

**Ballpark of Black Schole-Merton Model in option pricing**

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**Abstract**

*Options are instruments which have the special property of limiting the down side risk, while not limiting the upside potential, thus their use in hedging. The share of the options market in the Indian capital market has increase 64 % in just over a decade. This research paper emphasizes on the valuation of European call options by considering two industries comprising three companies respectively with 30 days of option expiry period from 2013 to 2015. Assessing the prices of two industries for particular period expiry with selected years for the study. It also explores relevance and accuracy of Black-Scholes Merton Option pricing model in predicting option prices. This research paper evaluates relative volatility of selected sample as the volatility is a significant factor influencing the option pricing; however, it is an awfully complex factor to forecast. Hence the crucial problem lies with the accurate estimation of volatility. The ballpark volatility can be used to establish future prices of the stock or the stock option.*

**Keywords:** Option Price, Black Schole Merton model, Volatility, European Call option

**INTRODUCTION**

Derivative products originally materialized, as hedging devices against oscillation in commodity prices and commodity-linked derivatives remain the solitary form of such products for almost three hundred years. The financial derivatives came into spotlight in post-1970 period due to growing instability in the financial markets. However, since their emergence, these products have become very popular and by 1990s, they accounted for about two-thirds of total transactions in derivative products. In recent years, the market for financial derivatives has grown tremendously both in terms of variety of instruments available, their complexity and also turnover. In the class of equity derivatives, futures and options on stock indices have gained more popularity than on individual stocks, especially among institutional investors, who are major users of index-linked derivatives.

**OBJECTIVES**

- To study the relevance and accuracy of Black-Scholes Merton Option pricing model.
- To study the degree of volatility of options comprising of two industries with respect to its maturity period.
- To study the Overpricing and under pricing of European call options.

**RESEARCH METHODOLOGY****Hypothesis**

Ho: There is no significant numerical difference between the Black Scholes Merton model value and market value.

H1: There is a significant numerical difference between the Black Scholes Merton model value and market value.

**Design of the Research**

- Methodology: The study intends to find the relevance and accuracy of Black-Scholes Merton Model in Indian Derivative Market. It can be considered as applied research.

- Sources of Data: The paper is based on the secondary data. Entire data required for the study have been collected from the website of NSE.
- Sampling method and sample: Purposive Sampling method is applied. Two Sectors actively traded Cement sector & Banking Sector stock options are selected. Sample comprises of only European Call Option.
- Statistical tools: Paired sample t test at 5 % significant level.
- Study period and Calculation: Annualized volatility computed based on the daily closing prices (Log Value) of the calendar year 2013, 2014 & 2015. Risk Free Rate – Government T Bill Yield at 8% kept constant to comply with assumptions of Black Schole Merton Model.
- Option Contract period for 30 days with strike price, one at the In the Money (ITM) and another one Out of the Money (OTM).

## REVIEW OF LITERATURE

- Abdullah Yusuf (June 17, 2014): The study has analysis the present study applies the GARCH model to estimate the volatility, and applies this estimated volatility to calculate option prices with the help of Black-Scholes-Merton model and applied GARCH model.
- Vipul Kumar Singh and Pushkar Pachori (2013): This study evaluated the prices are compared analytically through continuously updating the parameter of the models using cross sectional option date, almost on a daily basis and emphasizes on how to investigate the parameters of various models, pertaining specifically to a period of turbulence in the Indian economy. However, it remains challenging to root out price bias completely out of all models we have framed out and applied.
- Peter Kristofferson and Kris Jacobs (2003): It has emphasize that consistency in the choice of loss functions is crucial and described that for any given model, the loss function used in parameter estimation & model evaluation should be the same, and illustrated the important of these issues in an application of the so - called practitioner Black Scholes Merton model to S & P 500 index options.
- Varma (2002) :the study have evaluated the volatility pricing of the index options with the help of the Black-Scholes-Merton option pricing formula and the GARCH (1, 1) model and has found severe mispricing in Indian Index options. He has also established the significant difference in volatility smiles for call and put Options.
- Gurdip Bakshi, Charles Cao, Zhiwu Chen (1997): the study have focused on developing more realistic option pricing models, & tried to fill the gap by option model that allows volatility, interest rate and jumps to be stochastic, have also tried to examine several alternative models from different perspectives like hedging, out of sampling pricing etc.
- Vasanttilak Naik (1993): the study has developed a model in which the volatility of risky assets is subject to random and discontinuous shifts over time and analyses the trading strategies to hedge against the risk of jumps in the return volatility, he has justified that the model will capture the effect of such events on options market.
- Stan Becker (1981): the study has specifically the predictive ability of implicit standard deviations, taking into account the dividend problem and the problem of optimal weighting schemes of the standard deviations when there are several options on the same stock and transaction data information was used to study the importance of non-simultaneities in observing stock and option prices.

