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Pricing Of Options In Indian Derivative Market: An Empirical Analysis

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Abstract

There has been tremendous growth in the use of financial derivative Instruments. The equity derivative include stock options, index options, stock futures and index futures. Among these products the growth rate of index options is remarkable due to risk management and trading the option pricing models occupied an important place in derivatives market. In the process of pricing correct pricing is very important to take a decision whether to buy or sell. There are different pricing models such as hall and White model, model of Heston and so on, but for this study Black and Scholes model is used, since it is the most Universally accepted model in pricing options. The main objective of the study is to determine the theoretical price of stock option using Black and Scholes model, Blacks model and Binomial option pricing model with theoretical and GARCH space volatility. The study also tries to find out if there is a significant difference between model price and actual market price of an option. GARCH volatility was used in these models which resulted in over estimating most of the stock premiums. The present study will have an influence on various groups in the financial market like investors and finance managers.

Key words: *Volatility, Pricing, Black & Scholes, Binomial Option pricing.*

INTRODUCTION

Derivatives, such as futures or options, are financial contracts which derive their value from a spot price, which is called the "underlying". An option is a contract between two parties in which one party has the right but not the obligation to buy or sell some underlying assets, at a stated price on or before a specified future date. The best known options are calls and puts. A Call option grants its purchaser the right to buy, the Put option grants its purchaser the right to sell. Strategies of options help the investors to limit the downside risk as well as to keep the upside potential unlimited. There has been a tremendous growth in the use of financial derivatives instruments in India (Fleming, J., 1998). The equity derivatives products include Stock Options, Index options, Stock Futures, Index Futures and Volatility Futures. Among these products the growth rate of Index options has been remarkable. Derivatives enable transferring of risk from the market participants who are having risk and not liking to take risk to the participants who have risk appetite. Due to this there are more players participating in the market leading to increased trading volumes in the market of underlying assets. At any point of time there are only three contract months available for trading, with 1 month, 2 months and 3 months to expiry. These contracts expire on last Thursday of the month and have a maximum of 3-month expiration cycle (Schaefer,S.M. and Schwarz, E.S., 1987). A new contract is introduced on the next trading day following the expiry of the near month contract.

REVIEW OF LITERATURE

Eraker (2004) has studied the empirical performance of jump diffusion models of stock price dynamics from joint options and stock markets data. The paper introduces a model with discontinuous correlated jumps in stock prices and stock price volatility, and with state- dependent arrival intensity. They have shown that while complex jump specifications add little explanatory power in fitting options data, these models fare better in fitting options and returns data simultaneously.

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Saravanan and Kumar (2012) attempted to find out the accuracy of the Black-Scholes option pricing model in pricing the stock option. Mean Absolute Percentage Error and Mean Absolute Deviation tools are employed to find the pricing errors between the calculated option prices and Market price of the option. The findings show that there is a small difference between the market prices and the calculated option market price.

Panduranga (2013) has empirically tested Black-Scholes on selected Indian banks and found the model appropriate for pricing majority bank stocks. However in the other research paper for select cement stock options, calculated model prices and market prices showed differences which were significant. The results show that model is relevant for the former and partially relevant for the latter.

Arora and Sharma (2015) calculated the theoretical prices of equity options using Black- Scholes Model and compared with the market prices. Mean Squared Error Method is used to know the difference in prices. Depending upon the prices of stock, its volatility and volume of stock the efficiency of Black Scholes Model differs .

Thakker and Attarwala (2016) tested the effectiveness of the Binomial option pricing Model for Indian Equity Options Markets from the year 2010 to 2015 by making use of Nifty Option. The results show that there is significant difference between the market price and the calculated price which shows the ineffectiveness of the Binomial Option Pricing model in pricing nifty call options.

Saedi and Tularam (2018) have analysed critically the advances done recently in the Black- Scholes model and the methods of solution. The current financial derivatives markets has some main issues which include large preferences by investors, transaction costs, high volatility and are illiquid. Due to the Complexity there is a need of non-linear solutions to the Black-Scholes equation and hence the R3C scheme and Crank-Nicolson method should be focused more by including more real-life assumptions of current day trading.

Schin Lin (2019), has found that there exists long observed feature of implied volatility surface such as volatility smile and skew. Stock market volatility models are commonly used to model this financial phenomenon more accurately compare to conventional Black and Scholes pricing model. In this study correlation effect have been taken into consideration. For the reason that the combination of multi-scale Volatility processes and jump diffusion process results in a higher dimensional differential equation. The results show that an efficient explanation for volatility smirks when we incorporate jumps into both the stock process and the volatility process.

