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CONTENTS

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   REVIEW OF LITERATURE

   NEED/IMPORTANCE OF THE STUDY

   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

   ACKNOWLEDGMENTS

   REFERENCES

   APPENDIX/ANNEXURE

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- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

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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

A SIMPLE PRICING MODEL FOR CALL OPTIONS TRADED IN NSE NIFTY OPTION MARKET: THEORY, MODEL & EMPIRICAL TEST

JAYAPALAN.C
SUPERINTENDENT
KERALA STATE ELECTRICITY BOARD
VAIDHYUTHI BHAVANAM
THIRUVANANTHAPURAM

ABSTRACT
A simple option pricing model is suggested based on correlation of underlying stock with actual market behavior as reflected by market index, thereby market factor coefficient to enable the traders to quote the prices. The simplicity and ease of the proposed model may appeal to the traders, operators and other market participants. Daily option Prices at different strike prices for the underlying stocks are calculated by applying daily Market Factor coefficient, exercise price, strike price and time to maturity. Model is tested with call option prices of select underlying stocks which constitute Nifty index of the National Stock Exchange of India. Option prices produced by the proposed model are close to the actual price for varied range of strike prices. The Model works perfectly to call in-the-money, at-the-money, and near out-of-money. Pricing difference is tested through tools such as Mean Error, percentage mean error, Root Mean Square, Thiel's U statistic. Regression analysis is also explored with traded prices on Call option prices obtained by the model. The simplicity and workability of the proposed model are its main advantages over the existing models.

JEL CODES
G13, G14.

KEYWORDS
Deep in-the-money call option, Derivative trading, Market factor coefficient, NSE Nifty, Option pricing model.

INTRODUCTION
An Option means a choice. Options belong to a class of instruments referred to as 'Derivatives' because they derive their value from an underlying commodity or financial assets. By definition, "derivative is a contract or an agreement for exchange of payments, whose value derives from the value of an underlying asset or underlying reference rates or indices". Price of a derivative instrument is contingent on the value of its underlying asset. The underlying commodities and financial assets can range from products like wheat and cotton to precious items like gold, silver, petroleum and financial assets like stocks, bonds and currencies. The underlying assets on options include stocks, stock indices, foreign currencies, debt instruments, and commodities and futures contracts. These are called stock options, index options, commodity options and futures options. Options have richer history. Forward contract dated back to Mesopotamian tablets (1750 B.C.). Phoenicians, Grecians, Romans traded options. Organized exchanges began trading option on equities in 1973.

An option in a financial market is created through a financial contract. This financial contract gives a right to its holder to enter into a trade at or before a future specified date. An option provides a downside protection against risk and also an upside benefit from movements in the underlying asset prices; that is as a hedge against unexpected changes in market and tool against erosion of capital.

An option is a contract in which the seller of the contract grants the buyer, the right to purchase from the seller a designated instrument or an asset a specific price which is agreed upon at the time of entering into contract. Option buyer has the right but not an obligation to buy or sell. If the writer gives the buyer of the option the right to purchase from him the underlying assets, it is call option. If the writer gives the buyer of the option the right to sell the underlying asset, the contract is termed as put option.

In 'The *Theory of Option in Stocks and Shares'*, Castelli referred to option pricing techniques. Louis Bacheliers's applications of stochastic phenomena, Wiener's mathematical development by path integrals method are some earlier major achievements in the analytical evaluation of options. *Theorie de la speculation* deals with the probabilistic modeling of financial markets and leads to Brownian motion and the mathematical modeling of financial market. Paul Levy and William terms the Brownian motion process the Bachelier Wiener Process. Samuelson's log normal model for stock prices formed the basis of the Black-Scholes Model option. Ito developed and improved Multiple Wiener Integral termed as Ito calculus and the stochastic differential equation. Ito calculus is front-runner to the theory of stochastic calculus. It is an alternative approach to binomial trees.

At the time of introducing an option contract, the exchange specifies the period during which the option can be traded or exercised, the period is termed as Expiration period and date at which contract matures is Exercise date. The price at which the underlying asset may be bought or sold is exercise or strike price. Option premium or option price is the amount which the buyer of the option, whether it be a call or put has to pay to the option writer. Intrinsic value of an option is the value of the profits that are likely from the option. The difference between the option premium and intrinsic value is referred as time value. An option whose exercise price is equal to current spot price is said to be at-the-money. A call option is in-the-money when the strike price is below the current spot price of the underlying asset. A put option is in-the-money where the strike price is above the current spot price of the underlying asset. A call option is said to be out-of-the-money when the strike price is above the spot price of the underlying asset. Put option is said to be out-of-the money when the strike price is below the current spot price of the underlying asset.