## Black – Scholes Merton Option Pricing Model

The Black–Scholes model was first published by Fischer Black and Myron Scholes in their 1973 paper, "The Pricing of Options and Corporate Liabilities", in the Journal of Political Economy Robert Merton also participated in the model's creation; that is why the model is sometimes referred to as Black-Scholes-Merton Model. This model is also awarded the Nobel Prize in Economics, hence it is widely accepted

option pricing model. The model takes into account, spot price, variance, and strike price, time to expiry and risk free rate.

The formula for computing option price is as under:

Call Option Premium

$$C = SN(d_1) - Xe^{-rt} N(d_2) \quad (1)$$

Put Option Premium

$$P = Xe^{-rT} N(-d_2) - S_0 N(-d_1) \quad (2)$$

$$d_1 = \frac{[\ln(S/X) + (r + \sigma^2/2)Xt]}{\sigma \sqrt{t}} \quad (3)$$

$$d_2 = \frac{[\ln(S/X) + (r - \sigma^2/2)Xt]}{\sigma \sqrt{t}} \quad (4)$$

OR

$$d_2 = d_1 - \sigma \sqrt{t} \quad (5)$$

Here,

C = price of a call option

P = price of a put option

S = price of the underlying asset

X = Strike price of the option

e = Exponential (which has the constant value of 2.718218)

r = rate of interest

t = time to expiration (in years)

$\sigma$  = annualized standard deviation of stock return

ln = Natural logarithm

$e^{-rt}$  = is a discount term on continuous compounding.

N = represents a standard normal distribution with mean = 0 and standard deviation = 1

N(d1) = is the area under the distribution to the left of d1

N(d2) = is the area under distribution to the left of d2

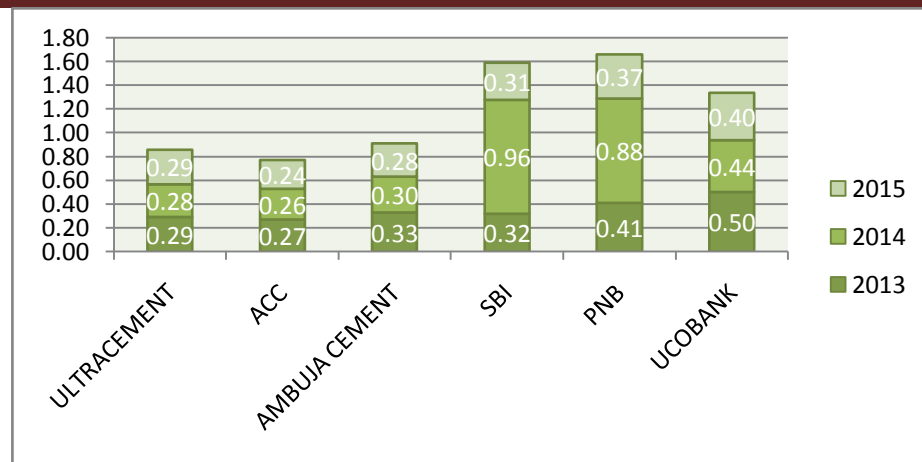
### DATA ANALYSIS AND INTERPREATION

Annuity Volatility = log values of daily closing price of stock are annualized and number of days considered in a year is 250 days.

