AN EMPIRICAL INVESTIGATION OF IMPLIED VOLATILITY IN THE CONTEXT OF PRICING CALL OPTIONS ON SELECTED OIL & GAS SECURITIES OF NSE

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Abstract: This paper deals with study on utility of implied volatility for adopting option strategy of securities dealt in Oil & Gas sector of Equity Derivative of NSE. A comparison of implied volatilities is made to determine profit or loss in the context of option strategy. This paper will provide as guiding source for financial service providers to suggest investor the price band and timing of investment. The analysis of research will be helpful for the investors, prospective investors, Investment Bankers, Mutual funds, Insurance companies, Banks, academician, Research scholars to know option strategy in the light of implied volatilities.

Key words: Implied volatility, B-S option pricing model, Underlying Securities, In the Money (ITM), Out the Money (OTM)

1.INTRODUCTION:

The national Stock Exchange Limited in India has introduced trading in S & P CNX Nifty options from June 4th, 2001 and Options on individual securities from July 2nd, 2001. An option is the right, but not the obligation, to buy or sell underlying at a stated date at a stated price. The writer of option grants the right to the option holder in exchange for option premium. The option buyer retains all the benefits minus the option price, the maximum benefit an option writer realizes is only the option premium set against the downside risk of unlimited loss. This paper focuses on option strategy in the light of implied volatility. Implied volatility is perceived volatility of the investor in the light of current option price (Premium) which is based on Black-Scholes option pricing model. It may also be defined as the forecast of the underlying stock volatility as implied by the option prices. In the light of implied volatility option strategy is

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adopted by taking a long position in call option at a strike price where the implied volatility is low and short position in call option at which implied volatility is high as a result of the two positions' net profit is positive [1]. The paper contributes in adoption of option strategies in the light of implied volatility which in return assist in identifying the strike prices and time to maturities. It is also instrumental in identifying the profitable company for the option contract. ANOVA test is conducted to know the significant of difference between mean profit of all the four companies and Tukey's HSD test to identify which of the two companies return is more significant.

2. OBJECTIVES OF RESEARCH:

The research paper is based on the following objectives

- To know how do implied volatilities vary "across options".
- To assist investor in determining optimum strike price and timing of investment.
- To analyze variance in returns of companies as a result of option contract.

3. CONCEPTUAL FRAMWORK:

The research is based on B-S model. The model was basically developed to determine the theoretical value of option premium. But in the current research the model is used to determine implied volatility which is a basis for adopting option strategies.

3.1. Black-Scholes Model: The Black-Scholes formulas for the prices of a European call on a non-dividend paying stock and a European put on a non-dividend paying stock are given below [19]

$$c = S_0 N(d_1) - Xe^{-rT} N(d_2)$$ Where, $$d_1 = \frac{\ln\left(\frac{S_0}{X}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

The interpretation of the symbol is as follows:

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c = Price of a European call on a non-dividend paying stock; S_0 = Spot price of the underlying asset

X = Strike price of the option; T = Time to expiration expressed in years

r = Risk-free rate. ('r' considered in this model is the continuous compounding rate given by In (1+r).

σ = is a measure of volatility that measures the annualized standard deviation of continuously compounded returns on the underlying asset. While determining value, we consider annualized *sigma*, which is equal to daily sigma multiplied by root of number of trading days per year (252 days assumed). Symbolically,

$$\sigma_{annual} = \sigma_{daily} \times \sqrt{\text{No. of trading days}})$$

N (d) = Cumulative standard normal deviation of a variable that is normally distributed with a mean of 0 and a standard deviation of 1. N (d_1) is the delta of the option that measure the change in option price for a given change in the price of the underlying asset and N (d_2) is the probability of option being 'in the money'.

3.2. Implied volatility: It can be expressed as: $\sigma = f(S_o, E, C_o, t, r_f)$**.** Where σ = Implied volatility. By taking option price (Premium) quoted in the market and working backward deduces the market's opinion about the volatility of the option over the remaining life of the option. This is called implied volatility which is arrived from the quoted price of option. Such implied volatility is obtained by using Black-Scholes model and is calculated by using "GOAL SEEK" command of "What If Analysis" in MS-Excel [18].

