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STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

SCOPE FOR FURTHER RESEARCH

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- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

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- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

ESTIMATION OF STOCK OPTION PRICES USING BLACK-SCHOLES MODEL

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ABSTRACT

This paper attempted to predict the accuracy of the Black-Scholes option pricing model in pricing the stock option contracts for the selected 8 companies. The study uses the Black-Scholes model along with its parameters to estimate the stock option contracts prices. This helps in finding whether the stock options are rightly priced or not. The study finally attempts to identify the pricing errors between the Market price of the option contracts and the calculated option prices. This is done with the help of Mean Absolute Percentage Error and Mean Absolute Deviation tools. The results of the study indicate that there were only a small difference between the calculated prices and the market price of the option contracts.

KEYWORDS
Stock option, Option pricing, Black-Scholes model, MAPE, MAD.

INTRODUCTION

There have been significant developments in the securities market in India during the recent decade years particularly with the introduction of derivative products since June 2000. The introduction of derivatives was well received by stock market players since derivatives serve as a risk reducing tool for the high volatile financial markets. An option contract is a type of derivatives contract, which has gained much attention by the investors. A option contract is a right to buy/sell a specified quantity of the underlying asset for a certain agreed price at a specified future date. There are different models for option pricing and valuation that are proposed by different researchers and academicians. Among them the Black-Scholes (1973) option pricing model serves the important and widely used option pricing models.

RESEARCH ON OPTION VALUATION

James D. Macbeth and Larry J. Merville (1979) attempted to test the Cox call option valuation model for constant elasticity of variance diffusion processes against the black-Scholes call option valuation model. They found that the Cox Valuation model fits market prices of call options significantly better than the Black-Scholes Model. Hull and White (1987) shows that, when volatility is constant. The Black-Scholes implied volatility of an at-the-money option approximately equals the expected future volatility over the life of the option. Jayanth R. Varma (2002) evaluated the volatility pricing of the index options with the help of the Black Scholes 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.

Shih-Pei Hsing (2003) examined the hedging positions of the options by comparing GARCH deltas with the help of Black – Scholes model with the GARCH (1, 1) Model with respect to moneyness of the option contract. Jonathan Kinlay (2005) tried to discover whether the forecasting models using high end-frequency data and incorporating both long and short-term memory effects is capable of outperforming implied volatility in forecasting. Misra and et al (2006) aimed at finding out the determinants of the implied volatility and the study resulted in higher volatility for deeply in-the-money and deeply out-of-the-money options than the at-the-money options. Shamiri

Dash and ET AL (2009) used GARCH models to forecast underlying stock volatility, and used the forecasted volatility in the Black-Scholes model in order to determine whether the corresponding options are fairly priced or not. Neelam Mundra and Ravi Agarwal (2009) examined the implied volatility function for selected individual equity call options from Indian Stock market and analysed the extend of mispricing volatility.

Vanitha Tripathi and Sheetal Gupta tested the predictive accuracy of the Black-Scholes model in pricing the Nifty index option contracts. It also examined whether the skewness and kurtosis adjusted Black-Scholes model gives better results than the original Black-Scholes model. Ravi Agarwal and ET AL (2010) the study examines the reasons for the differences between the theoretical option pricing formula and the prevailing market prices and to study the conformance of implied volatilities to volatility smile/skew.

DATA

This study takes into consideration of only 8 stocks for the estimation of the stock option prices. The period of the stock prices considered is for 3 years starting from 1st January, 2009 to 31, December, 2011. This helps in estimation the stock option prices for the day on 1st, January, 2012. The list of companies shown for the study is presented below,

TABLE 1: SHOWING LIST OF SELECTED COMPANIES

S.no	Name of the Company
1	Axis Bank Ltd.
2	Bajaj Auto Ltd.
3	ICICI Bank Ltd.
4	Infrastructure Development Finance Co. Ltd.
5	Jai Prakash Associates Ltd
6	Punjab National Bank
7	Sesagoa Ltd.
8	Tata Consultancy Services Ltd.

