Article

A Study of Black–Scholes Model's Applicability in Indian Capital Markets

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Abstract

Derivative trading, started in mid-2000, has become an integral and significant part of Indian stock market. The tremendous increase in trading volume in Indian stock market has reflected into high volatility in the option prices. The pricing of options is very complex aspect of applied finance and has been subject of extensive research. Black–Scholes option model is a scientific pricing model which is applied for determining the fair price for option contracts. This article examines if Black–Scholes option pricing model (BSOPM) is a good indicator of option pricing in Indian context. The literature review highlights that various studies have been conducted on BSOPM in various stock exchange across the world with mixed outcome on its relevance and applicability. This article is an empirical study to test the relevance of BSOPM for which 10 most popular industry's stock listed on National Stock Exchange have been taken. Then the BSOPM has been applied using volatility and risk-free rate. Furthermore, t-test has been used to test the hypothesis and determine the significant relationship between BS model values and actual model values. This study concludes that BSOPM involves significant degree of mispricing. Hence, this model alone cannot be adopted as an indicator for option pricing. The variation from market price is synchronised with respect to moneyness and time to maturity of the option.

Keywords

Options pricing, Black–Scholes model, time to maturity, NSE, volatility, moneyness

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Introduction

Indian stock market has grown manifold during last couple of decades and global investors are looking at Indian capital market as a lucrative investment option due to its attractive returns on equity and other investment instruments. Derivative trading, introduced in mid-2000 in India, has become an inseparable part of Indian stock market. A derivative is an instrument, the value of which depends on the value of underlying assets. These underlying assets can be a commodity, a security, a currency, any index, etc. There are various types of derivatives, and the most common are options, future, forward contract and swap. The feature of an option contract is that it involves two parties—buyer and seller—which gives the buyer the right, but not the obligation to buy or sell something at a later date at a price agreed on today. Trading in derivatives in India began in 2000. Since then there has been an enormous growth in derivative market. Traders prefer investing in derivative more than cash market. Higher volatility accompanied with increased awareness is the main reason for growth in derivative market. Due to high volatility in this sector, it is inevitable to have price calculation mechanism for traders in the market. There are many different price calculation models to forecast the fair value of options. The Black–Scholes model is one among them. This model is a scientific technique to calculate the fair price of option. Fischer and Myron (1973) developed a theoretical model (Black–Scholes option pricing model—BSOPM) for the pricing of options and stated that this model can determine the prices of call and put options depending on various relevant factors such as volatility, risk-free rate, strike price, spot value, time to maturity, etc. The model was developed mainly for the pricing European options on stocks. The model operates under certain assumptions regarding the distribution of the stock price and the economic environment.

(Black Fischer and Myron Scholes, 1973) Fischer and Myron (1973) stated in their study that the Black–Scholes mathematical model explains that the price of heavily traded assets follow a geometric Brownian motion with constant drift and volatility.

This mathematical pricing method follows the assumption that the movement in the price of option happens due to spot price of underlying assets. Following are the two main purposes of this research:

- The primary objective of this study is to determine the theoretical price of the options with the help of BSOPM using industry-wise categorisation.
- The second significant purpose is to find out the significant difference/relationship between theoretical prices (BSOPM price) and the actual market prices.

This research highlights that the volatility plays a significant role in determining the relationship between theoretical and actual prices. Higher volatility leads to higher deviation from actual price. Besides, there are many micro and macro factors affecting the model price and actual price. The results of this study show ineffectiveness of the BSOPM as there is insignificant relationship between actual market price and theoretical price of the options. The result is consistent with Nilakantan and Sethi (2012) who concluded that BSOPM involves certain degree of mispricing. This article further concludes that the difference in the fair and actual prices changes/increases based on the movement of moneyness of an option contract from the ‘in-the-money’ to ‘at-the-money’.

Literature Review

This study reveals that relationship between model value and actual value of options is insignificant. The P value explains the overall mismatch and inconsistencies between both the prices. But since this model

provides for existence of the arbitrage opportunity, the traders take the advantage of such opportunity in forecasting the market values for subsequent days. Mishra (2012) examined in his paper the exactness of choice in estimating models to value Nifty Indexed Futures trading on National Stock Exchange (NSE) of India. His paper endeavoured to address the issues identified with undervaluing of Nifty options by virtue of negative cost of convenience in future market. In this examination, the choices are cited utilizing both Black–Scholes (B-S) equation and Black–Scholes formula and the results concluded that the Black's formula deliver preferred option over utilization of Black and Scholes formula. From the examination of blunders, it is confirmed that Black model delivers less mistake than that of Black–Scholes display and therefore utilization of Black model is more fitting than that of B-S model for valuing Nifty options.

Ray (2012) stated that BSOPM was viewed as a huge undertaking in articulating and estimating options and corporate securities in light of the suspicion that a hazard-free loan cost existed. This pricing model is utilized even today to estimate what options ought to be worth; however, it is connected for the most part in institutional portfolio management divisions and in the scholarly world. In spite of a few escape clauses in Black–Scholes option evaluating model, there are a few reasons or wide utilization of this model. In their study, Rajanikanth and Lokandha (2015) advanced around how the investor ought to carry on in the option market. Each organization values are diverse and work with request factors for a specific industry. The options either call or put in European kind move with non-straight result for the two gatherings. This makes the investor to see how to price an option deliberately and profit in the option market. Sethi and Nilakantan (2016) explained in their study that there is a critical contrast between the BSOPM call price and the market call price. There were couple of different perceptions as underneath: Normally the mean of prices figured by BSOPM is more prominent than the real market prices. By and large, the deviation of the BSOPM price from the real market price is most elevated for out-of-money options when contrasted with at-the-cash and in-the-cash options. As the quantity of perceptions expanded, the deviation of BSOPM price from the genuine market price expanded. Kumar and Agrawal (2017) tried to assess the execution of the BS model in anticipating call option prices exchanged at the Indian subsidiary market. Call options are seriously mispriced by the BS model. The discoveries are to some degree steady and consistent with the few past exact investigations on the evaluating exactness of the BS model. There is a need to search for an elective model for estimating option.

According to Sharma and Arora (2015), Black–Scholes model is partially relevant as they tested the model on a selected group of 10 stocks of NSE and came out with a conclusion that this model does not account for market perceptions. Nagendran and Venkateswar (2014) conducted different sample tests to determine the relevance of the BSOPM model on the call options in Indian capital market, and they observed that an increase in the volatility of a stock reflects in the increased deviations of the model price and the actual market price. Panduranga (2013) researched banking stocks to find out the reliability of BSOPM model and three out of four stocks expressed no significant difference, yet they concluded that there was scope of improvement in the model to account for market conditions. Khan, Gupta, and Siraj (2012) in his study recommended that BSOPM formula should incorporate some new variables on the basis of given assumption related to risk-free rate, and he also suggested the calculation process of new risk-free rate of interest on the basis of modified variable.

