An Empirical Analysis on the Efficiency of Cost-of-Carry Model for
Pricing NSE Stock Exchange Futures Contracts
with special reference to Nifty Midcap 50 Index Futures

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Abstract

The study attempts to empirically test the pricing efficiency of the COC model especially adopted as a standard for calculating the price of the index futures. To achieve the objectives closing prices of the Nifty Midcap 50 index future contracts from NSE were collected for six year from January 2010 to December 2016. The theoretical prices being computed by the Cost of carry model were then compared with the actual prices of the index futures contracts which were collected from the NSE's website. The results validated the existence of mispricing in the calculation of future prices. Further, the extent of error was calculated with statistical forecasting models namely Mean Error (ME), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE). The outcomes have shown significant deviation from zero. Thus help us conclude that the prices being computed by the by the COC pricing model exhibit mispricing in index future derivatives.

Key words: Cost of carry model, index futures, derivatives

1. Introduction

1.1 Index derivatives in India

India has witnessed tremendous growth in the derivative segments in the past few decades. Both futures and options segments have performed extraordinarily. Also, since the Introduction of Index derivatives on 12th June 2000, the markets in derivative futures are continuously growing both in the case of market turnover and number of contracts being traded. The average turnover in daily basis has grown rapidly in index futures segment has also grown quickly from Rs 21483

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crore from the year 2001-02 to Rs 4478715 crore till 2018- 2019. Many researchers have made their contribution in analyzing the trend of these markets like (Sushma J, 2017). This triggers as a motivation to study the derivative future markets in India.

Also, derivatives are considered to play some very important econometric functions like price discovery, arbitrage, hedging. They also provide opportunities for effective risk management. The important questions, which lies here, is how can one takes decisions on whether to invest in futures for risk management or not. The only key factor, which influences the decision of investing in futures for managing the risk, is price predictability. There are many financial models prevailing in the market, which helps in the calculation of prices of future contracts. Among all of them, the widely used and standard model is the cost of carry. This study is an attempt of analyzing the pricing efficiency of this model.

Also, subsequently with Introduction of stock index futures, researchers have concentrated on the spot - futures relationships these are divided into three groups with three different approaches. The first group of literature investigated the validity of cost-of-carry model to discover the probable pricing inefficiencies in future markets. The second assembly of researchers investigated the causal relationship between the two markets namely spot – futures and the contribution these markets make to the price discovery procedure, whereas the third group of researchers studies the effects of volatility spillover between the spot and futures markets. This research work is a contribution to the first assembly of research which tests the pricing efficiency of the future pricing models.

1.2 The future pricing model

Pricing efficiency of the future pricing models has witnessed considerable volume of research by the international and national researchers. Most of these literatures have concluded that the futures markets are more efficient than the spot markets (Sushma J, 2019). There are few researchers who made deliberate efforts to forecast the prices of stock index futures under diverse assumptions and in different economic conditions. The review of these literature reveled that lot of researchers used a standard pricing model named the Cost of Carry Model (CCM) to determine the prices of the future derivative contracts.

The cost of carry pricing model is assumed to be one of the most appropriate model for calculating the prices of the stock index futures. The difference between the prices of index

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futures and the prices of the spot index is assumes to be the carrying cost. Additionally investigations can be done further to check if the carrying cost is positive or negative. Cornell and French (1983a, b) in their research incorporated arbitrage method for evolving a pricing model efficient enough to calculate the prices of the of future derivatives. They considered following assumptions:

1. The capital market is perfect –

2. There exists no transaction cost and taxes also there are no restrictions on short selling.

3. There exists no limit on borrowing or lending at the risk-free rate.

4. The risk-free rate is acknowledged with certainty.

The model is represented as

$$F = Se^{rt}$$ …………………………………………………………………………..(1)

Here F_t is considered as the theoretical price being calculated by the COC model at time t, S_t is considered as the spot price at time t, t is time to maturity which is being calculated as (T-t) and r is annualized risk-free interest rate.