There are varied kinds of options—American options, European options, Bermudian options, Exotic or path dependent options, Look Back options, Barrier Options, Asian options. *American option* can be exercised any time before its expiration date while the *European option* can only be exercised on its expiration date. *Bermudian option* is partly American and partly European which can be exercised on a limited number of occasions, as stated in the contract, also known as quasi-American option. *Asian option* (Average Rate option) is a typical option that enables the holder the right to deal at the average price of the underlying asset during the holding period of option. Since the volatility of the average rate is less than the price of the underlying asset, these options are cheaper. In *compound option* an option holder is given the choice to acquire an option on an option. *Exotic or path dependent* options have values that depend on the history of an asset price and not just its value on exercise. *Barrier option*, a path dependent option which can be cancelled or activated depending upon the price of the underlying asset at various situations. *Up and out Options* are the natures of put options which stand to be cancelled if the price of the underlying asset exceeds a certain level. *Up and in options* are of no value, if the price of the subject asset rises above a certain level. *Down* and *out* options are calls which are treated as cancelled price moved down to a certain level. *Look Back option* is a special type of option which enables the holder the right to buy at the lowest price and right to sell at the highest price of the underlying asset during the tenure of the option. *Chooser option is* the option in which the holder is given the chance to choose the same as a put or call option within a certain time period. In the *Flex option* the traders agree to non-standard terms. Trading and pricing of stock options have occupied dominant place in derivative market. Numerous pricing models have been developed, studied and tested. The Black-Scholes model is based on the geometric Brownian motion and follows a Gaussian distribution; it provides a closed form analytical expression for valuation of European style options. It is an option valuation model not a theorem. The model is developed based on assumptions and there are limitations with any such model. When the assumptions of the model are relaxed, discrepancy occurs. According to John C Hull "An option pricing model is no more than a tool used by traders for understanding the volatility environment and for pricing illiquid securities consistently with the market prices of actively traded securities. If traders stopped using Black-Scholes and switched to another plausible model—the prices quoted in the market would not change appreciably".

REVIEW OF LITERATURE

Mandelbrot(1963) observed that the asset prices returns are highly leptokurtic. Numbers of studies were conducted to test the Black-Scholes model and other pricing models. Latane and Rendleman(1976) observed that out-of–money put options are generally overpriced in the market. *Macbeth* and *Merville***(**1979) found that implied volatilities tended to be relatively high for in-the-money options and relatively low for the out-of-the-money options. A high implied volatility is indicative of a relatively high option price and low implied volatility is a low option price. *Rubinstein*(1985) in his study on trades reported on Chicago Board Option Exchange during the period 1976 to 1978 found that for out-of-the-money options, short maturity options had significantly higher implied volatilities than long maturity options. Study of *Whaley*(1986) showed that, overall the deviation between actual market prices and theoretical prices not significant. The model under prices in-the-money options. Some models assumed that volatility of stock price process is not constant but stochastic. Heston(1993) derived an option pricing formula when the log of underlying price distribution followed a Gamma process. Some option pricing models are based on series expansions of the underlying prices to obtain the model. Corrado and Su (1996) used a Gram-Charlier expansion of the normal distribution of returns. Popova and Ritchken (1998) created bounds on option prices when the underlying asset had the Paretian stable distribution. The study by Raj and Thurston(1998) on an intra day basis found that model under prices both calls and puts. Heston and Nandi (2000) developed a closed form option pricing formula based on a Generalized Autoregressive Conditional Heteroskedastic (GARCH) process and found lower valuation errors. Savickas (2001) developed option pricing formula based on the Weibull distribution. Anurag & Satish(2002), Gururaj and Chug(2002) Varma(2002), Narayana Rao(2003) Schenbagaraman(2003), analyse the volatility and pricing efficiency of options in India. Varma(2003) studies the pricing of volatility in the Indian Index Options market found that volatility is severely misprices and the Indian option market has moved from naïve model to Black Scholes Model. Actual Stock price movement does not follow lognormal distribution. Ait-Sahalia and Duarte(2003) consider call price as a one dimensional function of the strike price alone, by using only options with equal time to maturity and assuming that interest rate and dividend yield are deterministic function of time. Yatchew and Hardle(2006) introduced non parametric least squares estimator. They assume the call price to be a function only depending of strike price. Gatheral(2006) defines profession of models someone who finds equations that fit prices in the market prices with minimal errors. Taleb and Goldstein (2007) show that most professional operators and fund managers use a mental measure of mean deviation as a substitute for variance. Broadie & Detemple(2004), Han(2008),Mitra(2009), Garcia, Ghysels, & Renault(2010) in their models relaxed some of the assumptions of Black Scholes-Merton Model.

NEED FOR AND OBJECTIVES OF STUDY

For option traders theories should arise from practice. Option price as far as traders are concerned depends on market conditions thereby on stocks and indices. In effect market conditions and related parameters. Option traders normally do not depend on theories. Traders may take decisions based on market conditions, but avoid fragility of theories. Traders specializing in using the put call parity to convert puts into calls or calls into put termed as converters. Dealers who basically operated as market makers can able to operate and hedge most of their risk by hedging option with options or cover their position by offsetting.

Operationally price is not valuation. Valuation requires theoretical frame work with its assumptions and the structure of a model. For traders, a price means marked to buy or sell an option. Traders are engineers, whether rational or even not interested in any form of probabilistic rationality. Traders produce a price of an option compatible with the instruments in the market, other market parameters, with a holding time that is stochastic. Many of the option pricing models are highly complex and involve rigorous mathematical computation. With many number of sophisticated algorithms, traders are perplexed with to choose which model they have to quote the price in the market. As such there arises need for simple option pricing model.