Bonz and Angeli (2010) tested the applicability and relevance of the Black–Scholes model for price stock index options. They determined the theoretical prices of options under the BSOPM model assumptions and then compared these prices with the real market values to find out the degree of variation in two different time zones. They finally concluded that BS model performed differently in the period before and after the financial crisis. McKenzie and Subedar (2017) concluded in their report that BSOPM is relatively accurate. They concluded that the Black–Scholes model is significant at 1 per cent level in estimating the probability of an option. Genkay and Salih (2003) found out that the BSOPM model

pricing errors are bigger in the deeper out-of-the-money options, and volatility increases the mispricing. This result stated that the BSOPM model is not the appropriate pricing tool in high volatility. Kim, Jong, and Mohammed (1997) analysed the effect of implied volatility on option pricing models for at-the-money put options. The study found out the inference that the implied volatility estimates derived from the BSOPM European model were almost similar to those derived from the other more complex pricing methods. Chappell (1992) exclaimed that one problem with the Black–Scholes analysis is that the mathematical skills required in the derivation and solution of the model are fairly advanced and probably unfamiliar to many economists. Frino and Khan (1991) conducted cross-sectional experiments of the pricing technique using the historical data. His research found out the significance of this model and stated that the Black–Scholes model cannot be rejected. Bakshi, Charles, and Zhiwu (1997) explained in their research that considering the stochastic volatility is the primary concern in improving the Black–Scholes formula. Black and Scholes (1973) innovated a theoretical method to determine the options values, and they stated that the model follows a fixed systematic pattern based on relevant market indicators such as volatility, spot prices, time to expiry and expected risk-free rate of return.

Research Methodology

Research in any field demands for active, ongoing, diligent and systematic process to analyse, discover and interpret the facts, results, events and theories. In the present article, the scrips of the NSE-listed companies are allocated on the basis of 10 industries. Three stocks are selected from each industry based on their M Cap and popularity. The prices of an option are taken for the month of March 2018, to be expired on 28 March 2018. A total of 18 trading days samples (5 March 2018 to 28 March 2018) are selected for call and put option contracts, both, for one strike price of each of 30 stocks. BSOPM has been applied in calculating the fair option prices of all these stocks. The volatility has been determined using the daily closing prices of previous year. Volatility is a significant factor in finding out the prices of the options. The historical volatility has been measured applying the monthly log returns of the stocks. NSE and BSE indexes have been used for data collection. Both closing price and actual option premium have been collected from the website www.nseindia.com and www.bseindia.com. The model uses the assumptions that are as follows:

- European options and can only be exercised at expiration
- Efficient markets
- No dividend payments on stock during the whole life of the option
- No commissions
- There is no riskless arbitrage opportunities
- Both volatility and risk-free rate of the underlying assets are constant
- Log normal distribution is followed by the prices of the stocks, i.e. returns on the underlying are normally distributed.

The Black–Scholes formula incorporates the variables given as follows:

- Current underlying price
- Options strike price
- Time until expiration, expressed as per cent of a year
- Implied volatility
- Risk-free rate of interest.

The premium for a call option can be calculated as follows. Using the BSOPM equation:

$C = S * N(d1) + K * e^{(-r*t)} * N(d2)$,

where
C = Call premium
S = Current stock price (spot price)
t = Time until option exercise (in years)
K = Strike price of the option contract
r = Risk-free interest rate in the market
N = Cumulative standard normal distribution
e = Exponential term.

Following technique is used to calculate d1 and d2 :

$$d1 \quad \frac{\ln(S/K) + (r + v^2/2) * t}{v * t}$$

$d2 = d1 - (v * t)$ or $\frac{d2 = \ln S/K + (r \quad v^2/2) * t}{v * t}$

where v = volatility of the stock (standard deviation); ln = natural log.

The BSOPM is categorised into two sections:

The first section:

S * N(d1) times the price by the Δ (change) in the call premium with respect to Δ (change) in the underlying asset price. This section expresses the expected benefit of buying underlying outright.

The second section:

$K * e^{(-r*t)} * N(d2)$ gives the current price of paying the exercise price upon expiration.

The difference between the two sections is used to calculate the price of the option contract, as given in the equation below.

Following formula can be used to find out the premium for the put option:

$P = -S * N(-d1) + K * e^{(-r*t)} * N(-d2)$

In the present study, in order to find out the theoretical price of option and volatility of option, the following steps are used:

Step I: In order to determine the historical volatility, daily log returns have been calculated by using moving average method.
Daily return = ln(today's closing price/yesterday's closing price)
Daily standard deviation (SD) = (Variance of daily returns)$^{0.5}$
Historical volatility = Daily SD × $(250)^{0.5}$
(250 trading days in a year is taken for above calculation purpose)

Step II: In order to derive the fair value of call and put options of single strike prices, first we collect all required data in the Black formula from the NSE and then apply them in the BSOPM. The next action is to determine the variations between model value and the actual market prices.

Step III: The last step is the comparison of the fair option premium with the actual price of option premium.

Monthly log returns of the corresponding scrips have been used to find out the historical volatility:

Monthly return = ln[(this month's closing price)/(last month's closing price)]
Volatility = standard deviation of the monthly returns

Of note, 7.4 per cent is the risk-free rate of return which has been used in this study. This Rf is the current yield on 10-year government bonds issued by Indian Government. The time to maturity is calculated as the fractional value of the number of days remaining to the maturity date. NSC and BSE websites are referred for collecting the data, i.e. spot prices of the different stocks. BSOPM has been used then to determine the call and put option fair price using single strike price of all the stocks. Following hypothesis has been framed and paired sample test has been conducted to derive whether there is a significant difference between BSOPM price and real market price.

Null hypothesis (H0):	There is no significant difference between BSOPM prices and actual market prices
Alternate hypothesis (Ha):	There is significant difference between BSOPM prices and actual market prices

At 95 per cent level of confidence:
If P value > 0.05, then null hypothesis is accepted.
In the present article, a total of 60 hypotheses are framed (30 for call option contracts and 30 for put option contracts) and tested using the paired sample t-test. The paired t-test compares the means and standard deviations of the two series of numbers and determines if there is any significant difference between the two series of numbers. The following stocks are chosen for the analysis:

1. Cement industry
   - ACC
   - Ultra Cement Company
   - Ambuja Cement
2. Government power sector
   - ONGC
   - NTPC
   - BHEL
3. Banking sector (private)
   - Axis Bank
   - HDFC Bank
   - Federal Bank
4. Banking sector (nationalized)
   - Bank of Baroda
   - Bank of India
   - State Bank of India
5. Steel industry
   - Tata Steel
   - JSW Steel
   - Jindal Steel
6. IT sector
   - TCS
   - HCL
   - Wipro
7. Pharmaceuticals industry
   - Cipla
   - Sun Pharma
   - Dr Reddy
8. Automobile industry
   - Maruti Suzuki
   - Tata Motors
   - Ashok Leyland
9. Textile industry
   - Century Textile
   - Arvind
   - Raymond
10. FMCG
    - ITC
    - Dabur
    - Britannia

Data Analysis and Interpretation

In this article, BSOPM has been chosen to find out the theoretical prices of options. Tables 1–8 given in Annexure represent the BSOPM results and the market prices.