METHODOLOGY

The study is executed by calculating the stock option prices using the Black-Scholes option pricing model for the Call option and Put options prices of the stock options for four different strike prices for all the contracts respectively. Later the calculated option prices are compared with the market prices using the Mean Absolute Deviation and Mean Absolute Percentage Error.

BLACK-SCHOLES OPTION PRICING MODEL

Fischer Black and Myron Scholes (1973) made a major contribution in the subject matter of derivatives when they developed the theoretical model for the pricing of European options on non-dividend paying stocks. The model influenced the academicians and practitioners in a great way to price and hedge European options. The Black-Scholes model for pricing of European options assumes constant volatility and Gaussian log-returns. The Black-Scholes formulas for option prices at time Zero (0) of a European call option on a non-dividend paying stock and the European put option on a non-dividend paying stock are,

For Call option the formula is,

$$c = S_0 N(d_1) - Ke^{-rT} N(d_2)$$

For put option the formula is,

$$p = Ke^{-rT} N(d_2) - S_0 N(d_1)$$

Where,

$$d_1 = \frac{\ln(S_0/K) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}$$

$$d_2 = \frac{\ln(S_0/K) + (r - \sigma^2/2)T}{\sigma\sqrt{T}}$$

or

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

Where the variables are,

S_0 is the stock price of the underlying stock at time zero

K is the strike price

e has the value 2.7128

r is the risk free rate

T is the time to expiry

σ is the stock price volatility

$\ln$ is the Natural logarithm

$N(x)$ is the cumulative probability distribution function

MEAN ABSOLUTE DEVIATION AND MEAN ABSOLUTE PERCENTAGE ERROR

The Mean Absolute Deviation and Mean Absolute Percentage Error were used to test the check the efficiency of the predicted values of share prices and option prices with the market prices.

ESTIMATION OF OPTION PRICES USING BLACK-SCHOLES MODEL

The option prices for both call option and put options are calculated using the Black-Scholes option pricing formula. The stock option prices are estimated for 4 different strike prices, i.e. two strike prices above the market price of the share and two strike prices lesser than the market share price of the stock. The tables below show the estimated call option prices and the put option prices along with its strike price.

ESTIMATION OF CALL OPTION PRICES

Using Black-Scholes Option Pricing Model the call option prices are estimated for four different strike prices. The strike prices are chosen as two strike prices above the current market price of the underlying stock and two strike prices lesser than the current market price of the underlying stock. The call option prices for the selected 8 companies are shown below:

TABLE 2: ESTIMATION OF CALL OPTION PRICES

S.No	Name of the company	Strike Price	Calculated Call option Price
1	AXIS BANK	760	62.50
		780	51.01
		800	41.04
		820	32.54
2	BAJAJ AUTO	1350	171.43
		1400	139.46
		1450	111.63
		1500	87.94
3	ICICIBANK	660	60.05
		680	48.27
		700	38.15
		720	29.65
4	IDFC	85	9.47
		90	6.40
		95	4.09
		100	2.48
5	JPASSOCIATE	45	8.84
		50	5.48
		55	3.11
		60	1.63
6	PNB	750	42.21
		760	36.78
		780	27.37
		800	19.84
7	SESAGOA	140	20.41
		150	13.66
		160	8.55
		170	5.02
8	TCS	1000	196.08
		1050	157.12
		1100	122.82
		1150	93.62

Source: Computed

Table 2 shows the call option prices estimated using the Black-Scholes model. The call option prices of the companies for four different strike prices show that the option price becomes lesser as the strike price of the option becomes higher and option prices become high when the strike prices becomes lower. This shows that the strike prices nearer to the market price of the underlying stock will always be high and vice versa.