The study seeks to contribute the existing literature in many ways. Study is to examine the market factor, subsequently the pricing of option.

OBJECTIVES OF THE STUDY

1. To develop a model for pricing of call option to traders, professional and other market participants as reflected by Market Factor Coefficient (φ)based on the underlying assumptions.
2. To find the price of varied series of options of different stocks that constitutes NIFTY Index based on the proposed model.
3. To compare prices predicted by the model and observed prices in the market and its effectiveness.

RESEARCH METHODOLOGY

ASSUMPTIONS: In developing the model there are some underlying assumptions:

- Value of the option depends on market conditions or market forces. Traders quote their price based on such market conditions.
- Call Option is function of market factor coefficient (φ). Option price depends on current stock price, exercise price, time to maturity, market factor coefficient which in turn depends on market movement.
- Fund required for option transaction by long or short is on borrowed fund, rate of which is considered as rate equivalent to risk free interest rate. Since the trader has already decided to buy or sell option, it is assumed that rate has no impact on option price. As such no adjustment on this factor is required.
- Transaction cost in buying and selling the option do not be reflected in the price quoted by the trader.
- Traders normally do not exercise the option. Position is covered by offsetting or reverse transaction i.e., buy or sell.
- Corporate actions like dividend declaration, bonus issue, right issue, stock split, take over, acquisition, buyout, bankruptcy, window dressing are taken care of by the market thereby reflects in market and stock price reflects such changes or adjustment. It is assumed that no adjustment is required on this count.
- The option markets are efficient. Market factors reflect in fair value of the option. Volatility of the underlying stock has considered in the market factor coefficient.
- Number of contracts traded by the trader depends of on the availability of fund at his disposal. Options are tradable only for some strikes in the region.
- Traders may take decisions based on market conditions. Traders produce a price of an option compatible with market parameters.

For determining the market factor coefficient, historical data is considered in the estimation procedure. The current market price of the stock depends on market conditions. Options are tradable only for some strikes in certain range *(p,q) around the actual Spot Value St*. In a bullish regime actual Spot *St* will be near to *q.* In bearish regime it is closer to *p.* In practice the number of tradable options for given expiry could be small.

Let '*St*' current price of the stock traded on the day, when the trader marked to buy or sell option.

Xi^c and Xj^p are assumed to be set of exercise prices (X) for call or put options

Where

i = 1, 2… ……..Xq

j = 1, 2………… Xp

Let 'k_m' be the market index and 'k_j' be the closing price of the stock for 'd' number of days observed and recorded in intervals such as 0 to 7 days, 0 to 14 days, or any *0 to'd'* number of days etc. the option trader decided to trade on that call option. *For index options, closing price of the index option taken as k_m , and highest price during the traded day taken as'k_j.'* There are mainly three series of option contract available in the Indian market be gets matured in one month, two months or three months.

day	k_j	k_m	$(k_j - \bar{k_j})$	$(k_m - \bar{k_m})$	$(k_j - \bar{k_j})(k_m - \bar{k_m})$	$(k_m - \bar{k_m})^2$
0 1 2 3 d						
	$\sum k_j$	$\sum k_m$			$\sum (k_j - \bar{k_j})(k_m - \bar{k_m})$	$\sum (k_m - \bar{k_m})^2$

$$\bar{k_j} = \frac{\sum k_j}{n}$$

$$\bar{k_m} = \frac{\sum k_m}{n}$$

Market factor coefficient (φ_n) = $\dfrac{\sum (k_j - \bar{k_j})(k_m - \bar{k_m})}{\sum (k_m - \bar{k_m})^2}$ (1)

t Time to maturity from trading day to expiry date
e Exponential factor
St Current stock price of the stock on the day
X Strike Price

(φ_n) = Market factor coefficient for the day

N (φ) = Normal distribution of market factor coefficient φ from normal distribution Table

Market Coefficient (φ_n)is calculated up to the time trader decides to buy or sell the option based on the elapsed number of days

Proposed call option model $C = S_t N(\varphi_n) - Xe^{-t} N(\varphi_n)$

MAIN ADVANTAGES OF THE PROPOSED MODEL

1. Its simple form.
2. Ease of the model's implementation.
3. Practical application.
4. Adjustment factor and volatility taken care in the market factor coefficient.

DATA

The proposed model is tested using the actual values traded in the NSE option market. National Stock Exchange (NSE)of India promoted by financial institutions and erstwhile IDBI incorporated as per the provisions of the Companies Act, 1956 started operations in 1994 and within a year became largest exchanges in India operates in fully transparent and regulated environment marked by 50 stock index namely Nifty.

Derivatives occupy substantial share in the world of finance and in the Indian market, derivatives are governed by Securities Contract (Regulation) Act, 1956(SCRA). The SCRA was amended in 1999 to include derivatives within the purview of securities. Government of India accepted the recommendation of L C Gupta Committee Report on Derivatives (1997). The report suggested introduction of stock index futures as an initial step to be followed by other products, once the market stabilizes. Futures on bench market indices were introduced in June 2000. Index options in June 2001 followed by options on individual stocks in July 2001 and stock futures on individual stocks in November 2001.