Furthermore, paired sample t-test values are given in Tables 7 and 8 which indicate the results of 60 sets. Each set of data has the historical price data of 18 days. The paired t-test has been applied here to test the hypothesis. It measures the relationship between the BSOPM and the real market values of option contracts. The date analysis represents that null hypothesis is accepted in 7 pairs out of 30 call option sets, which indicates that there is no significant difference between BSOPM values and actual prices for these sets. However, the null hypothesis is rejected for remaining 23 call option pairs. The results indicate that there is significant difference between the fair prices and actual prices.

Similarly, for put option, out of 30 stocks only 7 pairs indicate that the difference is insignificant and remaining 23 sets show that the difference is significant. Since, from total 60 sets only 14 sets of the option prices result in P value > 0.05, hence we can reject our null hypothesis. This study reveals that there is a significant difference between the BSOPM values and the real market values because of high level of fluctuation. The paired t-test results indicate the mispricing in case of option contracts and draw the inference that there exist inconsistencies. Thus for a foreign investor, it becomes necessary to use other price determination method rather than relying on BSOPM. BSOPM values of the option premiums are different from real actual marker prices which makes it difficult for investors to consider this model for taking buying and selling decision. One important observation of this research is that the stocks with relative lower spot prices (underlying price) show more consistency and predictability as the premiums for these option contracts are relatively low.

Discussion

Theoretical Contribution of the Study

The BSOPM is discussed in almost all universities with MBA students and graduates .in economics. Before the existence of this model, the option markets were intuition-based and sparse. After the advent of BSOPM, the option markets are considered most lucrative and largest market. This model provided a benchmark for other researchers to come up with other relevant models. Today's economic world is uncertain and unpredictable; everything is changing rapidly with great amount of uncertainty and it is important for the decision-makers, investors, practitioners, students and researchers to use investment assessment tools and processes that can provide an indication of both uncertainty and the stock market ability to react to new information.

As a matter of fact, in the past many researches have been conducted to calculate the real options value of an investment (Benaroch & Kauffman, 1999; Brennan & Trigeorgis, 2000; Kodukula & Papudesu, 2006; Krychowski & Quélin, 2010; Mattar & Cheah, 2006) by using difference methods of option pricing, and among all methods BSOPM is the most widely used method. According to Derman and Wilmott (2008), BSOPM is the most convenient method for academics, practitioners and regulators because of its clear inputs, mean and robustness. Various studies have been conducted in the past on relevance of BSOPM and the results were with the mixed outcomes with respect to its relevance in predicting the future prices. However, as a matter of fact, despite being criticized by various researchers, practitioners and regulators for its assumptions, the formula remains in widespread use.

Table 1. Call Options of the Stocks

		Cement Industry						Govt Power Sector						Banking Sector (Private)					
		ACC		Ultra Cement Company		Ambuja Cement		ONGC		NTPC		BHEL		AXIS Bank		HDFC Bank		Federal Bank	
No.	Date	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual
1	5-Mar	139.3	259	271.67	536	22.5	38.25	14.6	38	5.7	5.15	12.05	25.05	56.7	145.4	50.3	116.2	6.96	15.7
2	6-Mar	130	259	302.99	536	18.4	38.25	14.4	38	5.65	3.9	10.15	25.05	50.8	145.4	3978	116.2	6.182	15.7
3	7-Mar	113.9	259	284.49	536	14.61	38.25	11.4	38	5.66	3.9	7.938	25.05	46.9	145.4	34.1	116.2	5.051	15.7
4	8-Mar	91.54	259	279.18	536	15.16	38.25	10.4	8.3	6.57	3.9	8.387	25.05	52.8	145.4	40.88	116.2	6.955	15.7
5	9-Mar	82.12	259	258.75	536	14.48	38.25	10.2	8.3	5.99	3.9	8.381	25.05	41	145.4	39.43	116.2	7.534	15.7
6	12-Mar	99.08	259	321.12	536	17.78	38.25	12.8	11	10.1	3.9	8.878	25.05	50.7	145.4	43.68	116.2	7.674	15.7
7	13-Mar	109.8	259	309.67	536	16.21	38.25	12.5	11.25	8.77	3.9	8.794	25.05	60.6	145.4	40.01	116.2	8.999	15.7
8	14-Mar	138.2	259	346.33	536	19.77	38.25	10.2	10	8.9	3.9	8.43	25.05	64.4	145.4	40.94	116.2	7.877	15.7
9	15-Mar	130.3	259	311.93	536	18.45	38.25	9.92	8.5	8.96	3.9	8.826	25.05	58.5	145.4	47.14	116.2	6.948	15.7
10	16-Mar	102	259	210.33	536	13.14	38.25	7.77	7.65	5.71	3.9	8.26	25.05	52.4	145.4	34.84	116.2	6.653	15.7
11	19-Mar	96.01	259	163.94	536	10.55	38.25	7.32	7.65	6.72	3.9	6.118	25.05	49	145.4	30.42	116.2	4.847	15.7
12	20-Mar	89.35	66	142.9	536	9.987	38.25	5.67	5.85	6.28	3.9	6.317	25.05	50.1	145.4	27.04	13.8	5.106	5.4
13	21-Mar	91.16	66	175.04	536	9.539	38.25	6.37	5.6	8.8	3.9	5.526	6	54.2	145.4	33.03	17.1	4.864	6
14	22-Mar	83.91	66	132.72	536	8.543	38.25	8.34	8.5	9.16	3.9	4.4	5.1	47.2	145.4	35.6	17.75	4.741	5
15	23-Mar	69.02	66	108.04	536	7.867	6.2	7.28	7.1	8.42	3.9	4.345	4.5	32.7	33	25.38	12.5	4.559	4.8
16	26-Mar	69.46	60	136.69	118	9.486	6.9	7.96	8.2	8.03	3.9	4.712	5.2	37.5	39.45	43.03	26.35	4.888	5
17	27-Mar	62.67	52.1	144.7	123	9.673	6.6	8.33	8.6	8.82	3.9	5.022	5.4	41	44	41.66	22.95	4.431	4.8
18	28-Mar	51.82	46.6	132.25	100	10.25	8	7.04	6.4	7.75	5.1	4.024	3.95	39.3	39.3	37.75	22.4	3.433	3.55