RESEARCH GAP

On review of the literature, it is found that various pricing models have been used in various studies on pricing of options which include Black-Scholes model, Black's Model, Binomial Model, Artificial neural network, One-factor model of interest rates etc for different products like commodity futures, stock options, index options, options on Treasury bonds, interest rates, compound options etc and attempts are made to find the relevance of the models in pricing the products. Very less studies have been done on comparison between Black-schools, Black's and Binomial model on Indian options market. The present study attempts to analyse the applicability of Black-Scholes, Black's and Binomial Model with historical and GARCH volatility for stock options from NSE on recent data set.

OBJECTIVES OF THE STUDY

- To understand the concept of Option Contracts and its pricing.
- To determine the theoretical prices of Stock options using Black-Scholes model, Black's model and Binomial Option Pricing Model with historical and GARCH volatility.
- To find out whether there is a significant difference between model prices and the actual market prices of options.

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RESEARCH METHODOLOGY

This study is an applied research as it intends to find the relevance of Black-Scholes Model, Black's and Binomial Option pricing models in Indian Derivative Market. Study population constitutes 4 stock options which are the constituents of the Nifty 50 index.

Sampling Framework

Deliberate Sampling method is applied for the current study. For this study two public sector and two private sector Manufacturing companies have been considered Viz.. Ambuja Cement, Coal India, Bharat Heavy Electrical Ltd, CIPLA.

Tools for data collection

The historical data has been collected from the National Stock Exchange website. Weighted average interest rate of Central Government Securities is taken as proxy for risk free rate. Annualized volatility has been computed based on the daily closing prices of the previous financial year for each stock.

DATA ANALYSIS AND INTERPRETATION

The study aims to investigate the predictive performance of Black-Scholes, Black's and Binomial Option pricing models with historical volatility and GARCH volatility. The Empirical analysis is divided into following sections.

- Pricing of Stock Options using Black-Scholes, Black's and Binomial Model with Historical Volatility.
- Pricing of Stock Options using Black-Scholes, Black's and Binomial Model with GARCH volatility.

The Paired sample t-test reveals whether there is a significant difference between the calculated call option prices and the market price of options and it also shows whether the models are overestimating or underestimating the call option premiums.

1. AMBUJA CEMENT

Table 1: Option premiums and market premiums under Historical and GARCH Volatility of AMBUJA CEMENT.

		Historical Volatility			GARCH Volatility		
Month And Year	Market Premium (Rs.)	BS Model Premium (Rs.)	Black Model Premium (Rs.)	Binomial Model Premium (Rs.)	BS Model Premium (Rs.)	Black Model Premium (Rs.)	Binomial Model Premium (Rs.)
Jan-18	9.5	4.69	5.1	4.98	8.28	8.68	8.89
	7.5	2.33	2.57	2.14	5.91	6.22	6.29
Feb-18	9.05	5.04	4.78	5.29	12.28	12.07	13.18
	6.4	2.51	2.31	2.45	9.88	9.69	10.69
Mar-18	9.85	5.82	5.97	5.96	9.49	9.63	10.03
	7.15	2.99	3.07	3.12	6.9	7.01	7.45
Apr-18	8.1	5.24	4.64	5.42	8.92	8.41	9.48
	6.5	2.55	2.15	2.58	6.41	5.99	6.9
May-18	9.65	5.53	5.43	5.69	13.04	12.98	13.95
	7.1	2.77	2.68	2.85	10.59	10.53	11.47
Jun-18	9.55	4.3	4.09	4.51	7.66	7.49	8.19