The study covers call options written on select underlying stocks which constitute Nifty Index covering software industry, heavy chemicals, banking sector, FMCG, automobiles, during the period. Data for the study has collected from the website of the National Stock Exchange of India, www.nseindia.com. The date, time, contract month, option type, strike price has collected from the data source. Trading days has considered for analysis and computation and not calendar days. The number of trading days per year is assumed 250 days. Historical data is used for calculating the market factor coefficient φ_n Each stock moves variedly depending on market conditions. For calculating the market factor coefficient (φ_n) , the values prevailed to the time when the option trader marked the price (decided to buy or sell) is to be taken for stock price (k_j) and market index (k_m). Closing price of stock (k_j) and the closing price of market index (k_m), for traded days (n) or any other traded days is considered for computation of the market factor coefficient (φ_n). Exercise or strike price (X) of available series is taken for calculation and St as current stock price.The Normal distribution of Market Factor Coefficient φ , from the normal distribution table viz, N (φ).

Using market data to test any asset pricing model involves
"An asset is incorrectly priced by the model.
Asset is incorrectly priced by the market.
Both the model and market price the asset incorrectly".

DATA ANALYSIS

The study investigates the pricing of call option series written on underlying stocks of the five Indian companies namely, Reliance, Infosys, State Bank of India, Hindustan Lever Limited, Tata Motors applying the proposed model using data in the month of November 2012 in the National Stock Exchange of India. From the equity segment of NSE, daily closing prices of Reliance, Infosys , Hindustan Lever limited, State Bank of India, Tata Motors and also that Nifty index were collected and daily market factor coefficient viz., φ_n has calculated as per eqn.(1) That is in finding out (φ_1) based on the values observed in day 0,1 and for φ_2 based on the values observed in day 0,1, and 2 and so on. After computing φ_n values for such days, daily theoretical prices for different strike prices of the options are computed based on the model suggested considering time to maturity, exercise price and current stock price. Observed values and theoretical prices of different series of options are tabulated. One of the ways to measure accuracy of the formulae is to compare the calculated values with actual call option prices in the market. The differences between actual and computed values are errors. One with lower error can be considered better. In the study errors are measured using Mean Error(eqn.3), Percentage Mean Error(eqn.4), Root Mean Square Error(eqn.5) and Thiel's U statistic(eqn.6).

MEAN ERROR (ME)

It can be computed by adding all error values and dividing total error by the number of observations.

$$ME = \frac{1}{N}\sum_{n=1}^{N} e_n$$

$$ME = \frac{1}{N}\sum_{n=1}^{N}(O_{tp} - O_a) \quad (3)$$

Where

O_{tp} = the theoretical/predicted price of the option

O_a = Actual price for observation.

N= Number of observations.

PERCENTAGE MEAN ERROR(PME)

$$PME = \frac{1}{N}\sum_{n=1}^{N}(O_{tp} - O_a)/O_a \quad (4)$$

ROOT MEAN SQUARE ERROR (RMSE)

It is square root value of mean squared error and similar to standard deviation.

$$RMSE = \sqrt{\frac{1}{N}\sum_{n=1} e^2{}_n}$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{j=1}^{N}(O_{tp} - O_a)^2} \quad (5)$$

THIEL'S U STATISTIC

Henri Thiel (1961) developed an inequality coefficient for measuring the degree to which one time series differs from another. *"Theil's U statistics is independent of the scale of the variables; it is also consutrcted in such a way that it necessarily lies between zero and one, with zero indicating perfect fit".* Thiel's U statistic is computed as under :

Thiels inequality coefficient (Thiel's U)

$$= \frac{\sqrt{\frac{1}{N}\sum_{n=1}^{N}(O_{tp} - O_a)^2}}{\sqrt{\frac{1}{N}\sum_{j=1}^{N}(O_{tp})^2} + \sqrt{\frac{1}{N}\sum_{j=1}^{N}(O_a)^2}} \quad (6)$$

A value close to zero indicates a good fit, whereas, value greater than, 1 indicates that the technique is actually worse than using a naive forecast. In comparing the two methods, the method that produces lower U statistic may be considered better than the other.

The analysis further involves regressing actual traded prices against the prices predicted by the model

Regression Model $Ycall = a_0 + a_1 Ycall + \varepsilon$ (7)

Zero intercept, unit slope and high R^2 means a good fit. SPSS packages has extensively used in exploring regression analysis.