Table 2. Put Options of the Stocks

		Cement industry						Govt Power Sector						Banking Sector (Private)					
		ACC		Ultra Cement Company		Ambuja Cement		ONGC		NTPC		BHEL		AXIS Bank		HDFC Bank		Federal Bank	
No.	Date	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual
1	5-Mar	17.43	6.9	89.95	59.5	4.03	1.4	2.23	1.55	5.67	1.75	0.808	2.9	7.14	1.2	80.22	28.85	3.216	3.05
2	6-Mar	19.28	6.9	75.061	49	5.382	1.4	2.23	1.55	5.61	1.75	1.124	2.9	8.48	1.2	93.78	28.85	3.606	3.05
3	7-Mar	23.55	6.9	80.398	49	7.092	1.4	3.17	4.5	5.5	1.75	1.681	1.55	9.41	1.2	102.1	28.85	4.344	3.05
4	8-Mar	31.76	6.9	80.589	49	6.635	1.4	3.53	4.5	4.64	1.75	1.496	2.7	7.48	1.2	89.05	28.85	3.015	3.05
5	9-Mar	35.74	6.9	87.448	49	6.855	1.4	3.56	4.5	5	1.75	1.457	1.2	11	1.2	89.79	28.85	2.662	3.05
6	12-Mar	25.56	6.9	57.995	49	4.845	1.4	2.32	4.5	2.43	1.75	1.202	1.2	7.12	1.2	78.99	28.85	2.407	3.05
7	13-Mar	21.09	6.9	59.79	49	5.372	1.4	2.33	2.25	2.9	1.75	1.183	1.2	4.82	9.15	82.7	28.85	1.85	3.05
8	14-Mar	13.22	6.9	47.542	49	3.878	1.4	3.1	2.25	2.76	1.75	1.236	1.2	4.04	9.15	79.77	28.85	2.196	3.05
9	15-Mar	14.4	6.9	55.437	49	4.2	1.4	3.14	2.25	2.66	1.75	1.097	1.2	4.81	9.15	70.06	28.85	2.535	3.05
10	16-Mar	21.65	6.9	95.487	49	6.483	1.4	4.18	3.45	4.49	1.75	1.198	1	5.82	6.65	85.95	28.85	2.608	2.9
11	19-Mar	21.6	6.9	117.03	49	7.637	1.4	4.13	3.9	3.46	1.75	1.754	2	5.9	7.8	88.43	28.85	3.456	3.25
12	20-Mar	23.34	6.9	130.88	106	7.868	6.9	5.26	5.1	3.64	1.75	1.62	1.95	5.43	9	93.19	28.85	3.183	3.8
13	21-Mar	21.85	6.9	103.02	106	8.016	5.7	4.55	5.1	2.25	1.75	1.894	2.15	4.41	6.5	80.16	28.85	3.26	3.5
14	22-Mar	23.91	6.9	133.09	115	8.667	5.7	3.2	3.3	2.04	1.75	2.435	2.6	5.61	7.1	74.28	28.85	3.254	3.45
15	23-Mar	30.16	6.9	155.15	115	9.087	5.7	3.68	4.1	2.24	1.9	2.395	2.65	9.92	11.6	90.65	28.85	3.291	3.8
16	26-Mar	26.91	27	114.99	115	6.945	7.85	2.96	2.9	2.14	2.3	1.961	2.3	7.16	8.5	57.55	49.25	2.774	3.7
17	27-Mar	29.57	29.5	104.94	92.9	6.579	7	2.67	3.25	1.77	1.85	1.737	2.05	5.84	7.85	57.42	50.5	2.985	3.2
18	28-Mar	35.53	33.3	111.25	89.4	5.954	5.1	3.22	3.25	2.08	2.15	2.205	2.3	6	8.05	60.4	50.5	3.706	3.7

Table 3. Call Options of the Stocks

		Banking Sector (public)						Steel Industry						IT Sector					
		Bank of India		Bank of Baroda		State Bank of India		TATA Steel		JSW Steel		Jindal Steel		TCS		HCL		WIPRO	
No.	Date	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual
1	5-Mar	17.2	71.2	12.6	10	32.93	80.15	106.6	1.8	18.49	21.05	35.28	77	273.7	378.4	161.5	244.3	18.61	38.9
2	6-Mar	12.3	71.2	10.6	10	27.66	80.15	109.5	1.8	19.28	21.05	32.09	77	224	378.4	162	244.3	16.04	38.9
3	7-Mar	10.8	71.2	9.2	7	20.9	18	99	1.8	16.96	21.05	30.68	77	211.4	378.4	178.1	244.3	14.96	38.9
4	8-Mar	9.86	10	9.91	7	27.49	16.2	89.01	1.8	16.62	21.05	32.29	77	193.3	378.4	179	244.3	14.72	38.9
5	9-Mar	8.67	7.5	8.47	7	24.83	16.2	66.48	1.8	17.81	21.05	24.29	77	213.4	378.4	171.3	244.3	14.47	38.9
6	12-Mar	7.08	5.5	8.33	5.85	24.01	16.2	77.18	1.8	20.42	21.05	28.49	77	222.5	378.4	195	244.3	17.3	38.9
7	13-Mar	10.8	5.5	13.1	10	25.09	16.2	81.4	1.8	23.61	21.05	27.91	77	113.3	115	184.3	244.3	21.01	38.9
8	14-Mar	11.2	9.6	15.5	12	26.57	16.2	74.53	1.8	21.5	21.05	27.87	77	111.9	103.5	192.1	244.3	18.99	38.9
9	15-Mar	11.5	9.6	14.1	12.4	24.02	16.2	67.47	1.8	18.21	21.05	27.89	77	101.4	96	186.1	244.3	18.52	38.9
10	16-Mar	11.5	9.6	13.9	12.4	22.87	16.2	58.71	1.8	15.39	21.05	24.82	77	78.97	78.8	194.3	244.3	19.92	38.9
11	19-Mar	9.04	9.6	7.92	6.8	19.4	16.2	40.9	18	11.57	21.05	20.92	15.3	76.86	74.15	153.1	244.3	14.82	38.9
12	20-Mar	9.09	8.75	8.95	7.35	19.94	19.2	51.86	12.2	12.19	21.05	28.38	16.95	91.17	77.9	163.4	244.3	17.76	38.9
13	21-Mar	10.7	10.2	8.68	6.7	19.02	17	44.36	14.35	13.31	21.05	26.18	16.95	85.63	73.3	163.4	244.3	18.69	38.9
14	22-Mar	9.8	8.75	8.22	5.65	14.92	11.95	43.01	15	11.95	21.05	22.36	14.95	72.42	63.9	156.5	244.3	14.14	38.9
15	23-Mar	6.98	6.25	7.26	5.05	11.16	8.4	34.03	22.8	11.71	21.05	15.95	9.25	65.28	53.5	182.9	244.3	11.79	9.5
16	26-Mar	9.11	8.05	11	8.5	16.99	14.25	41.31	13.25	14.84	11.2	16.71	10.8	60.12	53.6	192	244.3	6.32	5
17	27-Mar	11	9.95	12.1	9.75	22.03	19.4	46.24	10.75	17.35	13.8	23.85	17.5	71.56	59.3	196.8	244.3	6.163	4.6
18	28-Mar	9.75	8.1	11.1	7.9	18.74	15.85	33.9	17.9	11.45	8.25	17.25	11.15	70.51	61.35	193.2	244.3	9.018	7.75