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	7.2	1.86	1.72	1.67	5.26	5.12	5.61
Jul-18	10.5	5.55	4.95	5.56	8.05	7.53	8.4
	7.6	2.6	2.2	2.72	5.37	4.96	5.79
Aug-18	9.5	4.86	4.64	5.01	7.89	7.71	8.36
	5.8	2.2	2.04	2.17	5.38	5.23	5.77
Sep-18	7.85	5.23	4.81	5.3	7.17	6.81	7.5
	5.3	2.4	2.12	2.46	4.53	4.25	4.85
Oct-18	6.25	4.02	3.58	4.25	8.22	7.84	8.83
	4.1	1.7	1.43	1.41	5.88	5.57	6.28
Nov-18	6.15	3.66	3.08	3.88	5.58	5.04	5.98
	3.95	1.45	1.12	1.04	3.3	2.91	3.33
Dec-18	8.5	6.04	5.97	5.84	8.49	8.44	8.74
	6.85	2.81	2.75	3	5.7	5.65	6.15
Jan-19	6.9	4.18	3.78	4.44	7.04	6.68	7.55
	6.15	1.9	1.65	1.62	4.71	4.43	4.94
Feb-19	8.05	4.32	4.48	4.55	8.84	9.01	9.48
	5.65	1.91	1.99	1.73	6.46	6.59	6.94
Mar-19	7.25	4.03	3.91	4.29	7.66	7.57	8.24
	5.3	1.79	1.7	1.47	5.35	5.27	5.66
Apr-19	10	6.11	6.06	6.22	8.21	8.17	8.58
	7.25	3.22	3.17	3.4	5.52	5.48	5.94
May-19	9.05	5.31	4.59	5.59	8.56	7.9	9.14
	6.75	2.78	2.29	2.77	6.09	5.56	6.52
Jun-19	9	5.17	4.79	5.44	8.49	8.16	9.08
	6.9	2.66	2.4	2.62	6.05	5.77	6.47
Jul-19	9.85	5.3	5.38	5.52	8.58	8.67	9.12
	7.35	2.68	2.71	2.7	6.07	6.14	6.52
Aug-19	8.4	4.91	4.99	5.14	12.12	12.22	13.01
	5.8	2.37	2.41	2.32	9.72	9.8	10.53
Sep-19	9.25	5.35	4.6	5.35	8.2	7.57	8.59
	6.9	2.43	1.95	2.53	5.56	5.06	6.01
Oct-19	7.15	4.26	3.73	4.45	7.29	6.83	7.77
	4.6	1.8	1.48	1.63	4.87	4.51	5.19
Nov-19	7.95	5.68	3.77	5.77	9.33	7.63	9.85
	5.75	2.82	1.62	2.95	6.73	5.35	7.28
Dec-19	9.6	7.18	5.63	6.9	9.71	8.38	9.93
	6.85	3.83	2.74	4.09	6.81	5.74	7.33

Table 2: Comparison of Market premiums and model estimate premium as per Black- Scholes, Black's and Binomial Option Pricing model of stock options with Historical volatility.

		Paired Differences				**t**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**			

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					Lower	Upper			
AMBUJA CEMENT	Mkt premium – BS-model premium	3.91975	3.29283	0.30059	3.32455	4.51495	13.040	119	0.000
	Mktpremium - Bmodelpremium	4.28550	3.41382	0.31164	3.66843	4.90257	13.752	119	0.000
	Mktpremium - Binmodelpremium	3.89025	3.42073	0.31227	3.27193	4.50857	12.458	119	0.000

INTERPRETATION: For Ambuja Cements Ltd. option pricing using historical volatility the results reveal that the p value is less than 0.05 under Black-Schole model, Black's model and Binomial option pricing model which indicates that there is a significant difference between the calculated model prices and actual prices. All the three option pricing models are underestimating call option premium of Ambuja Cements Ltd.

Table 3: Comparison of Market premiums and model estimate premium as per Black- Sholes, Black's and Binomial Option Pricing model of stock options with GARCH volatility.

		Paired Differences					**t**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
AMBUJA CEMENT	Mktpremium - BSmodelpremium	0.35225	3.55195	0.32425	- 0.28979	0.99429	1.086	119	0.280
	Mktpremium - Bmodelpremium	0.68042	3.67974	0.33591	0.01528	1.34556	2.026	119	0.045
	Mktpremium - Binmodelpremium	- 0.05258	3.65903	0.33402	- 0.71398	0.60881	-0.157	119	0.875

INTERPRETATION: In the case of Ambuja Cements Ltd. call option pricing the results show that the p value is more than 0.05 under Black-Scholes and Binomial option pricing model with GARCH volatility which indicates that there is no significant difference between the calculated model price and actual price. These models are effective in pricing Ambuja Cements Ltd. Stock call option. While when Black's option pricing model with GARCH volatility is used the results reveal that there is a significant difference between the calculated model prices and actual prices of Ambuja Cements Ltd. Stock call options since the p value is less than 0.05. It is observed that the Black-Scholes and Black's model are underestimating call option premium of Ambuja Cements Ltd. Stock option while Binomial model has resulted in overestimating its call option premium.