RESULTS AND ANALYSES

Market Price of the underlying stocks, and that of Nifty index for the period under study is tabulated in Table 1

TABLE 1: CLOSING MARKET PRICE OF UNDERLYING STOCKS, NIFTY INDEX DURING THE PERIOD

Day	NIFTY	Reliance	Infosys	HLL	SBI	Tata Motors
0	5645	807	2365	537	2116	267
1	5698	808	2388	533	2152	270
2	5704	806	2378	533	2145	270
3	5724	805	2382	533	2173	267
4	5760	801	2404	535	2217	269
5	5739	797	2375	533	2242	284
6	5686	788	2349	529	2155	281
7	5684	787	2359	530	2190	281

Daily market factor coefficient (φn) for the period under study based on Market Index, i.e.,Nifty and market price of the underlying stocks is tabulated in Table 2. Time to maturity, exponential factors are also exhibited in Table 2. For the stockof Reliance, the Market factor coefficient shows positive values and in later period it shows negative trends. For the stock of Hindustan Level Limited, market factor coefficient (φn) is exhibiting negative in decreasing manner. While for Infosys, State Bank of India, Tata Motors market factor coefficient(φn) has not showing any specific pattern.

TABLE 2: MARKET FACTOR COEFFICIENT (φ_n) OF UNDERLYING STOCKS ON DAILY BASIS

Day	(φ_n)	Reliance	Infosys	HinduLever	SBI	Tata Motors	Time to maturity (Days)	Exponential Factor e^{-t}
1	(φ_1)	0.0189	0.4340	(-)0.0755	0.6792	0.0566	17	0.9343
2	(φ_2)	0.0046	0.3045	(-)0.0708	0.5654	0.0531	16	0.9380
3	(φ_3)	(-)0.0201	0.1653	(-)0.0560	0.6733	0.0145	15	0.9418
4	(φ_4)	(-)0.0518	0.3107	(-)0.0195	0.8633	0.0109	14	0.9455
5	(φ_5)	(-)0.0749	(-)0.0395	(-)0.0215	1.0491	0.0628	13	0.9493
6	(φ_6)	(-)0.0285	0.3157	(-)0.0071	1.0289	0.0331	12	0.9531
7	(φ_7)	0 .007449	0.3407	0.0010	0.9280	0.0116	11	0.9570

Theoretical call option prices at different exercise prices of underlying stocks were calculated based on the suggested model and presented in Table 3. For the options of Reliance, at Exercise Price of 780, the theoretical prices predicted by the model is in the band of 40.23 to 20.39. But the options actually traded in the market from 39.20 to 19.90. During the period, the stock prices were traded between 787 and 808 and options are deep in-the-money. At exercise price 820, at which option is near-*in-the-money, the* actual traded prices ranges from 21.26 to 1.14 and the prices predicted by the model from 13.85 to 5.20. The prices predicted by the model are over pricing. At exercise price 860, wherein the options of Reliance acts as far *out-of-money* and the options are worthless as predicted by the model.

Stock price of Infosys swings 2349 to 2404, and at exercise price 2350, which is *near in-the-money,* option prices predicted by the model works out 128.49 to 69.73. But the actual traded prices observed in the market during the period are in the price band of 42 to 81. 5. But at exercise price of 2450, near *out-of-money*, in the initial period model over prices and exhibits under pricing in later periods. At the exercise price of 2550, ie., far *out-of-money*, the model under prices in majority trading days.

Stock price of Hindustan Lever Ltd, traded in the vicinity of 530 to 540. At the exercise price of 520, option is deep in-*the-money*, the prices predicted by the model moves from 22.16 to 16.19. During the period under study, actual traded prices of options observed in the market range of 21.45 to 15.55. There is small variation in option prices between actual traded prices and those predicted by the model.

TABLE 3: THEORETICAL CALL OPTION PRICES PREDICTED BY THE SUGGESTED MODEL AT DIFFERENT EXERCISE PRICE

Stock/Exercise Price							
	1	2	3	4	5	6	7
Reliance							
780	40.23	37.32	34.63	30.45	26.58	21.78	20.39
820	21.26	19.10	16.10	12.32	8.73	3.15	1.14
860	2.00	(-) 0.34	(-) 2.40	(-)5.80	(-) 9.10	(-)15.47	(-)18.12
Infosys							
2350	128.49	107.63	95.48	113.57	69.80	68.10	69.73
2450	66.09	49.50	42.20	54.60	23.83	8.67	9.14
2550	3.70	(-)8.61	(-)11.08	(-) 4.38	(-)22.14	(-)50.79	(-)51.79
Hindustan Lever							
520	22.16	21.34	20.19	21.33	19.34	16.60	16.19
540	13.38	12.49	11.19	12.09	9.85	7.12	6.62
560	4.60	3.64	2.67	2.72	1.11	(-) 2.35	(-)3.00
SBI							
2100	142.75	125.12	146.34	186.72	211.97	130.24	148.43
2200	72.55	58.13	75.74	110.45	130.98	49.37	69.64
2300	2.34	(-)8.89	5.14	34.17	50.00	(-)44.66	(-)9.14
Tata Motors							
250	19.03	18.50	15.95	16.45	24.50	23.47	21.07
270	9.27	8.72	6.43	6.92	14.55	12.14	11.40
290	(-)0.49	(-)1.05	(-)3.10	(-)2.62	4.62	2.36	1.75

In the case of Hindustan Lever Ltd., *in-the-money option* prices predicted by the model and the observed prices shows a little variation. At exercise price of 540, option of HLL acts as *at-the-money* and the prices produced by the model is overpricing. At the exercise price of 560, the model predicts the option worthless at the end of the period.