Source

Table 4. Put Options of the Stocks

		Banking Sector (Public)						Steel Industry						IT Sector					
		Bank of India		Bank of Baroda		State Bank of India		TATA Steel		JSW Steel		Jindal Steel		TCS		HCL		WIPRO	
No.	Date	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual
1	5–Mar	5.54	5.9	12.3	5.9	6.914	4	10.19	1.8	18.75	20.3	14.92	13.1	37.46	108.4	1.225	1.6	9.675	7.15
2	6–Mar	7.81	5.9	13.9	5.9	8.645	5.9	9.36	1.8	17.74	20.3	16.18	13.1	51.33	108.4	1.145	1.6	11.16	7.15
3	7–Mar	8.7	8.45	15.2	5.9	11.83	8.15	11.04	1.8	19.48	20.3	16.61	12	54.68	108.4	0.694	1.6	11.74	7.15
4	8–Mar	9.22	8.45	14.2	5.9	8.314	6	12.97	1.8	19.46	20.3	15.42	12	60.7	60	0.634	1.6	11.7	7.15
5	9–Mar	10.1	8.45	15.6	5.9	9.26	6.7	19.7	1.8	18	20.3	19.91	12	51.19	60	0.738	1.6	11.66	7.15
6	12–Mar	11.1	8.45	15	5.9	8.977	6.1	14.6	1.8	14.89	20.3	16.09	12	44	45	0.29	1.6	9.016	7.15
7	13–Mar	7.72	8.45	10.3	8.1	8.263	5.2	12.98	1.8	12.49	20.3	16.06	12	100.8	101	0.372	1.6	6.884	7.15
8	14–Mar	7.27	8.45	8.49	6.15	7.439	4.95	14.52	1.8	13.49	20.3	15.71	12	99.8	97	0.267	1.6	7.662	7.15
9	15–Mar	6.92	8.45	9.13	6.35	8.285	5.4	16.38	1.8	15.56	20.3	15.33	12	107.1	100	0.296	1.6	7.7	7.15
10	16–Mar	6.72	8.45	8.99	5.8	8.581	5.9	19.28	1.8	17.69	20.3	16.8	12	129.3	125.5	0.205	1.6	6.809	7.15
11	19–Mar	7.87	8.45	13.5	12.7	9.612	6.9	27.06	18	20.71	20.3	18.28	12.15	123.6	120	0.608	1.6	8.982	7.15
12	20–Mar	7.64	6.3	12.1	10.25	9.045	6.7	20.08	12.2	19.49	20.3	13.18	7.75	104.6	99.35	0.393	1.6	7.029	7.15
13	21–Mar	6.37	5.5	12.1	10	9.277	6.65	23.45	14.35	17.76	20.3	13.98	7.75	107.8	91.75	0.356	1.6	6.364	7.15
14	22–Mar	6.75	5.7	12.3	9.6	11.67	8.55	23.56	15	18.86	20.3	15.91	9.2	120.6	111.7	0.41	1.6	8.677	7.15
15	23–Mar	8.84	7.5	13.1	10.9	14.71	12.6	29.09	22.8	18.69	20.3	20.69	20	127.2	120.8	0.139	1.6	10.18	7.15
16	26–Mar	6.43	5.1	8.61	6.15	8.988	6.5	21.66	13.25	14.1	10.25	18.39	12	124.9	119	0.062	1.6	15.53	7.15
17	27–Mar	5.1	4.2	7.57	5.25	6.226	4.35	18.26	10.75	11.71	8.1	–26.24	6.8	106.3	100	0.043	1.6	15.38	14.2
18	28–Mar	5.61	4.3	7.98	5.5	7.428	5	24.98	17.9	16.57	13.8	–35.99	11	104.4	94.6	0.042	1.6	11.2	14.2

Source

Table 5. Call Options of the Stocks

		Pharmaceutical Sector						Automobile Sector						Textile Sector						FMCG					
		Cipla		Sun Pharma		Dr Reddy		Maruti Suzuki		Tata Motors		Ashok Leyland		Century textiles		Arvind Textiles		Raymonds		ITC		Dabur		Britannia	
No.	Date	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual
1	5-Mar	35.68	68.65	62	91.8	146.6	453.2	261.3	209.3	28.04	68.55	3.844	1.65	91.5	242.75	31.88	66.5	64.57	193	12.1	32.75	8.19	28.2	112.09	69.05
2	6-Mar	38.39	68.65	48.8	91.8	142.5	453.2	183.5	158.8	24.31	68.55	3.665	1.65	73.7	242.75	29.08	66.5	57.9	193	9.65	32.75	7.12	28.2	82.972	69.05
3	7-Mar	35.62	68.65	43.6	91.8	123.4	453.2	204.1	162	24.89	24	4.136	1.65	65.3	242.75	23.27	66.5	48.4	193	11.7	32.75	7.27	28.2	101.5	69.05
4	8-Mar	33.95	68.65	36.4	91.8	118.4	453.2	221	172	23.05	24	5.33	1.65	67.7	242.75	27.77	19.75	55.16	193	10.9	32.75	7.81	28.2	86.907	69.05
5	9-Mar	29.56	68.65	31.2	28	108.8	453.2	189.7	137.5	20.7	24	6.703	1.65	48.8	242.75	22.89	19.75	52.03	193	11.1	32.75	8.63	28.2	82.899	69.05
6	12-Mar	34.23	68.65	33.9	28	117.3	453.2	241.3	186	26.84	18	5.626	1.65	72.7	242.75	30.13	19.75	61.56	193	19	32.75	8.44	28.2	85.514	69.05
7	13-Mar	32.72	68.65	40.6	28	138.8	453.2	213.4	160	26.98	18	8.06	1.65	89	242.75	28.15	19.75	62.52	193	18.3	32.75	7.18	28.2	84.632	69.05
8	14-Mar	31.86	68.65	38.1	28	137.6	453.2	250	200	27.35	23.5	7.853	1.65	85.3	242.75	27.19	19.75	72.73	193	17.1	32.75	6.98	28.2	68.196	69.05
9	15-Mar	27.58	68.65	35.4	28	137.5	453.2	241.7	199	26.48	23.5	8.298	8.35	76.5	242.75	28	19.75	70.4	193	15	32.75	6.86	28.2	80.139	69.05
10	16-Mar	21.11	68.65	26.8	25	108.8	453.2	170	152.3	18.11	15.85	6.209	6.65	68	242.75	23.26	19.75	60.21	193	11.2	32.75	5.31	28.2	75.692	69.05
11	19-Mar	20.24	68.65	22.8	21.3	91.59	453.2	196.7	160.7	15.24	13.65	5.195	6.65	53	242.75	18.66	19.75	46.45	193	9.94	32.75	4.42	5	56.811	69.05
12	20-Mar	16.77	68.65	28.8	27.1	114.1	453.2	204.9	180	16.62	15.05	5.259	6.65	49.5	242.75	19.5	19.75	50.41	193	9.86	11.5	4.19	5	57.53	69.05
13	21-Mar	15.65	68.65	25.9	24.8	102.8	453.2	233.6	194.7	13.84	11.8	5.963	6.7	48.4	242.75	20.34	19.75	60.61	193	9.65	11.5	5.05	5	58.223	69.05
14	22-Mar	11.44	68.65	27.9	25.9	81.3	453.2	154	129.6	15.79	13.75	3.305	4.2	45.3	242.75	16.37	13	56.68	193	9.05	11.5	3.28	5	57.342	69.05
15	23-Mar	10.35	68.65	24	22.2	61.11	78	119.7	99.75	11.94	10.1	3.243	3.9	34.5	242.75	13.61	9.25	37.23	26.4	7.53	7.95	3.49	5	55.804	69.05
16	26-Mar	10.5	68.65	23.4	22.1	73.94	80	163.4	126.5	11.87	10.05	3.957	4.6	39.1	242.75	17.02	13.05	49.15	19	8.45	9.95	2.49	2.15	54.875	69.05
17	27-Mar	11.28	68.65	24.1	22	71.81	84.5	195.8	145.1	11.06	9.75	4.115	4.75	43.2	242.75	20.14	16.05	48.34	19	8.85	8.65	5.03	3.6	88.169	62.5
18	28-Mar	11.07	7.5	18.3	16.9	59.03	70.5	195	159.5	9.002	8.1	4.256	4.45	36.6	24.1	14.34	10.85	36.07	24.95	6.64	6.65	6.26	7	87.921	62.5