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2. BHARAT HEAVY ELECTRONICS LTD

Table 4: Option premiums and market premiums under Historical and GARCH Volatility of Bharat Heavy Electronics Ltd,

		Historical Volatility			GARCH Volatility		
Month And Year	Market Premium (Rs.)	BS Model Premium (Rs.)	Black Model Premium (Rs.)	Binomial Model Premium (Rs.)	BS Model Premium (Rs.)	Black Model Premium (Rs.)	Binomial Model Premium (Rs.)
Jan-18	12.7	7.37	7.03	7.67	12.6	12.3	13.42
	8.05	2.71	2.51	2.29	7.95	7.72	8.44
Feb-18	11.15	9.2	6.86	9.26	13.83	11.72	14.49
	6.8	3.82	2.51	3.88	8.8	7.23	9.48
Mar-18	10.4	7.14	5.6	7.55	11.85	10.37	12.69
	6.15	2.75	1.96	2.17	7.34	6.26	7.66
Apr-18	10.9	6.72	5.36	7.16	11.8	10.48	12.68
	6.8	2.53	1.85	1.78	7.39	6.42	7.67
May-18	15.55	12.24	11.13	11.87	16.39	15.43	16.8
	10.4	6.03	5.28	6.49	10.86	10.1	11.75
Jun-18	13.15	8.59	6.27	8.69	12.9	10.79	13.54
	8.5	3.36	2.14	3.31	7.95	6.41	8.52
Jul-18	13.15	8.06	7.54	7.94	11.67	11.22	12.11
	8.25	2.67	2.39	2.56	6.64	6.31	7.1
Aug-18	14	11	10.23	10.03	13.88	13.23	13.8
	8.9	4.32	3.84	4.65	8.11	7.62	8.77
Sep-18	10.85	8.28	7.71	7.89	10.36	9.86	10.44
	5.9	2.54	2.25	2.51	5.03	4.7	5.35
Oct-18	6.55	4.72	4.33	5.01	8.15	7.79	8.75
	4.45	2.39	2.13	2.32	5.82	5.53	6.24
Nov-18	9.25	5.76	5.26	5.66	10.27	9.86	10.8
	6.5	2.78	2.44	2.97	7.72	7.37	8.37
Dec-18	7.5	2.4	2.4	2.57	5.21	5.22	5.62
	5.3	1.47	1.47	1.5	4.29	4.29	4.64
Jan-19	7.95	3.52	3.74	3.64	5.98	6.18	6.36
	5.7	1.53	1.65	1.49	4.05	4.21	4.36
Feb-19	6	3.1	3.05	3.3	7.36	7.33	7.94
	3.9	1.35	1.32	1.15	5.56	5.53	5.99
Mar-19	9.3	4.89	5.08	4.82	7.84	8.01	8.2
	7	2.03	2.14	2.13	5.28	5.41	5.72
Apr-19	7.1	4.25	3.88	4.35	6.98	6.65	7.39
	4.7	1.71	1.5	1.66	4.55	4.3	4.89
May-19	7.75	3.85	3.19	4.07	7.21	6.59	7.74
	5.8	1.6	1.24	1.38	4.92	4.44	5.25
Jun-19	6.85	6.12	3.63	5.82	9.39	7.25	9.71
	4.75	2.91	1.4	3.13	6.69	4.97	7.24
Jul-19	9.55	6.22	5.96	5.84	8.67	8.45	8.83
	6.8	2.93	2.75	3.15	5.86	5.69	6.33

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Aug-19	8.1	5.73	5.61	5.54	8.6	8.51	8.9
	5.6	2.66	2.57	2.85	5.92	5.85	6.42
Sep-19	6.95	3.94	3.79	4.06	6.6	6.47	7
	4.55	1.5	1.41	1.37	4.21	4.11	4.51
Oct-19	5.1	3.47	3.07	3.63	6.67	6.31	7.14
	2.95	1.54	1.3	1.48	4.79	4.5	5.16
Nov-19	9.3	6.24	5.65	5.91	8.73	8.24	8.93
	6.7	2.99	2.6	3.22	5.95	5.55	6.43
Dec-19	8.25	5.2	5.07	5.26	8.07	7.96	8.49
	5.65	2.45	2.36	2.58	5.53	5.44	5.98

Table 5: Comparison of Market premiums and model estimate premium as per Black- Scholes, Black's and Binomial Option Pricing model of stock options with Historical volatility.

