterministic relationship between spot and futures prices. If the actual futures price differs from the theoretical futures price, there exists an arbitrage opportunity and an arbitrageur can set up a risk-less position and earn more than the risk-free rate of return.

The objective of this paper is to find out whether the spot-futures parity relationship holds in case of index futures based on NSE Nifty. If there is a violation of this relationship what are factors responsible for this violation. The results indicate that there is a violation of spot-futures parity relationship for many futures in case of NSE Nifty futures. The average arbitrage profit earned is Rs. 2422 per contract where as maximum arbitrage profit of Rs. 8069 was possible in one of the futures.

Another objective of this paper is to find out the factors behind the violation of spot-futures parity theorem. The different factors considered are : time to maturity; whether violation is more in rising markets or in declining markets; whether violation is more when theoretical futures price exceeds actual futures price or when actual futures price exceeds theoretical futures price; number of contracts traded; and change in open interest. The results of estimated regression models indicate that arbitrage profits are more: for far the month futures contracts than for near the month futures contracts; for undervalued futures market (relative to the spot market) than for overvalued futures market (relative to the spot market); for high liquid futures than for less liquid futures; when new contracts are added than when outstanding contracts are settled. The results do not indicate anything whether the arbitrage profits are higher in declining markets or in rising markets.

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