**Table No.1: Annualized Volatility (in %)**

Companies	Annualized Volatility		
	2013	2014	2015
ULTRACEMENT	0.29	0.28	0.29
ACC	0.27	0.26	0.24
AMBUJA CEMENT	0.33	0.30	0.28
SBI	0.32	0.96	0.31
PNB	0.41	0.88	0.37
UCOBANK	0.50	0.44	0.40

**Chart No.1: Annualized Volatility (in %)**



**Table No.2:** Prediction of European Call Option of Cement Sector for 30 Days in 2013

Companies		Strike Price	Exercise Price	Option Value as per Black Scholes Model (BSM)	Market Price
ULTRATECH	ITM	1,850	1878.3	33.93	131
	OTM	1900		64.36	48.05
ACC	ITM	1200	1218.75	17.70	60
	OTM	1220		29.57	36.45
AMBUJA	ITM	180.00	182.35	4.38	7
	OTM	185		3.14	4.9

**Table No.3:** Prediction of European Call Option of Cement Sector for 30 Days in 2014

Companies		Strike Price	Exercise Price	Option Value as per Black Scholes Model	Market Price
ULTRATECH	ITM	2350	2382.2	41.64	118.15
	OTM	2400		72.06	87
ACC	ITM	1320	1337	19.80	103.95
	OTM	1340		32.05	94.35
AMBUJA	ITM	215	217.6	4.49	10.9
	OTM	220		7.55	8.7

**Table No.4:** Prediction of European Call Option of Cement Sector for 30 Days in 2015

Companies		Strike Price	Exercise Price	Option Value as per Black Scholes Model	Market Price
ULTRATECH	ITM	2950	2975.3	63.97	110.95
	OTM	3000		95.94	85.35
ACC	ITM	1500	1512.4	22.13	54.25
	OTM	1550		57.93	30.55
AMBUJA	ITM	235	237.6	4.57	9.85
	OTM	240		7.68	7.15

**Table No 5:** Prediction of European Call Option of Banking Sector for 30 Days in 2013

Companies		Strike Price	Exercise Price	Option Value as per Black Scholes Model	Market Price
SBI	ITM	2000	2046.75	36.19	105.55
	OTM	2050		63.61	78
PNB	ITM	760	760.05	32.63	17.7
	OTM	780		45.03	11.45
UCOBANK	ITM	75	75.75	3.70	3.4
	OTM	77.5		5.15	2.15

**Table No.6:** Prediction of European Call Option of Banking Sector for 30 Days in 2014

Companies		Strike Price	Exercise Price	Option Value as per Black Scholes Model	Market Price
SBI	ITM	2540	2542.25	277.42	106
	OTM	2560		288.82	94.25
PNB	ITM	940	943.8	92.47	64.4
	OTM	960		103.93	40.4
UCOBANK	ITM	102.5	103.9	4.08	10.7

	OTM	105		5.49	7.2
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**Table No.7:** Prediction of European Call Option of Banking Sector for 30 Days in 2015

Companies		Strike Price	Exercise Price	Option Value as per Black Scholes Model	Market Price
SBI	ITM	270	278.15	3.94	15.8
	OTM	280		9.39	10.4
PNB	ITM	150	153.65	3.72	6.9
	OTM	155		6.48	4.7
UCOBANK	ITM	62.5	63.8	1.89	2.1
	OTM	65		3.32	1.45

**OUTPUT OF SPSS**

Following Tables are the SPSS output of Paired Sample T-Test to evaluate the Black Schole Merton model and market prices of Thirty day call option price. To arrive at the below output above tables are drawn on as input.

**Table No.8:** ACC 30 Days European Call option

## Paired Samples Test

		Paired Differences				t	df	Sig. (2-tailed)	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower				Upper
Pair 1	BSMV - MV	-33.30667	39.71194	16.21233	-74.98179	8.36845	-2.054	5	.095

From the above table, the P value is greater than 0.05(significance), hence null hypothesis is accepted. It means that there is no significant numerical difference between Black Scholes Model Value and Market value of ACC European call option for 30 days from 2013 to 2015.