		Paired Differences					**t**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
BHEL	Mktpremium – Bsmodelpremium	0.85992	6.16255	0.56256	-0.25401	1.97384	1.529	119	0.129
	Mktpremium – Bmodelpremium	2.01275	6.45925	0.58965	0.84519	3.18031	3.413	119	0.001
	Mktpremium - Binmodelpremium	0.54517	6.63860	0.60602	-0.65481	1.74514	0.900	119	0.370

INTERPRETATION:

In the case of Bharat Heavy Electricals Ltd. call option pricing using historical volatility the results reveal that the p value is more than 0.05 under Black-Sholes model and Binomial option pricing models which shows that there is a no significant difference between the calculated model price and actual price of Bharat Heavy Electricals Ltd. call options. This indicates that Black-Scholes model and Binomial option pricing models are effectively pricing call option of Bharat Heavy Electricals Ltd. But the p value is less than 0.05 under Black's option pricing model indicating that there is a significant difference between the calculated model prices and actual prices. Black-Scholes model, Black's model and Binomial option pricing models are underestimating call option premium of Bharat Heavy Electricals Ltd

Table 6: Comparison of Market premiums and model estimate premium as per Black- Scholes, Black's and Binomial Option Pricing model of stock options with GARCH volatility.

		Paired Differences				**t**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**			

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					Lower	Upper			
BHEL	Mktpremium – Bsmodelpremium	-3.44767	8.55443	0.78091	-4.99395	-1.90139	-4.415	119	0.000
	Mktpremium - Bmodelpremium	-2.22717	8.33070	0.76049	-3.73300	-0.72133	-2.929	119	0.004
	Mktpremium – Binmodelpremium	-6.28550	20.39642	1.86193	-9.97231	-2.59869	-3.376	119	0.001

INTERPRETATION: In the case of Bharat Heavy Electricals Ltd. option pricing using GARCH volatility the results reveal that the p value is less than 0.05 under Black-Scholes model, Black's model and Binomial option pricing model with GARCH volatility indicating that there is a significant difference in Bharat Heavy Electricals Ltd. call options. All thethree option pricing

1. CIPLA

Table 7: Option premiums and market premiums under Historical and GARCH Volatility of CIPLA.

		Historical Volatility			GARCH Volatility		
Month And Year	Market Premium (Rs.)	BS Model Premium (Rs.)	Black Model Premium (Rs.)	Binomial Model Premium (Rs.)	BS Model Premium (Rs.)	Black Model Premium (Rs.)	Binomial Model Premium (Rs.)
Jan-18	34.9	21	23.61	20.21	30.75	32.89	31.75
	25.85	8.32	9.82	8.68	19.79	21.42	21.36
Feb-18	35.7	20.47	20.93	19.69	32.79	33.18	34.1
	24.65	7.86	8.01	8.15	22.08	22.37	23.87
Mar-18	33	17.63	17.86	17.41	29.94	30.16	31.42
	22.3	6.11	6.13	5.87	19.67	19.82	21.19
Apr-18	34	24.39	23.81	21.96	34.51	34.06	34.95
	22.6	9.8	9.31	10.43	22.94	22.57	24.73
May-18	30.45	17.5	15.39	17.62	31.41	29.69	33.19
	20.9	6.45	5.23	6.09	21.33	19.97	22.97
Jun-18	37.6	25.37	24.08	22.99	34.63	33.61	34.93
	27.3	10.78	9.82	11.46	22.87	22.04	24.61
Jul-18	24.75	11.69	10.96	12.33	23.08	22.49	24.75
	14.7	4.7	4.23	3.68	16.02	15.53	17
Aug-18	30.05	18.23	16.12	18.1	29.78	28.05	31.22
	19.95	6.72	5.48	6.57	19.43	18.09	20.91
Sep-18	21.6	12.8	11.41	13.37	21.98	20.79	23.43
	12.55	3.74	3.06	1.84	12.68	11.83	12.98
Oct-18	15.95	14.1	11.97	14.55	23.77	21.95	25.23
	14.7	8.34	6.75	8.79	18.56	16.98	20.03
Nov-18	22.35	12.8	12.36	13.18	22.72	22.38	24.13
	16.95	7.09	6.71	7.41	17.56	17.26	18.96
Dec-18	22.6	11.09	9.79	11.47	21.49	20.41	22.91