3.3. Using Black Scholes model for American Option: The Black-Scholes model has been designed for the European type options which will be exercised only on expiration date. But, the Indian stock options are of American type, which can be exercised on or before expiration date. Hence, strictly speaking one can't use the formula in Indian option market. But, thanks for the fact that "It is never optimal to exercise early for an option that pays no dividend" [2]. Because of this, if we eliminate all arbitrary opportunities of American options, then as per the above fact,

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one will not exercise the options early hence can be treated like European options. In view of the above, all risk-free arbitrage opportunities, if any, to be eliminated from the sample to make use of the BS model for American type options. Thus, for the sample taken from Indian stock options, Black-Scholes formula can be used theoretically as well as practically.

4. REVIEWS OF LITERATURE:

4.1. Reviews on Black-Scholes Model: Dr. Rekha Kala A.M. and Dr. Shyam Lal Dev Pandey, (2012) conducted study to analyze the feasibility of Black-Scholes-Merton differential equation model for stock option pricing in Indian stock exchanges. The result of the analysis found that Black-Scholes-Merton model is more useful in call option pricing than the put option pricing and also impact of timing is more relevant for the put option pricing than for call option pricing [5]. **Jayapalan.C (2013)** provided a simple option pricing model to traders and other market participants in the market, to enable them to quote the optimum price through market prices of the underlying stock with market Index. The simplicity and ease of the proposed model may appeal to the traders, operators and other market participants [10]. **Mark Rubinstein (1994)** has pointed out that the performance of the Black-Scholes model has determined in recent years in the sense that options on the same stock with the same strike price that should have the implied volatility actually exhibit progressively different implied volatilities. He attributed this to an increasing fear of another market crash like that in 1987, noted that, consistent with this hypothesis, low strike price option are priced higher (i.e., with higher implied volatilities) than are other options. The market prices these options as though there is bigger chance of large drop in the stock price than would be suggested by the Black-Scholes assumptions. **Robert E. Whaley (1982)** examined the performance of the Black-Scholes formula relative to that of more complicated option formulas that allow for early exercise. His findings indicate that formulas allowing for the possibility of early exercise do better at pricing than the Black-Scholes formula. The Black-Scholes formula seems to perform worst for options on the stock with high dividend paying stock. The true American call option formula, on the other hand, seems to fare equally well in prediction of option prices on stocks with high or low dividend payouts [16].

4.2. Reviews on volatility and implied volatility: Isaac J. Faber and Kelsey Eargle (2014) focused whether a superior forecast for security volatility can be derived by finding a balance between

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historical data, implied volatility and an empirical implied distribution [9]. **Kawee Numpacharoen and Nattachai Numpacharoen (2013)** purposed their research to derive a new algorithm for obtaining a realistic implied correlation matrix. One contemporary method has limited scope from its simplified assumption of equi-correlation matrix. However, the result of this limitation is not realistic and cannot be applied to most applications. Another existing method may produce the realistic correlation matrix that is not positive-semi define. To handle this problem, they expanded the existing algorithm to obtain the realistic implied correlation matrix by using the relationship between two implied volatility of the portfolio of the underlying. Once the realistic and valid implied correlation matrix is obtained, they suggested the usage of this information in various applications such as portfolio optimization; stress testing, option pricing, dispersion trading, and so forth [11].

Puja Padhi (2011) examines the implied volatility linkages among the Asian, American and European stock markets. For this purpose, the study makes use of implied volatilities calculated from the market prices of stock index options from India (IVIX), Japan (VXJ), Hong Kong (VHSI), South Korea (VKSOPI), the US (VIX) and Germany (VDAX). The results of the study suggest that the US implied volatility index has substantial impact over the variations of other international implied volatility indices, thus raising the possibility of it constituting a usable risk factor for investors trading internationally; another issue here relates to abrupt changes in the VIX giving rise to potentially destabilizing contagion over volatility internationally. The implications of their results for India specifically at the market's current state of financial development are, at first glance, comforting, since none of the examined volatility indices bears a notable impact over their Indian equivalent [15]. Madhu Sudan Kumar at el, (2013) has used different simple methods to calculate the expected return and to interpret the annualized volatility. They have seen from the results that the same set of data gives variations in expected returns and affects the volatility. Their analysis shows that approximate value of option prices derived by different methods are very closed to the data of option price mentioned in Derivatives option trading at NSE [13].