ESTIMATION OF PUT OPTION PRICES

Using Black-Scholes Option Pricing Model the put option prices are estimated for four different strike prices. The strike prices are chosen as two strike prices higher than the current market price of the underlying stock and two strike prices lesser than the current market price of the underlying stock. The put option prices for the selected 8 companies are shown below

TABLE 3: ESTIMATION OF PUT OPTION PRICES

S.No	Name of the company	Strike Price	Calculated Put option Price
1	AXIS BANK	760	25.49
		780	33.94
		800	43.91
		820	55.36
2	BAJAJ AUTO	1350	42.01
		1400	59.89
		1450	81.92
		1500	108.08
3	ICICIBANK	660	47.00
		680	58.28
		700	70.72
		720	84.22
4	IDFC	85	2.27
		90	4.19
		95	6.87
		100	10.24
5	JPASSOCIATE	45	1.06
		50	2.69
		55	5.30
		60	8.81
6	PNB	750	23.78
		760	28.32
		780	38.86
		800	51.27
7	SESAGOA	140	2.90
		150	6.12
		160	10.99
		170	17.42
8	TCS	1000	14.58
		1050	25.47
		1100	41.02
		1150	61.68

Source: Computed

Table 3 shows the put option prices estimated using the Black-Scholes model. The put option prices of the companies for four different strike prices show that the option prices becomes lesser as the strike price of the option becomes higher and option prices become high when the strike prices becomes lesser. This shows that the strike prices nearer to the market price of the underlying stock will always be low and vice versa. This significance is in contradiction to the call option pricing strategy.

COMPARISON OF THE MARKET PRICES AND THE CALCULATED OPTION PRICES

The calculated option prices are compared with the market prices of the options under the different strike prices chosen for the study. This helps in knowing the accuracy of the estimated option prices. The comparison is done between the market prices and the option prices estimated historical volatility. The comparison is done for the call and put options under different strike prices. The comparison is done by estimating the deviation and error of estimation using the tools Mean Absolute Deviation and the Mean Absolute Percentage Error. The comparison of the prices are explained in the further sections

COMPARISON OF THE CALCULATED CALL OPTIONS PRICES WITH THE MARKET PRICES OF THE CALL OPTIONS

The comparison of the market prices and the calculated call option prices for different strike prices using the Mean Absolute Deviation and Mean Absolute Percentage Error. The results of the comparison are displayed below,

TABLE 4: COMPARISONS OF MARKET PRICES AND THE CALCULATED CALL OPTION PRICES

S.No	Name of the company	Strike Price	Market price	Calculated Call option Price	MAD	MAPE
1	AXIS BANK	760	60.9	62.50	0.80	3%
		780	42.45	51.01	4.28	20%
		800	32.8	41.04	4.12	25%
		820	24.9	32.54	3.82	31%
2	BAJAJ AUTO	1350	150.4	171.43	10.52	14%
		1400	113.7	139.46	12.88	23%
		1450	73.4	111.63	19.12	52%
		1500	50.35	87.94	18.80	75%
3	ICICIBANK	660	57.6	60.05	1.22	4%
		680	45	48.27	1.64	7%
		700	33.35	38.15	2.40	14%
		720	23.9	29.65	2.87	24%
4	IDFC	85	9.45	9.47	0.01	0%
		90	6.15	6.40	0.13	4%
		95	3.55	4.09	0.27	15%
		100	1.95	2.48	0.26	27%
5	JPASSOCIATE	45	8.95	8.84	0.05	1%
		50	5.1	5.48	0.19	7%
		55	2.5	3.11	0.31	25%
		60	1	1.63	0.32	63%
6	PNB	750	43.8	42.21	0.79	4%
		760	30.7	36.78	3.04	20%
		780	28.7	27.37	0.66	5%
		800	13.05	19.84	3.40	52%
7	SESAGOA	140	20.25	20.41	0.08	1%
		150	11.5	13.66	1.08	19%
		160	6.5	8.55	1.03	32%
		170	2.85	5.02	1.08	76%
8	TCS	1000	185	196.08	5.54	6%
		1050	138	157.12	9.56	14%
		1100	94	122.82	14.41	31%
		1150	62.75	93.62	15.44	49%

Source: Computed

From Table 4 it is inferred that the Mean absolute deviation for the market prices and the calculated prices of call options. The MAD values were ranging from 0.01 to 19.12. The comparison shows that the deviations were either minimum or zero for the lowest strike prices for all the selected call options. Relatively it was increasing for the higher strike prices.