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	17.1	5.62	4.72	5.71	16.47	15.55	17.79
Jan-19	19.9	11.6	10.8	11.99	18.8	18.12	19.94
	14.35	6.13	5.55	6.36	13.69	13.12	14.77
Feb-19	22.35	13.62	13.95	13.78	25.16	25.47	26.65
	16.95	7.65	7.84	8.15	19.96	20.22	21.6
Mar-19	18.9	10.2	11.02	10.62	16.81	17.57	17.89
	14	4.99	5.49	4.99	11.83	12.44	12.71
Apr-19	21.35	14.31	14.39	14.15	18.28	18.36	18.78
	15.45	7.98	7.99	8.53	12.53	12.58	13.49
May-19	21.15	13.75	12.63	13.82	20.36	19.42	21.32
	16.45	7.69	6.85	8.2	14.94	14.14	16.13
Jun-19	20.25	14.29	12.12	14.47	20.47	18.56	21.44
	15.3	8.29	6.69	8.85	15.02	13.44	16.21
Jul-19	20.55	9.99	9.99	10.66	15.67	15.7	16.83
	15.4	5.37	5.33	5.03	10.99	10.99	11.57
Aug-19	39.6	13	12.78	13.43	18.62	18.44	19.66
	15.9	7.41	7.2	7.81	13.37	13.21	14.4
Sep-19	20.7	12.77	10.64	13.19	19.35	17.44	20.47
	16.2	7.19	5.68	7.57	14.15	12.57	15.26
Oct-19	25	15.41	13.81	15.37	20.2	18.8	20.89
	16.65	9.12	7.9	9.75	14.51	13.34	15.62
Nov-19	20.05	10.05	10.25	10.71	16.4	16.62	17.62
	15.4	5.41	5.5	5.09	11.7	11.87	12.37
Dec-19	22.25	13.24	12.74	13.68	17.05	16.61	17.92
	13.4	3.88	3.6	2.43	7.62	7.33	7.23

Table 8: Comparison of Market premiums and model estimate premium as per Black- Scholes, Black's and Binomial Option Pricing model of stock options with Historical volatility'

		Paired Differences					**t**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
CIPLA	Mktpremium – Bsmodelpremium	8.46817	4.27712	0.39045	7.69504	9.24129	21.688	119	0.000
	Mktpremium – Bmodelpremium	8.81508	4.24221	0.38726	8.04827	9.58190	22.763	119	0.000
	Mktpremium – Binmodelpremium	8.72425	4.41075	0.40264	7.92697	9.52153	21.667	119	0.000

INTERPRETATION: For Cipla Ltd. option pricing using historical volatility the results show that the p value is less than 0.05 under Black-Scholes model, Black's model and Binomial option pricing models when historical volatility is used. This indicates that difference between the calculated model

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prices and actual prices of Cipla Ltd. is significant. The call option premium of Cipla Ltd. is found to be underestimated by the three option pricing models.

Table 9: Comparison of Market premiums and model estimate premium as per Black- Scholes, Black's and Binomial Option Pricing model of stock options with GARCH volatility.

		Paired Differences					**t**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
CIPLA	Mktpremium - BSmodelpremium	1.22633	3.40666	0.31098	0.61055	1.84211	3.943	119	0.000
	Mktpremium – Bmodelpremium	1.52517	3.29558	0.30084	0.92947	2.12087	5.070	119	0.000
	Mktpremium - Binmodelpremium	0.55650	3.84066	0.35060	-0.13773	1.25073	1.587	119	0.115

INTERPRETATION: It is observed that for Stock call option pricing of Cipla Ltd. the results show that the p value is more than 0.05 under Binomial option pricing model with GARCH volatility which indicates that there is no significant difference between the calculated model prices and actual prices. Binomial option pricing model with GARCH volatility has effectively priced call option of Cipla Ltd. But the p value is less than 0.05 when Black-Scholes model and Black's model with GARCH volatility is used for calculating option price indicating that there is a significant difference between the calculated model prices and actual prices of Cipla Ltd. call options. All the three models i.e. Black-Scholes model, Black's model and Binomial option pricing model with GARCH volatility are underestimating call option premium of Cipla Ltd. option.

2. COAL INDIA

Table 10: Option premiums and market premiums under Historical and GARCH Volatility of COAL INDIA.