TABLE 4: DIFFERENCES IN CALL OPTION PRICES AS PER SUGGESTED MODEL AND ACTUAL TRADING PRICES

Stock/Exercise Price							
	1	2	3	4	5	6	7
Reliance							
780 model	40.23	37.32	34.63	30.45	26.58	21.78	20.39
Actual	39.20	37.20	35.75	31.20	27.75	21.30	19.90
difference	*1.03*	*0.12*	*(-)1.12*	*(-)0.75*	*(-) 1.17*	*0.48*	*0.49*
820 Model	21.26	19.10	16.10	12.32	8.73	3.15	1.14
Actual	13.85	12.40	11.70	10.50	8.45	5.80	5.20
diff	*7.41*	*6.70*	*4.40*	*1.82*	*0.28*	*(-) 2.65*	*(-) 4.06*
860 Model	2.00	(-) 0.34	(-) 2.40	(-)5.80	(-) 9.10	(-)15.47	(-)18.12
Actual	3.70	3.20	3.00	2.85	2.15	1.60	1.45
diff	*(-)1.7*	*(-)3.54*	*(-)5.40*	*(-)8.65*	*(-)11.25*	*(-)17.07*	*(-)19.57*
Infosys							
2350 Model	128.49	107.63	95.48	113.57	69.80	68.10	69.73
Actual	76.95	67.25	73.25	81.25	58.50	42.00	45.10
diff	*51.54*	*40.38*	*22.23*	*32.32*	*11.30*	*26.10*	*24.63*
2450 Model	66.09	49.50	42.20	54.60	23.83	8.67	9.14
Actual	29.00	23.90	26.55	28.90	17.85	11.50	11.55
diff	*37.09*	*25.60*	*15.65*	*25.70*	*5.98*	*(-) 2.83*	*(-) 2.41*
2550 Model	3.70	(-)8.61	(-)11.08	(-) 4.38	(-)22.14	(-)50.79	(-)51.79
Actual	9.15	7.20	8.15	8.50	4.65	3.30	3.15
diff	*(-)5.45*	*(-)15.81*	*(-)19.23*	*(-)12.88*	*(-)26.79*	*(-)54.09*	*(-)54.94*
Hindustan Lev							
520 Model	22.16	21.34	20.19	21.33	19.34	16.60	16.19
Actual	21.45	20.75	19.80	20.10	19.90	16.85	15.55
diff	*0.71*	*0.59*	*0.39*	*1.23*	*(-)0.56*	*(-)0.25*	*0.64*
540 Model	13.38	12.49	11.19	12.09	9.85	7.12	6.62
Actual	9.35	8.85	8.10	8.30	7.90	6.25	5.35
diff	*4.03*	*3.64*	*3.09*	*3.79*	*1.95*	*0.87*	*1.27*
560 Model	4.60	3.64	2.67	2.72	1.11	(-) 2.35	(-)3.00
Actual	3.40	3.10	2.65	2.55	2.40	1.85	1.60
diff	*1.2*	*0.54*	*0.02*	*0.17*	*(-)1.29*	*(-)4.2*	*(-)4.60*
SBI							
2100 Model	142.75	125.12	146.34	186.72	211.97	130.24	148.43
Actual	107.05	100.30	118.60	146.50	168.85	88.30	106.85
Diff	*35.70*	*24.82*	*27.74*	*40.22*	*43.12*	*41.94*	*41.58*
2200 Model	72.55	58.13	75.74	110.45	130.98	49.37	69.64
Actual	54.85	50.40	62.50	81 .45	98.50	35.80	43.90
diff	*17.70*	*7.73*	*13.24*	*29.00*	*32.48*	*13.57*	*25.74*
2300 Model	2.34	(-)8.89	5.14	34.17	50.00	(-)44.66	(-) 9.14
Actual	24.30	22.10	27.75	38.05	47.10	11.90	14.20
diff	*(-)21.96*	*(-)30.99*	*(-)22.61*	*(-)3.88*	*2.90*	*(-)56.56*	*(-)23.34*
Tata Motors							
250 Model	19.03	18.50	15.95	16.45	24.50	23.47	21.07
Actual	24.75	24.30	22.50	23.25	35.65	32.50	32.00
diff	*(-) 5.72*	*(-)5.80*	*(-)6.55*	*(-)6.80*	*(-)11.15*	*(-)9.03*	*(-)10.93*
Tata Motors							
270 Model	9.27	8.72	6.43	6.92	14.55	12.14	11.40
Actual	11.05	10.95	9.75	10.10	18.20	15.35	14.75
diff	*(-) 1.78*	*(-)2.23*	*(-)3.32*	*(-)3.18*	*(-)3.65*	*(-)3.21*	*(-)3.35*
290 Model	(-) 0.49	(-)1.05	(-) 3.10	(-)2.62	4.62	2.36	1.75
Actual	3.60	3.70	3.25	3.15	6.35	4.65	4.15
diff	(-) 4.09	(-)4.75	(-)6.35	(-)5.77	(-)1.73	(-) 2.29	(-) 2.40

Stock price of State Bank of India traded in the band of 2116 to 2242 in the NSE market. At exercise price of 2100, option prices predicted by the suggested model are in the range of 125.12 to 211.97 and observed prices in the market in between 88.30 and 146.50. At the exercise price of 2200 that is near *out-of-money* prices predicted by the model overprices heavily . At exercise price of 2300 the model severely under prices.