The Mean percentage error value was ranging between 76 percent and 0 percent. The MAPE percentage becomes higher as the strike price of the option contracts is higher. This shows that the calculated prices were slightly higher than the market price of the option contracts.

COMPARISON OF THE CALCULATED PUT OPTIONS PRICES WITH THE MARKET PRICES OF THE PUT OPTIONS

The comparison of the market prices and the calculated put option prices for different strike prices using the Mean Absolute Deviation and Mean Absolute Percentage Error. The results of the comparison are displayed below,

TABLE 5: COMPARISONS OF MARKET PRICES AND THE CALCULATED PUT OPTION PRICES

S.No	Name of the company	Strike Price	Market price	Calculated Put option Price	MAD	MAPE
1	AXIS BANK	760	28	25.49	1.26	9%
		780	35.7	33.94	0.88	5%
		800	46.1	43.91	1.09	5%
		820	56.6	55.36	0.62	2%
2	BAJAJ AUTO	1350	16.7	42.01	12.65	152%
		1400	29.65	59.89	15.12	102%
		1450	35	81.92	23.46	134%
		1500	72.05	108.08	18.02	50%
3	ICICIBANK	660	17.3	47.00	14.85	172%
		680	24	58.28	17.14	143%
		700	32	70.72	19.36	121%
		720	41.4	84.22	21.41	103%
4	IDFC	85	2.1	2.27	0.09	8%
		90	3.6	4.19	0.30	16%
		95	6	6.87	0.43	14%
		100	8.8	10.24	0.72	16%
5	JPASSOCIATE	45	0.9	1.06	0.08	18%
		50	2.15	2.69	0.27	25%
		55	4.5	5.30	0.40	18%
		60	8.05	8.81	0.38	9%
6	PNB	750	32.55	23.78	4.38	27%
		760	27.4	28.32	0.46	3%
		780	48.7	38.86	4.92	20%
		800	49.8	51.27	0.73	3%
7	SESAGOA	140	2.95	2.90	0.02	2%
		150	5.9	6.12	0.11	4%
		160	9.75	10.99	0.62	13%
		170	16.65	17.42	0.39	5%
8	TCS	1000	6.15	14.58	4.21	137%
		1050	11.15	25.47	7.16	128%
		1100	20.45	41.02	10.29	101%
		1150	35.4	61.68	13.14	74%

Source: Computed

From table 5 it is evidenced that the Mean absolute deviation was less than 1 for 15 options of various strike prices. The MAD values were between 0.02 and 23.46. The Mean percentage error value was ranging between 172 percent and 2 percent. This shows that the calculated option prices were higher than the market price of the options.

CONCLUSION

The present study tests the predictive accuracy of the BS model in pricing the stock options for the selected companies and examines whether the estimated stock option prices are the same that of the original market prices The basic assumptions of the Black-Scholes Model like the Log-normal property of the stock prices, constant volatility, etc were also estimated before the estimation of the stock option prices. The study takes the stock price values for the study period from January 1, 2009 till December 31, 2011. The results conclude that calculated option prices were almost same of the market price when the strike prices are lower and the difference becomes more as the strike price becomes larger than that of the underlying asset price. This is evidenced by the Mean Absolute Deviation results and the Mean Absolute Percentage Error results. Thus it can be concluded that the market stock option prices ae relatively underpriced than the theoretically calculated prices which is a good indicator that the exchange allows a buyer friendly environment.

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