2. Review of Literature

Many researchers have acknowledged the presence of price discrimination between the calculated theoretical price and the actual prices of the future contract they found that the actual futures prices were constantly below the theoretical value being calculated by the CCM. Fung and Draper (1999) in their research investigated the effects of mispricing of futures contracts using Cost of carry model by some economic factors like easing restrictions on short sales, Time-to–maturity of contract, cash market volatility, dividend payout rates and trading costs. Darren Butterworth & Phil Holmes (2012) in their research investigated on UK stocks and on two index future market namely FTSE mid 250 index futures and FTSE 100. Yiannos A. Pierides and Panayiotis C. Andreou (2008) did their research on Athens futures market. Wolfgang Buhler & Alexander Kemp (1995) studied the German futures market. Brailsford and Cusack (1997) researched on selected individual shares and on Australian Stock Exchange. Gay & Jung, (1999) investigated the underpricing in futures derivatives with respect to stock index futures. Brenner, Uno, Jun and Subrahmanyam, (1990) researched on Japanese individual Stocks and the derivative futures market. The above all researchers concluded that the theoretical price being

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calculated by CCM model is higher than that of actual futures prices. From the above literature it is evident that many researchers have done their empirical studies to test the Cost of Carry pricing model and found significant discrepancies between actual futures prices and theoretical prices estimated by the CCM. The model explains that Market volatility should not have impact on the future contract's prices. on the other hand, some researchers concluded that there exists a considerable correlation between the Index volatility and the Index futures mispricing. Fung, Paul, Joseph K W; Draper, (1999) investigated on Hong Kong index futures namely the Hang Seng Index and concluded that there is a correlation between the pricing error and the market volatility is positively related. This result is significantly similar to the findings of Yadav and pope (1990) who did research on FTSE 100 index futures Markets. John J. Merrick, Jr (1987) investigated on the S&P 500 Index futures and concluded that presence of the volatility influences the extent of mispricing in the futures prices. Gay and Jung (1999) studied relationship between the prices of Korean stocks index futures and the volatility. Stephen P. Ferris, Park & K Wang woo Park, Hun Y. (2002) did their research on S & P 500 futures index their research concluded that there exists inverse relationship between the prices of futures and the volatility. This means if there exists mispricing it is evident of the existence of increased volatility and that leads to lower pricing errors. This suggests that as the volatility increases, the investors start selling their underlying and their future positions with reasonably bigger drops in the pices of the futures contracts. Nai-fu Chen, Robert a. Haugen, and Charles j. Cuny, (1995) investigated on the S&P 500 index futures. They concluded that there exists inverse relationship between mispricing and volatility. This suggests that with increase in volatility the pricing error decreased. Thus they concluded that with increased volatility the basis. Panayiotis C. Yiannos A, Andreou and Pierides (April 2008) researched on the Athens futures market and concluded that the existence of mispricing in the prices calculated by the CCM is basically because of the existence of transaction costs, volume of volatility and the time to maturity of the contract.

On analysis of the above literature, it is clear that there exist pricing errors in the prices being computed by the CCM. But review of above literature portrays the maximum studies were conducted in the abroad and there are very fewer studies on the Indian markets. This motivates us to conduct an empirical analysis to test the pricing efficacy of the cost of carry pricing model.

3. OBJECTIVES OF STUDY

1. To check the data normality.

2. To evaluate the performance of stock index futures with respect to Nifty Midcap 50.

3. To analyze the pricing effectiveness of Cost of Carry pricing model with reference to Nifty Midcap 50 index future contracts.

4. HYPOTHESIS

4.1 Normality test:

(H_{01}): The data is significantly normal.

(H_{11}): The data is not significantly normal.

4.2 Pricing Efficiency Tests:

For testing the pricing efficiency of the COC model, the hypotheses are:

(H_{02}): Prices of Nifty midcap 50 calculated by COC model are efficient.

(H_{12}): Prices of Nifty midcap 50 calculated by COC model are not efficient.

4.3 Testing statistical significance of pricing errors of the pricing model.

1. For testing Mean Error (ME) statistics.

(H_{03}): There is no significant disparity in the values of Mean Error (ME) of the prices calculated by COC model.

(H_{13}): There is significant disparity in the values of Mean Error (ME) of the prices calculated by COC model.

2. For testing Mean Absolute Error (MAE) statistics.

(H_{04}): There is no significant disparity in the values of Mean Absolute Error (MAE) of the prices calculated by COC model.

(H_{14}): There is significant disparity in the values of Mean Absolute Error (MAE) of the prices calculated by COC model.

3. For testing Root Mean Square Error (RMSE) statistics.

(H_{05}): There is no significant disparity in the values of Root Mean Square Error (RMSE) of the prices calculated by COC model.