**Table No.9:** Ambuja 30 Days European Call Option

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	BSMV - MV	-2.05500	3.40070	1.38833	-5.62381	1.51381	-1.480	5	.199

From the above table, P value is more than 0.05(significance), hence null hypothesis is accepted. It means that there are no significant numerical differences between Black Scholes Model Value and Market value of Ambuja Cement European call option for 30 days from 2013 to 2015.

**Table No.10:** ULTRATECH Cement 30 Days European Call option

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	BSMV - MV	-34.75000	46.35115	18.92278	-83.39255	13.89255	-1.836	5	.126

From the above table, the P value is greater than 0.05(significance), hence null hypothesis is accepted. It means that there is no significant numerical difference between Black Scholes Model Value and Market value of Ultra Tech cement European call option for 30 days from 2013 to 2015

**Table No.11:** PNB 30Days European call option

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	BSMV - MV	23.21500	24.48633	9.99650	-2.48182	48.91182	2.322	5	.068

From the above table, the P value is more than 0.05(significance), hence null hypothesis is accepted. It means that there are no significant numerical differences between Black Scholes Model Value and Market value of PNB European call option for 30 days from 2013 to 2015.

**Table No.12:** SBI 30 Days European call option

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 BSMV - MV	45.15500	110.05003	44.92774	-70.33542	160.64542	1.005	5	.361

From the above table, the calculated value is more than 0.05(significance), hence null hypothesis is accepted. It means that there are no significant numerical differences between Black Scholes Model Value and Market value of SBI European call option for 30 days from 2013 to 2015.

**Table No.13:** UCO Bank 30 Days European call option

Paired Samples Test								
	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 BSMV - MV	-.55167	3.39077	1.38428	-4.11006	3.00673	-.399	5	.707

From the above table, the calculated value is more than 0.05(significance), hence null hypothesis is accepted. It means that there are no significant numerical differences between Black Scholes Model Value and Market value of UCO Bank European call option for 30 days from 2013 to 2015.

**Table No.14:** Banking Sector for 30 Days

Paired Samples Test								
	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 BSMV - MV	22.60611	64.11436	15.11190	-9.27721	54.48943	1.496	17	.153

From the above table, the P value is more than 0.05, hence null hypothesis is accepted. It means that there is no significant numerical differences between Black Scholes Model Value and Market value of Banking Sector (3 Companies) European call option for 30 days from 2013 to 2015.

**Table No.15:** Cement Sector for 30 Days of 3 Companies

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 BSMV - MV	-23.37056	36.60648	8.62823	-41.57453	-5.16658	-2.709	17	.015

From the above table, the calculated value is less than 0.05(significance), hence null hypothesis is rejected. It means that there is a significant numerical differences between Black Scholes Model Value and Market value of Cement Sector (3 Companies) European call option for 30 days from 2013 to 2015.

### CONCLUSION

Black Scholes model is used to find out the value of European call option for the two industries namely Banking and Cement. From the output of Paired sample t test reveals that calculated Black Scholes Morton Option values deviates from market prices for the cement industry and there is no significant difference between the calculated options values and market value for or the banking industry by considering two strike prices one is ITM and another one is OTM. In this study, I have selected 3 companies from each industry to check the accuracy of the option value with reference to market value. Paired t test is used to back up the statistics and calculation.

This study explores that more the maturity period more the volatile in the prices of options. The same has shown with paired sample t Test Company wise and industry wise together. Out of the selected sample, SBI and PNB shows high volatility in 2014. The option prices are depend on the time period, the longer the time, the higher the option pricing and shorter the time, the lower the option pricing. So, you should be careful while deciding the contract period. In this study I have kept risk free rate constant as per the assumptions of Black Scholes Model.

This study suffers from the several limitations that the selected sample is low and only 30 days maturity period is considered currently which also includes only two industries. To conclude, BlackScholes model of option pricing is best suited for European call option and found accurate by considering the strike and exercise price for the different maturity period and different years.

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