Source

Table 6. Put Options of the Stocks

		Pharmaceutical Sector						Automobile Sector						Textile Sector						FMCG			
		Cipla		Sun Pharma		Dr Reddy		Maruti Suzuki		Tata Motors		Ashok Leyland		Century textiles		Arvind Textiles		Raymonds		ITC		Dabur		Britannia	
No.	Date	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual	Fair	Actual
1	5-Mar	20.45	7.65	8.23	9	43.77	10	371.8	174.8	12.42	2.55	9.647	24.35	50.7	4	15.49	5.75	54.62	22.75	4.22	2.2	14.7	3.8	256.16	457.5
2	6-Mar	18.42	7.65	11.9	10.6	44.48	10	474.4	174.8	14.31	2.55	9.798	24.35	62.1	4	16.82	5.75	59.19	22.75	5.53	2.2	16	3.8	305.31	457.5
3	7-Mar	19.67	7.65	13.7	12.5	52.63	10	434.2	174.8	13.66	2.55	8.898	24.35	68.1	4	20.64	5.75	67.42	22.75	4.24	2.2	15.5	3.8	265.36	457.5
4	8-Mar	20.31	7.65	16.8	17	54.2	10	402.7	174.8	14.54	2.55	7.222	24.35	64.7	4	16.96	5.75	59.51	22.75	4.55	2.2	14.5	3.8	288.09	457.5
5	9-Mar	22.99	7.65	19.6	18.8	58.58	10	441.9	174.8	15.91	2.55	5.774	24.35	83.1	4	20.16	5.75	61.37	22.75	4.36	2.2	13.1	3.8	291.71	457.5
6	12-Mar	18.4	7.65	16.7	16.3	49.83	10	349.2	300	11.15	2.55	6.387	24.35	55.7	4	14.14	5.75	49.75	22.75	1.57	2.2	12.6	3.8	272.4	457.5
7	13-Mar	18.91	7.65	12.9	10.5	38.6	10	377.4	300	10.81	9.1	4.35	24.35	43.9	4	14.93	5.75	47.95	22.75	1.63	2.2	14.1	3.8	269.39	457.5
8	14-Mar	19.01	7.65	13.7	11.3	37.96	10	325.5	300	10.35	7.4	4.373	24.35	45	4	15.15	5.75	40.05	22.75	1.83	2.2	14.1	3.8	300.18	457.5
9	15-Mar	21.6	7.65	14.7	12.7	36.93	10	327.9	275	10.5	7.5	3.997	24.35	49.4	4	14.29	5.75	40.5	22.75	2.29	2.2	14	3.8	268.65	457.5
10	16-Mar	26.99	7.65	19.6	17	49.3	49	418.9	275	15.54	12.7	5.338	5.3	54.3	4	17.03	5.75	46.44	22.75	3.57	2.2	16.3	3.8	272.87	457.5
11	19-Mar	26.12	7.65	21.3	19	55.63	49	354.1	350	16.93	14.75	5.863	6.5	63.5	4	19.51	16.9	54.74	22.75	3.84	4.45	17.1	3.8	302.12	457.5
12	20-Mar	29.61	7.65	16.3	14.8	41.24	49	335.2	300	15.28	12.35	5.657	6.2	65.6	4	18.28	16.9	49.74	22.75	3.76	5.25	17.3	3.8	294.37	457.5
13	21-Mar	30.46	30	17.8	15.6	45.78	60	293.5	289.7	17.51	15.35	4.89	6.2	65.3	4	17.11	16.9	40.52	22.75	3.75	4.5	15.2	3.8	286.69	457.5
14	22-Mar	36.66	30	15.9	14.1	58.15	71	393.8	349.9	15.19	13.3	7.762	8.65	67.1	4	20.26	16.9	42.18	22.75	3.95	4.8	19	3.8	283.08	457.5
15	23-Mar	38.03	30	18.2	16.1	74.39	95	450.6	440	18.75	16.5	7.68	9.6	79.7	70	22.88	19.6	59.26	22.75	4.77	5	18	3.8	281.12	457.5
16	26-Mar	35.13	30	17	14.2	56.79	70.1	341.7	298.7	17.39	15.75	6.133	7.5	67.6	70	17.52	19.6	43.04	61	3.75	5.25	19.8	3.8	264.92	457.5
17	27-Mar	32.77	30	15.9	14	56.63	72.8	288.9	251.8	17.85	16.75	5.771	6.1	60.9	70	14.42	11.25	42.36	61	3.4	4.05	13.1	3.8	192.44	457.5
18	28-Mar	32.28	34.1	20.2	18.6	66.17	77.4	281.1	244.7	20.16	19.9	5.441	5.75	67.1	61	19.11	15.3	52.92	41.95	4.64	4.4	10.9	3.8	187.42	457.5