(H_{15}): There is no significant disparity in the values of Root Mean Square Error (RMSE) of the prices calculated by COC model.

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5. Research Methodology

5.1 DATA COMPILATION AND ANALYSIS

(a) Data collection: This research paper examines 1739 future contracts written on underlying index Nifty Midcap 50 future contracts during January 2010 to December 2016. To execute this sample of 1739 future contracts was obtained by collecting the closing prices of the index Nifty Midcap 50 from Indian National Stock Exchange's website. To obtain the homogeny among the data and reduce the impact of time gaps in the closing prices, only highly traded future contracts of near month were considered.

(b) Period: This research paper examines 1739 future contracts written on underlying Index Nifty midcap 50 for the time frame of 6 years (from January 2010 to December 2016).

(c) Data sources: The study used primary data for the various inputs required in the COC model. The data was collected from the Indian Stock Exchange's website. For the risk-free interest rate the rate of 90 days T. Bills was used. This was collected from the website of RBI (Reserve Bank of India) and is collected from the website www.rbi.org.in.

(d) Time to expiry: In the above-mentioned formula term. "t" is the time left for the future to expire. Here, calendar days have been used to calculate "t", irrespective of intervening holidays. Further "t" is annualized by dividing "t" by 365 days.

(e) Pricing accuracy: The accuracy of the prices being calculated by the COC model is tested by the forecasting models namely Mean Error (ME), Root Mean Squared Error (RMSE) Mean Absolute Error (MAE). The formulas for the above models are as follows.

Pricing Error (ε) = $AF_t - F_t$ …………………………………………………….(2)

1. Mean Error (ME): the value of mean error is the average error values. This is represented in the formulas as follows.

$$ME = \frac{1}{N}\sum_{j=1}^{N}(AF_t - F_t)$$ …………………………………………………..(3)

2. Mean Absolute Error (MAE):

3. $MAE = \frac{1}{N}\sum_{j=1}^{N}|(AF_t - F_t)|$. …………………………………………(4)

4. Root Mean Square Error (RMSE):

$RMSE = \sqrt{MSE}$…………………………………………………….……..(5)

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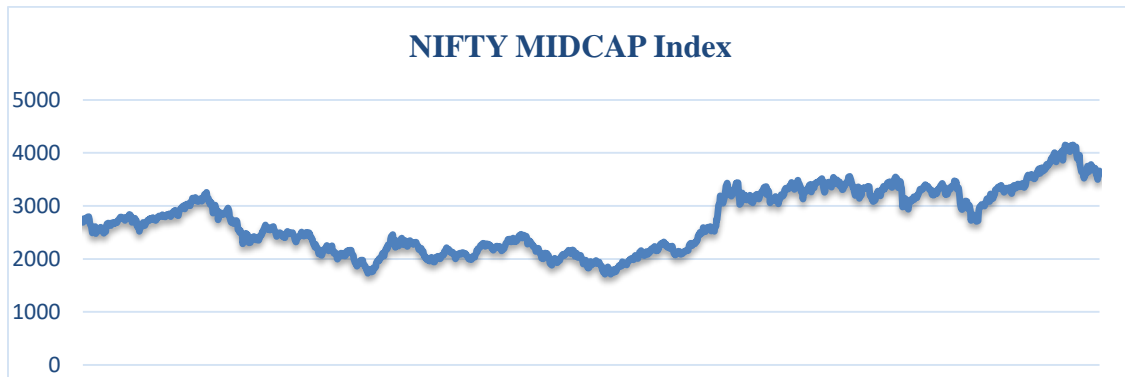
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6.**Empirical Results**