In the case of Tata Motors, option is in-the-money at exercise price of 250, the suggested model shows under pricing. *At-the-money call* (270) and far *out-of-money* (290) also shows under pricing.

Result of error matrices for the call options showing Mean Error(ME), Percentage Mean Error(PME), Root Mean Square, Thiel's U Statistic of options at different strike prices is presented in Table 5.

TABLE 5: ERROR MATRICES OF THE CALL OPTION PRICES AS PER THE SUGGESTED MODEL

Stock/Exercise Price				
	Mean Error	Percentage Mean Error	Root Mean Square Error(RMSE)	Thiel's U Statistic
Reliance				
780	(-) 0.13	(-)0.30%	0.8222	0.0132
820	1.99	6.00%	4.5678	0.1913
860	(-) 9.60	(-)511.41%	11.4663	0.9073
Infosys				
2350	29.79	47.60%	32.1630	0.1997
2450	14.97	52.99%	20.6537	0.3207
2550	(-) 27.03	(-)660.85%	32.6829	0.9089
HLL				
520	0.39	2.01%	0.6869	0.0176
540	2.66	32.91%	2.9173	0.1576
560	(-) 1.17	(-) 72.59%	2.4560	0.4374
SBI				
2100	36.45	31.56%	37.0807	0.1320
2200	19.92	33.42%	21.6827	0.2391
2300	(-) 22.30	(-)136.45%	28.5884	0.4931
TataMotors				
250	(-)8.00	(-) 28.37%	8.2879	0.1713
270	(-)2.96	(-) 23.68%	3.0267	0.1288
290	(-)3.91	(-)107.84%	4.2578	0.6090

In the case of options of Reliance at exercise price of 780, the mean error is (-) 0.13 and average level of under pricing is (-)0.3%, which is acceptable. Whereas at the exercise price of 820, the option is *in-the-money* and mean error is 1.99 and percentage mean error of 6% as such errors are acceptable. The Model overprices by 47.66% and 52.99% for the options of Infosys at exercise price of 2350 and 2450 respectively with mean error of 29.79 and 14.97. Whereas at exercise price of 2550, the mean error is as high as (-) 27.03, model under prices highly for the *out-of-money* options of Infosys. The average level of over pricing in the case of in-the-money options of Hindustan Lever Limited (520) is 2.01% and mean error 0.30 which is negligible. Prices predicted by the model is in line with the price actually traded in the market. At exercise price 540(HLL), mean error is 2.66 which comparatively low. At exercise price of 560 the model under prices by 72.59%. In the Banking sector that is for State Bank of India, mean error is 36.45 at exercise price of 2100 and 19.92 at exercise price of 2200. That is average overpricing by 31.56% and 33.42%. Whereas mean error is (-) 22.3 at exercise price of 2300 with average under pricing by 136.54%. In the case of Tata Motors, the model under prices by 28.37% at exercise price of 250, and 23.68% at exercise price of 270. But the model severely under prices in the case of far out-of-money call options of Tata Motors.

For the deep *in-the-money* options of Reliance (780), Root Mean Square Error is 0.8222 and Thiel's U Statistic 0.0132. Lower value of RMSE and U Statistic means that model indicating high degree of fitness. That is the model works well for the *deep in-the-money call options*. At exercise price 820, that is, near in-the-money, RMSE is 4.5678 and Thiel's U Statistic 0.1913. Comparatively low value of RMSE and Thiel's U Statistic, the model fits to the observed traded prices in the case of the *near in-the-money options.* RMSE is as low as 0.6869 and Thiel's U Statistic 0.0176 in the case of deep *in-the-money* options of Hindustan Lever Limited (520) which again confirms that the model gives high degree of fitness in the case of deep in the money call options. For *the at-the-money* call of HLL(540) RMSE is 2.9173 with U statistic 0.1576 which augments the conformity of the prices predicted by the model with traded prices in the market. For the near in-the-money options of Infosys Thiel's U Statistic gives 0.20, that is model fitness is not high. In the case of in-the-money options of SBI, Thiel's U statistic works to 0.1320 indicating degree of fitness. Options of Tata Motors shows fitness with mode in the case of deep in-the-money and near in-the-money.

For the out of-money options of Reliance at 820, RMSE is 11.4663 and U statistic 0.9073 indicates high degree of mis fitness between prices predicted by the model and observed prices. For the out of money options HLL(560) there is high degree of mis fitness with U statistic of 0.4374. For the far out-of-money options of Infosys (2550), Thiel's U statistic 0.91, that is high degree of misfitness.