Source:

Table 7. Paired Sample t-Test for BSOPM Premium Value and Actual Market Premium Value: Call Option

S. No.	Stock Name	T	Df	P Value	Test Results	Conclusion
1	ACC Cement	−4.37	17	0.00	Rejected	Significant difference
2	Ambuja Cemnat	−6.43	17	0.00	Rejected	Significant difference
3	**Arvind Textile**	**−0.67**	**17**	**0.51**	**Accepted**	**No significant difference**
4	Ashok Lay	2.19	17	0.04	Rejected	Significant difference
5	Axis Bank	−7.70	17	0.00	Rejected	Significant difference
6	Bank of Baroda	12.38	17	0.00	Rejected	Significant difference
7	**Bank of India**	**−1.60**	**17**	**0.13**	**Accepted**	**No significant difference**
8	BHEL	−5.95	17	0.00	Rejected	Significant difference
9	**Britannia**	**1.97**	**17**	**1.97**	**Accepted**	**No significant difference**
10	Century Textile	−14.97	17	0.00	Rejected	Significant difference
11	Cipla	−11.71	17	0.00	Rejected	Significant difference
12	Dabur	−4.77	17	0.00	Rejected	Significant difference
13	Dr Reddy	−8.01	17	0.00	Rejected	Significant difference
14	Federal Bank	−5.40	17	0.00	Rejected	Significant difference
15	HCL	−18.93	17	0.00	Rejected	Significant difference
16	HDFC Bank	−3.69	17	0.00	Rejected	Significant difference
17	ITC	−5.44	17	0.00	Rejected	Significant difference
18	Jindal Steel	−3.49	17	0.00	Rejected	Significant difference
19	JSW Steel	−2.88	17	0.01	Rejected	Significant difference
20	Maruti Suzuki	13.33	17	0.00	Rejected	Significant difference
21	NTPC	9.17	17	0.00	Rejected	Significant difference
22	**ONGC**	**−1.57**	**17**	**0.14**	**Accepted**	**No significant difference**
23	Raymonds	−6.36	17	0.00	Rejected	Significant difference
24	**SBI**	**−0.20**	**17**	**0.84**	**Accepted**	**No significant difference**
25	**Sun Pharma**	**−1.36**	**17**	**0.19**	**Accepted**	**No significant difference**
26	**Tata Motors**	**−0.77**	**17**	**0.45**	**Accepted**	**No significant difference**
27	Tata Steel	−7.51	17	0.00	Rejected	Significant difference
28	TCS	−2.47	17	0.02	Rejected	Significant difference
29	Ultra Cement	−7.24	17	0.00	Rejected	Significant difference
30	Wipro	−6.90	17	0.00	Rejected	Significant difference

Note: The bold text represents that the there is no significant difference between BSOPM model prices and actual prices of the stock.

Table 8. Paired Sample t-Test for BSOPM Premium Value and Actual Market Premium Value: Put Option

S. No	Stock Name	T	Df	P Value	Test Results	Conclusion
1	ACC Cement	7.09	17	0.00	Rejected	Significant difference
2	Ambuja Cemnat	6.45	17	0.00	Rejected	Significant difference
3	Arvind Textile	5.85	17	0.00	Rejected	Significant difference
4	Ashok Lay	4.44	17	0.00	Rejected	Significant difference
5	**Axis Bank**	**0.60**	**17**	**0.55**	**Accepted**	**No significant difference**
6	Bank of Baroda	5.93	17	0.00	Rejected	Significant difference
7	**Bank of India**	**1.73**	**17**	**0.10**	**Accepted**	**No significant difference**
8	BHEL	2.37	17	0.03	Rejected	Significant difference
9	Britannia	24.14	17	0.00	Rejected	Significant difference
10	Century Textile	7.28	17	0.00	Rejected	Significant difference
11	Cipla	7.13	17	0.00	Rejected	Significant difference
12	Dabur	20.96	17	0.00	Rejected	Significant difference
13	Dr Reddy	2.23	17	0.04	Rejected	Significant difference
14	**Federal Bank**	**1.79**	**17**	**0.09**	**Accepted**	**No significant difference**
15	HCL	14.26	17	0.00	Rejected	Significant difference
16	HDFC Bank	10.31	17	0.00	Rejected	Significant difference
17	**ITC**	**0.95**	**17**	**0.35**	**Accepted**	**No significant difference**
18	**Jindal Steel**	**0.12**	**17**	**0.90**	**Accepted**	**No significant difference**
19	JSW Steel	2.29	17	0.03	Rejected	Significant difference
20	Maruti Suzuki	4.19	17	0.00	Rejected	Significant difference
21	NTPC	4.63	17	0.00	Rejected	Significant difference
22	**ONGC**	**0.78**	**17**	**0.45**	**Accepted**	**No significant difference**
23	Raymonds	5.52	17	0.00	Rejected	Significant difference
24	SBI	27.65	17	0.00	Rejected	Significant difference
25	Sun Pharma	6.96	17	0.00	Rejected	Significant difference
26	Tata Motors	4.77	17	0.00	Rejected	Significant difference
27	Tata Steel	12.75	17	0.00	Rejected	Significant difference
28	**TCS**	**1.06**	**17**	**0.30**	**Accepted**	**No significant difference**
29	Ultra Cement	5.21	17	0.00	Rejected	Significant difference
30	Wipro	3.08	17	0.00	Rejected	Significant difference

Note: The bold text represents that the there is no significant difference between BSOPM model prices and actual prices of the stock.

This present article is an attempt to find out the relevance and scientific contribution of the Black and Scholes model in Indian stock market context. For this purpose, 10 popular stocks were taken from NSE in India. The aim of this article is to find out the applicability of the BSOPM in Indian stock market and the results of this article conclude that the relationship between theoretical price and actual prices of the stocks is insignificant but is consistent with the results given by Sharma and Arora (2015) who conducted

the study by taking 60 sets of stocks and found out that BSOPM shows significant degree of mispricing. This study shows that there is difference between BSOPM values and actual values of the stocks for the given time duration.

Since this research has taken the data for 18 trading days and limited only to 30 sets of stocks, the results of this article cannot be generalized. Thus it is recommended for future researchers, students and practitioners to conduct their research by taking large sample size and long duration to test BSOPM relevance. Furthermore, the academicians, researchers or regulators may take sectorial data such as information technology (IT), cement, FMCG, banking, pharmacy or any other industry to test this model as few previous studies have inferred that model values are same as predicted and shown significant relationship between BSOPM value and actual value if the data are taken sector wise as confirmed by Panduranga (2013) who conducted his study on selected stocks from cement industry and stated that model was relevant for the cement stocks and there was significant relationship between BSOPM value and actual value of cement stocks. In future, this research can be extended by comparing BSOPM model with other pricing models such as binomial model, Monte Carlo model, etc.