In the study Nifty Midcap 50 index is selected to check the effectiveness of the COC pricing model. The behavior of the selected index during the sample period is shown below in figure1.
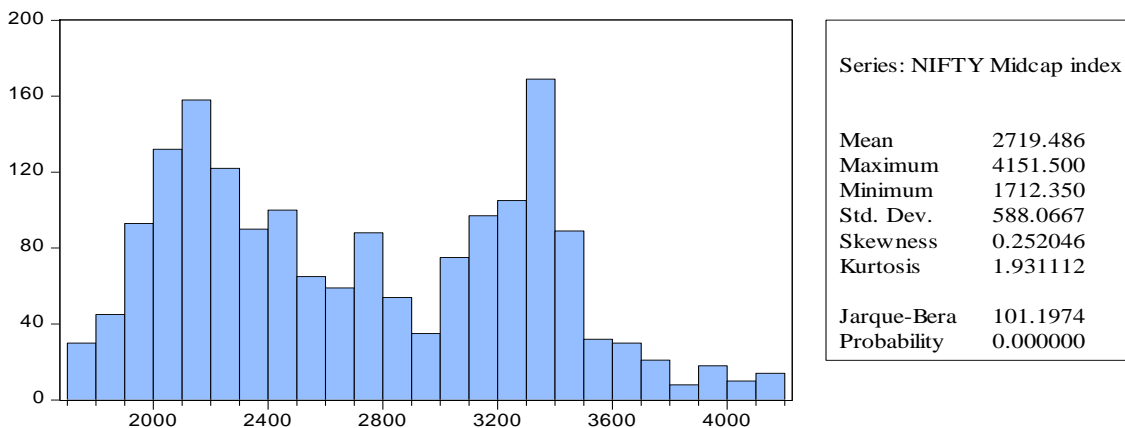
6.1 Normality test:

(H_{01}): The data is significantly normal.

(H_{11}): The data is not significantly normal.

(Source: Developed by Researcher)

Table 1: Descriptive Statistics for Nifty Midcap 50

Series: NIFTY Midcap index	
Mean	2719.486
Maximum	4151.500
Minimum	1712.350
Std. Dev.	588.0667
Skewness	0.252046
Kurtosis	1.931112
Jarque-Bera	101.1974
Probability	0.000000

(Source: Developed by Researcher)

The descriptive statistics of the selected index is also estimated in the study. The descriptive analysis of the index includes the evaluation of the mean, maximum, minimum, standard deviation, and the skewness and kurtosis measures of the series. The nifty midcap 50 series represents the index indicating the valuation of the included midcap companies in the index. The

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descriptive statistics of the nifty midcap 50 series indicates that the series has the minimum value of 1712 and the maximum value of 4151 during the selected period in the study. The mean/average value of the nifty midcap 50 series during the selected period is found to be 2719. The results also indicate that the standard deviation of 588 is found in the behavior of the index. The negligible positive skewness is found in the behavior of the nifty midcap 50index. In addition to this leptokurtic distribution is also detected in the distribution of the selected series. The Jarque Bera test statistic of the distribution of the nifty midcap 50 is found to be 101.19 with the probability value of 0.000, which is less than five percent significance level. hence the null hypothesis that the data is having normal distribution cannot be accepted here. The distribution of nifty midcap 50index is not normal due to the presence of leptokurtic distribution in the series.

Result 1: The null hypothesis (H_{01}) stating, "The data is is significantly normal is rejected and the alternate hypothesis (H_{11}), which states, " The data is not significantly normal is accepted.

6.2 Comparison of expected and actual price:

The hypothesis for testing Pricing performance of COC model:

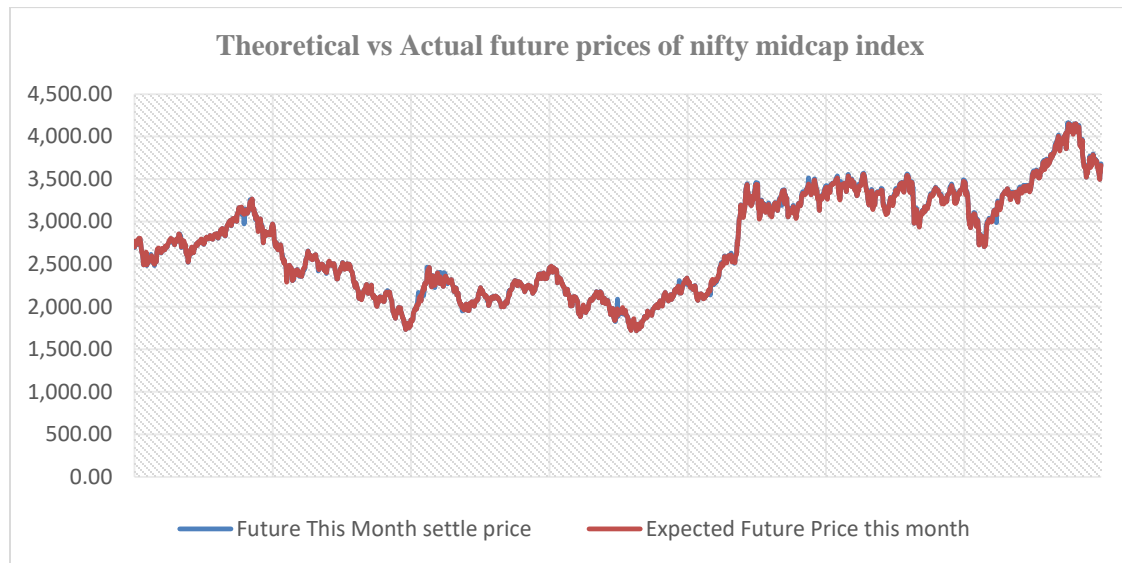**(H_{02}):** Prices of Nifty midcap 50 calculated by COC model are efficient.