5. RESEARCH METHODOLOGY:

5.1. Need of the study: The significance of study is highlighted based on following purposes:

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- How the implied volatility of options does relate to the best strike prices?
- To depict the significance of implied volatility in option strategy.
- To assist investor in determining optimum strike price and timing of investment for risk management.
- How does the option strategy can be adopted for maximization of profit by way of option contract?
- To analyze variance in returns of companies as a result of option contract.

5.2. Hypothesis: The proposed research is based on the following Hypotheses:

H1 : There is no significant difference in the mean returns of all the four companies across different time to maturities by way of option contracts. (ANOVA-test)

H2 : There is no significant difference between the mean returns of all pairs of companies across different time to maturities by way of option contracts (TUKEY's test)

5.3. Quantitative Design: The quantitative design selected for the proposed paper is experimental. In quantitative design measures are taken to identify the influence of implied volatility on strike prices and the effect of that on option profit.

5.4. Sample Summary: The sampling method followed for the proposed paper is convenient and quota where in only the public sector companies dealt in Oil and gas sector are included. There are 136 companies dealt in option market in NSE out of which 9 companies are dealt in Oil and gas sector of which four public companies are selected for the proposed research. The stocks are liquid based on the trading volume and is included in Fortune 500 and continuously traded in Derivative Market during the course of research. Prices of option and underlying are obtained from the official web site of NSE. MIBOR is assumed as risk free rate for calculating implied volatility.

5.5. Number of samples: The data for the proposed research will be obtained on Hindustan Petroleum Corporation, Indian Oil Corporation, Bharat petroleum Corporation and Oil and

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Natural Gas Corporation of Derivative segment of NSE. Securities Exchange Board of India (SEBI) so far has introduced 136 stocks option in NSE [17]. But all the stocks are not liquid at NSE. Therefore, our sample consists of four individual stocks of oil and gas sector that are the most liquid based on the trading volume and listed throughout the period of study. On each day on an average five strike prices of each of the four companies is analyzed in five data points with a difference of five trading days. As a result on each day twenty strike prices and during twenty five days one hundred strike prices are studied.

TABLE.1. REVENUE, PROFIT AND LOT SIZES OF SAMPLED COMPANIES

Ranks*	Underlying Stock	Revenue	Profit	Lot size
88	Indian Oil Corporation Ltd (IOC)	$85.5 bn	$0.8 bn	600
229	Bharat Petroleum Corporation Ltd., (BPCL)	$44.8 bn	$0.3 bn	1100
260	Hindustan Petroleum Corporation Ltd., (HINDPETRO)	$39.9 bn	$0.1bn	1300
369	Oil & Natural Gas Corporation Ltd., (ONGC)	$30.9 bn	$4.5bn	300

Source: Indian Petroleum and Natural Gas Statistics 2012-13 (In fortune 500*)

5.6. Tools of the study: In the course of research Black-Scholes model is used to calculate implied volatility and Analysis of variance test is applied to know the mean difference in the profit of option contract. Tukey's HSD test is applied on the rejection of ANOVA to find the causes of variance. Historical volatility is the only non-observable factor which assists in arriving at implied volatility. For the purpose of analysis descriptive statistics is used.

6. DATA ANALYSIS:

The calculated net profit in a sequence for each of the four companies and all the time to maturities by way of option contract is depicted in the table.2 below. The study is conducted from 27th Dec., 2013 to 30th Jan., 2014 by including prices from both equity and Derivative