TABLE 6: MODEL FITNESS/MISFITNESS OF DIFFERENT CALL OPTIONS DIFFERENT STOCKS

Types of option	Reliance	Infosys	Hindustan Lever	State Bank of India	Tata Motors
deep *in- the-money* option	Model Fitness- High	Fitness-medium	Fitness high		Fitness high
near in-the-money option	Fitness medium			Fitness-high	Fitness-high
at-*the-money option*			Fitness-medium		
near out of-money		Fitness-low		Fitness medium	
far out-of-money	misfitness-high	misfitness-high	Misfitness –high	Mis fitness-high	Misfitness-high

TABLE 7: REGRESSION ANALYSIS CALL OPTION ACTUAL TRADED PRICES WITH SUGGESTED MODEL

Stock/ Exercise Price	Intercept (sig t)	Slope (sig t)	R^2	F-statistic (Sig F)
Reliance				
780	0.143 (0.932)	0.991 (0.000)	0.987	378.272 (0.000)
820	-10.819 (0.000)	2.320 (0.000)	0.991	566.043 (0.000)
860	(-)21.726(0.002)	6.287 (0.006)	0.804	20.556 (0.000)
Infosys				
2350	4.494 (0.845)	1.398 (0.009)	0.777	17.410 (0.009)
2450	(-)24.620 (0.022)	2.857 (0.000)	0.937	73.825 (0.000)
2550	(-)73.395 (0.000)	8.360 (0.001)	0.913	52.205 (0.001)
HLL				
520	(-)0.783 (0.755)	1.061 (0.000)	0.937	74.373 (0.000)
540	(-)3.617 (0.041)	1.811 (0.000)	0.958	115.196 (0.000)
560	(-)9.882 (0.001)	4.477 (0.000)	0.937	74.976 (0.000)
SBI				
2100	25.661 (0.113)	1.090 (0.000)	0.952	99.668 (0.000)
2200	2.053 (0.822)	1.293 (0.000)	0.974	92.001 (0.000)
2300	(-)58.457 (0.001)	2.360 (0.001)	0.958	55.842 (0.001)
Tata Motors				
250	3.305 (0.182)	0.594 (0.001)	0.926	62.194 (0.001)
270	(-)1.548 (0.207)	0.890 (0.000)	0.960	121.15 (0.000)
290	(-)9.496 (0.002)	2.358 (0.002)	0.879	36.266 (0.002)

In regression analysis a good fit is marked by unit slope, zero intercept and high R^2. Regression results are tabulated in Table 7. Deep *in-the-money* option of Reliance(780) gives intercept of 0.143 with slope of 0.991 and R^2 of 0.987. That is slope is near to unity, the model fits to the deep *in-the-money* call options. In the case of deep in the money options of HLL(520) gives negative intercept(-0.783) and slope greater than unity(1.061) means that model over prices slightly. For the at-the-money call option of HLL(540) R^2 works to 0.958, a measure of good fitness. R^2 Values of SBI are more than 0.95.

CONCLUSIONS

The aim of the research was to provide 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, Nifty, thereby daily Market Factor Coefficient. From the tables of Normal distribution Table the N (φn) is arrived out. Strike price, exercise price, time to maturity are also taken into the model. There are various models which help us to get the price close to the true price of an option. Each has their own assumptions and limitations besides relaxing and addition to the established Black-Scholes-Merton Model (BSM). With many sophisticated algorithms traders are perplexed with to choose which model and to quote the price in the market. Many of the models are highly complex and involve rigorous mathematical computations. Daily theoretical prices of the different options were calculated and mean error, percentage, mean error, root mean square error, Thiel's U statistic were calculated. In the case of Reliance *deep-in-the-money option,* study revealed that pricing shows little variation. It is further revealed that the options of Tata Motors, the model generally under prices. But in the case of HLL prices produced by the model and observed prices did not exhibit marked variation. Study noted that for the *out-of-money options*, in majority cases the prices produced by the model are worthless. Study concluded that the model fitness is high in the case of *deep in-the-money* and fit well to the near *in-the-money options.* For the near *out-of-money* also model is workable. But in many of the days for the far *out-of-money* options the model feasibility is not viable.

It is true that no research is complete and co comprehensive, as any duration, sample size reflects on the incompetence to cover the horizon. In the study the data collected was over a limited period. In the present study, the idea is to introduce an option pricing model with limited mathematical computations and rigor relaxing and adding certain assumptions of the BSM Model.

LIMITATIONS OF THE STUDY

For computing the market factor coefficient (φ), market index NSE Nifty has considered. As there are many number of indices, such as BSE Sensex, Dow Jones, Nasdaq, IBEX Index(Spain), FRSE MIB(Italy) etc.,covering segment wise, sector wise and also nation wise, applying different bench mark index may or may not have impact on values of market factor coefficients (φ). Study is resorted only for a limited number of days. Relaxation and addition of assumptions may give divergent values.

SCOPE FOR FURTHER RESEARCH

In the present study the data was collected from the NSE Nifty, that is representing the characters of emerging markets. In many of the studies on option pricing model, data were from the matured markets such as United States of America, United Kingdom, Japan. Further research on the proposed model can be extended both to mature markets and emerging markets such as FTSEMIB(Italy) , IBEX Index(Spain)

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