This article rejects the null hypothesis stating no significant relationship between BSOPM prices and actual prices. The null hypothesis may be rejected for the few reasons such as the option market is inefficient, inputs to the Black–Scholes model have been incorrectly calculated or the mathematical structure of the Black–Scholes model is incorrect and may require few modifications. Therefore in future, the researchers may give consideration to above observation while using this model for option pricing. This model has been drawing attention of researcher, academicians and practitioners after its development in 1970, and in spite of its limitation it has been regularly applied by researchers in their study. Besides in some cases the model gives the same result as predicted and for some the results deviate from the predicted value. Hence, it is suggested to use this model carefully considering its limitations

Overall this study draws the attention of researchers, practitioners and regulator and supports them to analyse thoroughly the assumption of this model "with" encourages them for further in depth analysis of this model's assumptions and apply this pricing model with certain modifications. The limitation of the BSOPM should be tested and consideration should be given to the assumptions that are not addressed. This model provides an important theoretical work on optimal portfolio choice and multiperiod equilibrium in capital markets and allows researchers, students and practitioners to use market option price quotations as a measurement of market volatility.

Managerial Implication of the Study

BSOPM is a popular tool for option pricing. This method is very common and popular among researchers, students, academicians and practitioners. Apart from them, many investors, managers and major corporations use this model for future planning, purchasing, asset valuation, pricing or accounting purposes. They further use BSOPM in valuing put and call options. Many finance managers and corporations use BSOPM to determine the value of Employee Stock Ownership Plan (ESOP) and other equity-based compensation plans, warrants, convertible, securities, debt/bonds, etc. Even after the major economic crisis of 2008–2009 due to their unrealistic assumptions and flawed results, the mathematical or quantitative model-based trading continued to attract investors, researcher, practitioners and corporates for speculating future stock price. Derivative trading in spite of the complex features continued to gain popularity along with its underlying mathematical models of valuation. However, as inferred by Rubinstein (1985) in his study that in practice there is no way of knowing in advance the true value of the underlying stock volatility due to its uncertainty. After the publication for Black–Scholes model

(Black & Scholes, 1973) during 1970, the researchers and practitioners emphasized in finding out some empirical evidences from the key financial markets encompassing all sectors. For example, MacBeth and Merville (1979) carried on a research comparing the real market prices of call options with the prices predicted by Black and Scholes (1973). Such researches motivated other researchers from several other realms to apply BSOPM. Since then the Black–Scholes model has continued gaining popularity in different domains from business (Corrado & Su, 1996) to construction projects (Barton & Lawryshyn, 2011). Del Giudice, Evangelista, and Palmaccio (2016) in his study attempted to review the practicality of Black–Scholes model in different sectors and his outcome revealed that practical application of Black–Scholes model lies in the business studies sector focusing on the financial markets. A study conducted by Hong (2004) used the data from 1994 to 2003 from Malaysian stock markets and concluded that the BSOPM prices were significantly different and were below the market prices. The paper further inferred that this model can be applied as an investment strategy by investors in the Malaysian stock exchange only when the systematic pattern of deviation is known for the specific investment. Mohanti and Priyan (2014) conducted their research on the similar path by using BSOPM taking daily closing prices of S&P CNX Nifty index options contracts in the Indian stock market and concluded that the Indian index option market is efficient. Hence, this brief review about BSOPM explains that in some case the model results are in line with model predictions and in some cases there are discrepancies. The present study has been conducted by using the data for 30 sets of stocks for 18 trading days and the results concluded that there exists certain degree of mispricing which is consistent with many other researches (Sharma & Arora, 2015; Srivastava & Shastri, 2018).

Since its origin, BSOPM has been used in many different fields by many researchers ranging from construction projects (Barton & Lawryshyn, 2011) to IT projects (Benaroch, 2002) to evaluate the outcome of this model and provide for valid quantitative method for price forecasting to be used by corporate world. Hence as evidenced by few reviews in this section, the model produces mixed outcomes. The applicably of this BSOPM holds true for some cases while for other cases the result of the model cannot be generalized. The present study can be extended further in reality by using large sample size and longer time period to obtain the same value as predicted by this model. This article gives an insight about the mispricing aspect of BSOPM and can be useful for the corporates and investors. In future, the managers can apply this model along with some other pricing model such as binomial model, Monte Carlo, etc. to test the reliability of this model. BSOPM can be practically extended to many other different varieties of instruments with embedded options such as with cap, floor, swap look back options, etc.

The corporate world, finance managers, investors, accounts managers, etc. should analyse thoroughly the assumptions of this BSOPM and should be careful in terms of volatility while applying this pricing model. The limitation of the model should be tested and consideration should be given to the assumptions that are not addressed.

However, overall it can be concluded that BSOPM provides important practical applications such as pricing, hedging opportunity, information disclosure, etc. Thus this article provides an insight for finance managers, investors, accounts managers and corporate world where they can use the results of this study as an approximation for taking future decisions.

Conclusion

The present study finds out that the BSOPM and real actual values are insignificantly related. This research derives the finding that the difference between the prices increases as the moneyless of the

option contract moves from 'in-the-money' to 'at-the-money', which is due to movement of stock against the expectation of an investor and due to increase in volatility, and it is similar to the research outcome obtained in the study by Ali and Naima (2019) who examined the efficiency of three pricing models by comparing the call prices and highlighted that the results are different based on different types of moneyness. The BSOPM is partially relevant and can be adopted by an investor to anticipate the overpricing and underpricing of the option contract if all other constraints of the model are considered thoroughly.

This article reveals that there are significant differences in P values which can be attributed to many other indicators that influence the capital market as confirmed with the research outcome obtained in the study by Srivastava and Shastri (2018) who concluded that the significant differences in P values can be caused by a number of different factors that drive the financial market. Like all other markets, demand and supply are two dominating variables driving the prices of the option contract. The prices of the options are driven by many macro and micro indicators, directly or indirectly, such as GDP, inflation, interest rates, crude oil prices, exchange rates, per capital income, gold rates, recession in the economy, etc. The news and events related to the particular company, industry or market also influence the market movements. These events and information affect the market sentiments of the related stocks and therefore drive the prices accordingly.

In this article, it has been observed that the prices of banking sector are more consistent with the theoretical values than those with others. FMCG is also more consistent with theoretical values, but in cement industry both call and put options are significantly different. The reason for this can be perceptions of the investors for the specified period of study who may be bidding for the Bullish market. Hence the prices of the cement industry, government sector, automobile industry and even IT sector the contracts for both put and call options are significantly different from their theoretical values.

There are many other pricing models which can be adopted to calculate the theoretical price of the option. Since the assumptions of BSOPM are fundamental and suffer from few limitations, it is suggested to adopt other pricing models too for more accurate calculation of options prices. Investors can adopt other pricing models that will consider the assumptions which are not considered under BSOPM.

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