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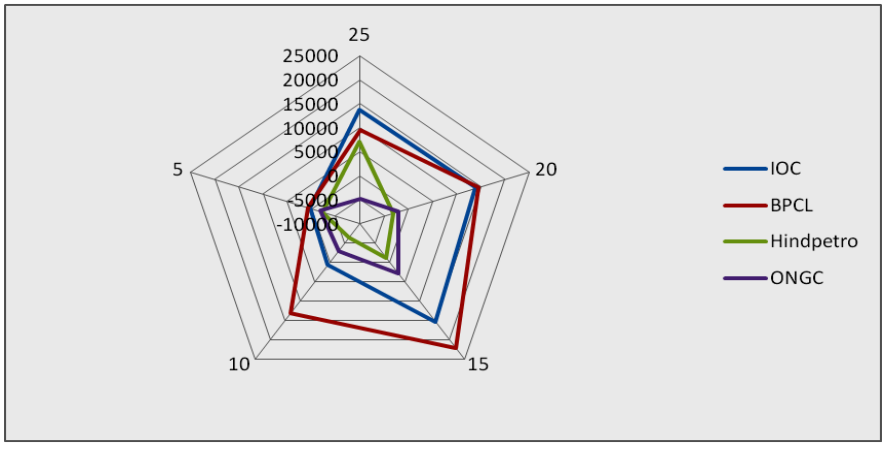
segment. This period includes 25 trading days which is divided into five time to maturities i.e., 25, 20, 15, 10, and 5 days. Computation of implied volatilities, pay offs and profit of all the four companies are made for five times to maturities (TTM).

TABLE.2. NET PROFIT/LOSS AS A RESULT OF CALL AND WRITING CALL OPTION

Companies	Time to Maturities (Trading days)				
	25	20	15	10	5
IOC	13620	13950	15360	690	300
BPCL	9405	14410	22110	13255	770
Hindpetro	7085	-3055	-1170	-6500	-2210
ONGC	-4965	-1995	2895	-2910	-1740

FIGURE.1. RADAR DIAGRAM DEPICTING THE MOST PROFITABLE COMPANY IN RELATION TO MATURITY.



The above table and radar diagram indicates profit horizon of IOC and BPCL is more among all the four companies and option contracts with fifteen days TTM are more profitable.

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7. EMPIRICAL IVESTIGATION AND CONCLUSION:

7.1. One way Analysis of variance test: To know the significance of difference between the mean returns of all the four companies One way Analysis of variance test is carried out the result of which is depicted below:

ANOVA: Single factor summary

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	43920	8784	57702330
Row 2	5	59950	11990	60610413
Row 3	5	-5850	-1170	25297188
Row 4	5	-8715	-1743	8329433

ANOVA						
Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	727859373.8	3	242619791	6.387279	0.004732	3.238872
Within Groups	607757450	16	37984840.6			
Total	1335616824	19				

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Conclusion: For comparing the mean return between companies' profit one way Analysis of variance is conducted. The result of the test indicates that the calculated value of F-Ratio (i.e., 6.387279) is more than the critical value (i.e., 3.238872) where n_1 is equal to 3 and n_2 is equal to 16 at 5% LOS. Therefore, the null Hypothesis is rejected; therefore the mean profit of all the four companies is not uniform across different options. At the end it is concluded that out of twenty data points in a month twelve data points provide desired result, therefore the model holds good in sixty percent cases and fifteen days of time to maturity seems to be desired period of investment in a diversified portfolio of Oil and Gas sector of Derivative Market of NSE.

7.2. Post HOC analysis and conclusion: Since the difference between the mean returns is significant therefore to know which of the two companies profit is more significant Post Hoc analysis is carried by using Tukey's HSD test. Equal number of data points triggers the use of Tukey's HSD test. The outcome of the test is obtained by using SPSS which is depicted following table:

Multiple comparison of Profit under Tukey's HSD

(I) Companies	(J) Companies	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-3208.00000	3897.51847	.843	-14358.8777	7942.8777
	3	9952.00000	3897.51847	.089	-1198.8777	21102.8777
	4	10525.00000	3897.51847	.068	-625.8777	21675.8777
2	1	3208.00000	3897.51847	.843	-7942.8777	14358.8777
	3	13160.00000*	3897.51847	.018	2009.1223	24310.8777

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	4	13733.00000*	3897.51847	.013	2582.1223	24883.8777
3	1	-9952.00000	3897.51847	.089	-21102.8777	1198.8777
	2	-1.31600E4	3897.51847	.018	-24310.8777	-2009.1223
	4	573.00000	3897.51847	.999	-10577.8777	11723.8777
4	1	-10525.00000	3897.51847	.068	-21675.8777	625.8777
	2	-1.37330E4	3897.51847	.013	-24883.8777	-2582.1223
	3	-573.00000	3897.51847	.999	-11723.8777	10577.8777

*. The mean difference is significant at the 0.05 level.