		Historical Volatility			GARCH Volatility		
Month And Year	Market Premium (Rs.)	BS Model Premium (Rs.)	Black Model Premium(Rs.)	Binomial Model Premium(Rs.)	BS Model Premium (Rs.)	Black Model Premium(Rs.)	Binomial Model Premium(Rs.)
Jan-18	15.45	11.98	13.33	11.6	16.19	17.34	16.6
	10.5	5.62	6.49	6	10.58	11.47	11.42
Feb-18	16.3	13.74	13.98	13.05	16.62	16.84	16.65
	9.95	6.98	7.11	7.45	10.59	10.74	11.38
Mar-18	12.05	8.09	8.24	8.59	11.43	11.59	12.22
	7.3	3.54	3.59	2.99	6.8	6.9	6.92

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Apr-18	13.9	8.69	8.03	9.2	16.49	15.91	17.69
	9.75	4.01	3.58	3.6	11.79	11.32	12.59
May-18	18	14.33	13.25	14.05	22.39	21.51	23.33
	13	7.9	7.09	8.45	16.91	16.16	18.25
Jun-18	16.8	11.8	10.08	11.54	18.68	17.25	19.47
	11.85	5.58	4.44	5.94	13.31	12.15	14.4
Jul-18	18.2	12.01	11.86	11.27	15.99	15.87	16.2
	12.7	5.3	5.17	5.67	10.24	10.13	11.05
Aug-18	18.2	13.04	12.41	12.09	17.27	16.76	17.43
	10.25	6.08	5.62	6.49	11.41	11	12.29
Sep-18	12.65	10.66	9.71	10.52	15.49	14.69	16.1
	7.2	4.69	4.07	4.92	10.14	9.51	10.95
Oct-18	6.1	8.89	3.55	9.1	14.82	9.64	15.69
	3	3.63	1	3.5	9.85	5.98	10.58
Nov-18	15.4	13.08	10.65	12.11	19	17.05	19.41
	9.45	6.11	4.49	6.52	13.32	11.74	14.36
Dec-18	7.15	6.81	7.57	7.18	13.09	13.8	14.03
	4.5	2.38	2.73	1.58	8.51	9.04	8.95
Jan-19	13.5	10.01	10.12	9.59	14.2	14.3	14.58
	8.3	3.85	3.88	4.04	8.76	8.83	9.48
Feb-19	13.85	10.86	10.28	10.19	13.09	12.59	13.04
	8	4.36	3.98	4.64	7.23	6.87	7.81
Mar-19	11.1	5.98	6.44	6.31	9.81	10.26	10.5
	6.55	3.45	3.76	3.54	7.35	7.72	7.92
Apr-19	9.2	5.83	5.97	6.22	10.16	10.32	10.93
	6.8	3.47	3.55	3.45	7.79	7.92	8.35
May-19	14	7.89	8.1	8.18	11.66	11.86	12.35
	8.75	5.07	5.2	5.41	9.03	9.19	9.75
Jun-19	10.7	8.18	7.8	8.46	9.95	9.6	10.42
	7.95	5.31	5	5.68	7.2	6.91	7.75
Jul-19	9.5	7.35	6.68	7.68	8.96	8.34	9.47
	7.05	4.63	4.11	4.91	6.33	5.82	6.79
Aug-19	10.95	9.04	8.23	9.12	13.97	13.28	14.67
	8.15	5.94	5.28	6.35	11.24	10.63	12.11
Sep-19	11.25	8.29	7.35	8.41	11.95	11.12	12.53
	8.6	5.26	4.52	5.63	9.22	8.5	9.94
Oct-19	6.9	8.74	4.85	8.74	11.57	7.97	11.99
	3.2	3.25	1.36	3.19	6.37	3.99	6.76
Nov-19	7.35	7.55	3.81	7.84	9.35	5.68	9.84
	5.25	4.76	2.09	5.07	6.67	3.78	7.17
Dec-19	5.3	9.23	3.87	9.31	11.26	6.08	11.63
	4.35	6.11	2.16	6.53	8.36	4.16	8.98

Table 11: Comparison of Market premiums and model estimate premium as per Black- Scholes, Black's and Binomial Option Pricing model of stock options with Historical volatility.

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		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
COAL INDIA	Mktpremium – Bsmodelpremium	4.01175	5.49107	0.50126	3.01920	5.00430	8.003	119	0.000
	Mktpremium – Bmodelpremium	4.68458	5.21956	0.47648	3.74111	5.62806	9.832	119	0.000
	Mktpremium - Binmodelpremium	4.08775	5.42108	0.49487	3.10785	5.06765	8.260	119	0.000

INTERPRETATION: In the case of stock call options of Coal India Ltd., the results reveal that that there is a significant difference between the calculated model prices and actual prices of these stocks when Black-Scholes model, Black's model and Binomial option pricing models with historical volatility are used for pricing. The p value is less than 0.05 in the case of these stock call options under all the three models when historical volatility is used. Black-Scholes model, Black's model and Binomial option pricing models are underestimating call option premium of these stocks.