(H_{12}): Prices of Nifty midcap 50 calculated by COC model are not efficient.

Following formula of COC model is being used in the study for the analysis.

$$\textbf{Future price } = \textbf{spot price} * \ \textbf{e}^{\textbf{rt}}$$

The comparison is done between the estimated theoretical future prices of the nifty midcap index with the actual future prices of the index. The diagram representing the estimated theoretical future prices of the nifty midcap 50 index and the actual future prices of the index is shown below:

Figure 2: Theoretical and actual nifty midcap future prices

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Theoretical vs Actual future prices of nifty midcap index

(Source: Developed by Researcher)

The difference of the estimated theoretical future prices of the selected index and the actual future prices of the index mispricing of the COC model.

From table 2, this can be predicted that the calculated prices by the COC model are also not normally distributed. They have a Jarque-Bera distribution pattern. Also, the theoretical prices are deviating from the actual future that shows a behavior of mispricing. This makes us arrive at result 2.

Result 2: seeing the results the null hypothesis (H_{02}) assuming that prices of Nifty midcap 50 calculated by COC model are efficient is rejected and the alternate hypothesis (H_{12}) assuming that prices of Nifty midcap 50 calculated by COC model are not efficient is accepted.

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Table 2: Descriptive statistics of theoretical and actual

	Expected nifty midcap future prices	Actual nifty midcap future prices
Mean	2724.500	2728.220
Median	2673.550	2670.000
Maximum	4151.500	4160.000
Minimum	1715.500	1716.450
Std. Dev.	584.9928	589.2350
Skewness	0.248946	0.254011
Kurtosis	1.936761	1.934573
Jarque-Bera	99.87469	100.9506
Probability	0.000000	0.000000

(Source: Developed by Researcher)

6.3 Testing COC forecasting efficiency with statistical errors:

The overall pricing accuracy of the COC Model has been also tested on the parameters of ME, MAE and RMSE Statistic to bring the clarity in research. The results are shown in Table 3.

The hypothesis for testing statistical significance of pricing errors of the COC model.

(H_{03}): There is no significant disparity in the values of Mean Error (ME) of the pricescalculated by COC model.

(H_{13}): There is significant disparity in the values of Mean Error (ME) of the prices calculated by COC model.

(H_{04}): There is no significant disparity in the values of Mean Absolute Error (MAE) of theprices calculated by COC model.

(H_{14}): There is significant disparity in the values of Mean Absolute Error (MAE) of the prices calculated by COC model.

3. For testing Root Mean Square Error (RMSE) statistics.

(H_{05}): There is no significant disparity in the values of Root Mean Square Error (RMSE) of the prices calculated by COC model.

(H_{15}): There is no significant disparity in the values of Root Mean Square Error (RMSE) ofthe prices calculated by COC model.

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Table 3: statistical representation of pricing errors of the COC model.

Total No. of observations	Mean Error (ME)	Mean Absolute Error (MAE)	Root Mean Squared Error (RMSE)
1739	-6.514	120.918	189.452

(Source: Developed by Researcher)

Result 3: The above table shows that the mean pricing bias of mean error (ME) is negative this shows that the prices calculated by the COC model are less than the actual prices. Since the values so calculated is not near to zero, makes us reject the null hypothesis (H_{03}) which is, "There is no significant disparity in the values of Mean Error (ME) of the prices calculated by COC model." and accept the alternate hypothesis (H_{13}) which is "There is significant disparity in the values of Mean Error (ME) of the prices calculated by COC model."