Legend: 1. IOC 2. BPCL 3. HPCL 4. ONGCL

The mean difference between BPCL and ONGC is very significant which is indicated with its P-value which is less than .05. They are reasons for significant difference in the mean profits by way of option contract of all the four companies. The profits of BPCL and ONGC are extremely high and low respectively during research period.

LIMITATIONS: The following are the limitations of the study

1. The study is confined to only call options.
2. Strike prices which are not traded are excluded from the study
3. Implied volatility at certain strike prices may not be calculated because GOAL SEEK [20] command of MS EXCEL does not support due to lack of synchronization among strike, spot, and option prices.

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4. The study is confined to only Oil and Gas sector of Equity derivative of NSE and can't be generalized.

REFERENCES

1. *Financial Risk Management*, the ICFAI University (2005), Nagarjuna Hills, Hyderabad. pp. 195-196.

2. John C. Hull, (2006) *"Options, Futures, and Other Derivatives" (*6th Edition), Prentice-Hall of India private Limited, New Delhi, pp. 302.

3. *Portfolio Management.* The ICFAI University (2005), Nagarjuna Hills, Hyderabad. pp.356.

4. *Security Analysis,* The ICFAI University (2005), Nagarjuna Hills, Hyderabad. pp. 492

5. Dr. Rekha Kala A.M. at al., (2012), *"A feasibility Analysis of Black-Scholes-Merton Differential Equation Model for Stock Option Pricing by Using Historical Volatility: With reference to selected stock options traded in NSE",*Asian Journal of Finance & Accting, Volume 4, No.2, 2012. Pp.86-105.

6. Ganti Subramanyam (1999) "*Financial Derivatives Foster Efficiency and Growth*", *Research papers on applied finance*, pp.579-589.

7. Ghanathe Ramesh at al, (2013), *"Derivative market in India"*, International Journal of Research in Commerce, IT and Management, Vol., 3, November, (2013), pp.37-40.

8. Guru, Anuradha, Indian Derivative Markets: Some Policy Issues (January 15, 2009). NSE NEWS, January 2009. Available at SSRN: http://ssrn.com/abstract=1428685

9. Isaac J. Faber and Kelsey Eargle. (2014),*" An Improved Composite Forecast For Realized Volatility",* Journal of Statistical and Econometric Methods, vol.3, no.1, 2014, pp. 75-84.

10. JAYAPALAN.C (2013) *"A simple pricing model for call options traded in NSE Nifty option market: theory, model & empirical test"* International journal of research in commerce and management, Volume no. 4, Issue no. 03, March, 2013, PP. 147-155.

.

11. Kawee Numpacharoen and Nattachai Numpacharoen, (2013), "*Estimating Realistic Implied Correlation Matrix from Option Prices"*, Journal of Mathematical Finance, Nov 2013, pp. 401-406.

12. Kedarnath Mukjerjee and Mishra .R.K. (2004), *"Impact of Open Interest and trading volume in Option Market on Underlying Cash Market: Empirical evidence from India Equity Option market"*, paper presented at " International Conference on Business and Finance, 2004", December 27-28, 2004, jointly organized by the ICFAI University, India and Philadelphia University, USA.

13. Madhu Sudan Kumar, Shom P. Das and Motahar Reza, (2013), *"Effect of Return and volatility calculation on option pricing: Using Bank Nifty"*, International Journal of Innovation, Management and Technology. Volume 4, No. 4, August 2013. Pp. 443-446.

14. Nejat Seyhun and Xuewu Wang, (2012), "*Return Predictability and Stock Option Prices"*, International Research Journal of Applied Finance, Vol. 3, Issue. 2, February, 2012, pp.171-205.

15. Puja Padhi. (2011) "*On the Linkages among Selected Asian, European and the US Implied Volatility Indices"*, NSE Working Paper.

16. Robert E. Whaley, "*Valuation of American Call options on Dividend-paying Stocks: Empirical Test*, Journal of Financial Economics 10 (1982).

17. www.nseindia.com source for obtaining the secondary data.

18. http://www.youtube.com/watch?v=TevtNOSqFsM - URL assist in using the GOAL SEEK command of MS-Excel

19. Black, F.and M. Scholes, "The Pricing of Options and Corporate Liabilities,"Journal of political Economy, 81 (May/June 1973): 637-59

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