Table 12: Comparison of Market premiums and model estimate premium as per Black- Scholes, Black's and Binomial Option Pricing model of stock options with GARCH volatility.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
COALINDIA	Mktpremium - BSmodelpremium	-1.25367	5.90320	0.53889	-2.32071	-0.18662	-2.326	119	0.022
	Mktpremium - Bmodelpremium	-0.60450	5.77766	0.52743	-1.64886	0.43986	-1.146	119	0.254
	Mktpremium - Binmodelpremium	-1.91817	6.15829	0.56217	-3.03132	-0.80501	-3.412	119	0.001

INTERPRETATION: The results reveal that Black's option pricing model with GARCH volatility effectively prices the Coal India Ltd. call option. The p value is more than 0.05 indicating that there is no significant difference between the calculated model price and actual price. But when Black-Scholes and Binomial option pricing model with GARCH volatility are used to find the option price of Coal India Ltd. it is observed that the p value is less than 0.05 indicating that there is a significant difference between the calculated model prices and actual prices. Black-Scholes model, Black's and

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Binomial option pricing model with GARCH volatility are overestimating call option premium of Coal India Ltd.

MAJOR FINDINGS

1. In the case of Black-Scholes option pricing model using historical volatility it is observed that out of 4 stock options chosen for the study pricing of one stock call options i.e. Bharat Heavy Electricals Ltd. was done efficiently by the Black- Scholes model as the calculated prices are close to market prices but for other 3 stock call options it was observed that there is a significant difference between the actual and calculated call option prices of these stock option.

2. It is observed that the Black-Scholes model using historical volatility is underestimating majority of the stock call option premiums

3. Bharat Heavy Electricals Ltd. is found to be having no significant difference between the calculated model price using Binomial model with historical volatility and the market price and hence is effective in pricing these options. While the remaining stocks call options are found to be having a significant difference between the calculated model price using Binomial model and actual price.

4. It is observed that when the use of historical volatility is done the Black-Scholes, Black's and Binomial option pricing models resulted in underestimating most of the stock option premiums.

5. Among all the three option pricing models used in the present study by making use of GARCH volatility in their pricing equation, it is found that Blacks model is more efficient followed by Black-Scholes model and Binomial option pricing model.

6. It is found that the pricing efficiency of Stock options improves when GARCH volatility is used instead of historical volatility for volatility variable in the pricing equation of all three option pricing models namely Black-Scholes, Black's and Binomial option pricing model.

7. It is observed that Black-Scholes, Black's and Binomial option pricing model with historical volatility resulted in underestimating most of the stock option premiums. While when GARCH volatility was used the models were found to overestimate the stock option premiums in most cases.

SUGGESSTIONS

The concept of non –constant volatility has been introduced by GARCH process. It is revealed that all modes are effectively pricing most of the call options of stocks when GARCH volatility is used. Price is dependent upon the volatility calculated. Black-Scholes, Black's and Binomial Model with GARCH volatility can be used by investors and other participants to price the premiums as these models are found to be relevant for Indian market in many cases. Other approaches to test the model such as using implied volatility, calculated risk-free rate etc., can be carried out to evaluate the pricing performance.

CONCLUSION

The Black and Scholes model of option pricing is known for mispricing option on several parameters. Different models have been used in different studies in pricing of options which include Black's model, Binomial model, Artificial Neural Network etc. This study got in modifications to Black and Scholes, Black's and Binomial option pricing model related to the assumption based on volatility variable. GARCH volatility was used in the pricing equations. In the study an attempt was made to combine the study on applicability of pricing models and also on forecasting volatility. Empirical tests were conducted of the Black and Scholes, Black's and Binomial option pricing

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models with GARCH volatility. The outcome of the study was that GARCH Volatility variable resulted in improving pricing efficiency of the models in comparison to theoretical volatility variable. The calculated premium using the Black and Scholes, Black and binomial option pricing model is very close to market premium. These models with historical volatility resulted in underestimating most of the stock option premiums whereas the GARCH volatility was used in these three option pricing models it resulted in overestimating most of the stock option premiums. The present study will have an influence on various groups in the financial market like investors and finance Managers.

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