Result 4: from table 3 we observe that the mean pricing bias of Mean Absolute Error (MAE) is 120.918, which is way too far from zero. This shows that there is high pricing error in between the theoretical prices calculated by COC model and actual future prices. Thus the null hypothesis (H_{04}) stating, "There is no significant disparity in the values of Mean Absolute Error (MAE) of the prices calculated by COC model." is rejected and the alternate hypothesis (H_{14}) stating, "There is significant disparity in the values of Mean Absolute Error (MAE) of the prices calculated by COC model." Is accepted.

Result 5: the above table 3 shows the mean pricing biases of pricing errors calculated by Root Mean Squared Error (RMSE). The value so calculated is 189.452, which is far from the benchmark i.e. zero. Thus the null hypothesis (H_{05}) which is "There is no significant disparity in the values of Root Mean Square Error (RMSE) of the prices calculated by COC model" is rejected and accept the alternate hypothesis (H_{15}) which is "There is significant disparity in the values of Root Mean Square Error (RMSE) of the prices calculated by COC model" is accepted.

7. FINDINGS &CONCLUSIONS

An Empirical Analysis on the Efficiency of Cost-of-Carry Model for Pricing NSE Stock Exchange Futures Contracts with special reference to Nifty Midcap 50 Index Futures

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This study was focus to forecast the prices of index futures contracts by using the standard Cost of Carry Model for NIFTY Midcap 50 futures index of the National Stock Exchange (NSE) of India. The study focused on analysing the mispricing in the NIFTY Midcap 50 index futures. The results exhibit the presence of mispricing in the selected index future contract. Further, the efficiency of the COC model was investigated with the statistical forecasting models. Namely, Mean Error (ME), Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE). The COC model exhibited biases in pricing the future contracts in the entire forecasting models. This allows us to conclude that the pricing capacity of the cost of carry model is not efficient.

Reference

● Brenner, M., MG Subrahmanyam& J Uno (1990). "Arbitrage Opportunities in the Japanese Stock and Futures Markets". Financial Analysts Journal, 46, 14–24. ⒮

● J.K.W,Fung& Draper, P. (1999). "A Mispricing of Index Futures Contracts and Short Sales Con- straints". The Journal of Futures Markets, 19(6), 695-715.

● Gay, G.D. & Jung, D.Y. (1999). A Further Look at Transaction Costs, Short Sale Restrictions, and Futures Market Efficiently: The Case of Korean Stock Index Futures. The Journal of Futures Markets, 19(2), 153-174.

● Joseph K. W. Fung & Paul Draper (1999), Mispricing of Index Futures Contracts and Short Sales Constraints, The journal of Futures Markets, 695-715. ⒮

● Merrick, John (1987), Volume Determination in Stock and Stock Index Futures Markets an analysis of arbitrage and volatility, The Journal of Futures Markets, 483-496.⒮

● Nai-fu Chen, Charles J. Cuny, and Robert a. Haugen (1995), Stock Volatility And The Levels Of Basis And Open Interest In Futures Contracts; The journal of Finance; 50 (1); 281-300. ⒮

● Panayiotis C. Andreou&Yiannos A. (2008), " An Empirical Investigation Of Stock Index Futures Market Efficiency: The Case Of The Athens Derivatives Exchange; The European Journal of Finance, 14 (3), 211–223. ⒮

● Pradeep K. Yadav& Peter F. Pope (1990), Stock Index Futures Arbitrage: International Evidence, The journal of Futures Market, 10 (6), 573-603. ⒮

● Sushma, Jolly (2017), Derivatives in India: A study on evolution, growth and trends inIndian capital markets, VSRD International Journal of Technical & Non-

An Empirical Analysis on the Efficiency of Cost-of-Carry Model for Pricing NSE Stock Exchange Futures Contracts with special reference to Nifty Midcap 50 Index Futures

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TechnicalResearch, Vol. VIII Issue VI June 2017 / 189e-ISSN: 0976-7967, p-ISSN: 2319-2216

● Stephen P. Ferris, Hun Y. Park &Kwangwoo Park (2002), Volatility, Open Interest, Volume, and Arbitrage: Evidence From The S&P 500 Futures Market, Applied Economics Letters, 369 – 372.

● Sushma, Jolly (2019), An Empirical Analysis on the informational efficiency of future markets in India-with special reference to Nifty 50 Index Futures,Unnayan, International Bulletin management and economics, ISSN 2349-7165, Jan 2019 edition, volume 10, pg 331-340.

● www.nseindia.com

● 13.https://www.rbi.org.in/