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Approximating the Implied Volatility for Black Scholes Option Pricing in Indian Options Market

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Abstract

Volatility is still the most mysterious component of Option Pricing Theory. The Black Scholes Option Pricing Model is the one foundation stone of Option pricing theory, but it has only one unknown parameter i.e. Implied Volatility. This paper tries to make a comparative analysis of the seven closed-form approximations of Implied Volatility in Indian options market. The study tries to capture the relative accuracy and information content on different basis like time to maturity, interest rate and moneyness for one month options over a long term of twelve years i.e. from June 2001 to Dec. 2012.The results indicate that the Corrado and Miller approximation and the Keber and Schuster approximation are relatively much accurate than the other approximations being compared.

Key Words

Implied Volatility, Black Scholes, Approximation, Errors, Options.

INTRODUCTION

Volatility has a central role in Derivative Pricing Theory. The Black-Scholes Model has volatility as the only parameter among strike price, time to expiration, interest rate and the spot price that has to be forecasted. The underlying asset's volatility is needed in the pricing of an option and there are options with volatility as the underlying assets. The unknown parameter of Option Pricing through the Black Scholes Option Pricing Model is Implied Volatility. This paper focuses on finding the best estimate of implied volatility which can be calculated through a closed-form solution with the known parameters and thus can be used as a substitute for the Black scholes implied volatility.

REVIEW OF LITERATURE

Latane and Rendleman (1976) first noted that each observable variable has a changing impact on the resulting call premium. Their model approximates volatility by taking implied volatilities for all options traded on a given underlying asset and putting weights according to the partial derivative of the Black Scholes equation with respect to each implied volatility. Beckers (1981) investigated the predictive ability of implied volatility. They considered closing price data of CBOE stock options for the period April 1975 to July 1977. He considered dividend and the significance of weights in interpretation of volatilities. Beckers concluded that the predictive power of implied volatility was superior to the historical volatility in estimating cross-sectional stock volatility. He also found that implied volatility was biased and informational inefficient, since historical volatility provided additional information for volatility forecasting.

Hull & White (1987) studied that when volatility is constant Black Scholes Implied Volatility of an At-The-Money option is approximately equal to the expected future realised volatility during the option life. Haeberle, Kahl and Curtis (1990) computed the direct implied volatility using Curtis and Carriker approximation for nearest to the money options of soyabean and corn futures contracts. They analysed the data for the time period of 1986 to 1988. They estimated that premiums using the measure of implied volatility were more accurate than premiums estimated using the measure of historic volatility. Their results also showed that the use of implied volatility led to more accurate predictions than the use of historic volatility on the majority of days. Canina and Figlewski (1993) examined the information content of implied volatility by regressing the realised volatility on the corresponding implied volatility for the remaining life of asset. They did not find any significant correlation between the volatilities, implied and realised, across different maturities and moneyness. They also found a weak predictive ability of implied volatility as compared to historical volatility in the time horizon of greater than sixty days. Genmill (1993) compared implied volatility with an autoregressive random variance model's volatility for At-The-Money FTSE 100 option prices and concluded that the implied volatility provided the indication for future volatility. Lamoureux and Lastrapes (1993) investigated implied volatility under the framework of Hull and Whites (1987) stochastic volatility option pricing model. They analysed the volatility forecasts with the GARCH and historical volatility estimates for At-The-Money CBOE call options. They concluded that implied volatility was biased but informative, and that historical volatility contributed additional information in forecasting future stock return volatility. Jorion (1995) examined the information content and the predictive power of implied volatility for foreign currency future options. He analysed that the implied volatility was better for forecasting for the next day rather than for the remaining life of the option. Chance (1996) estimated the approximation for the implied volatility using a closed-form equation for Near-The-Money options. Chambers and Nawalkha (2001) reviewed Bharadia *et al.* Approximation method in comparison to the Corrado & Miller method and modified Chance method. They found that the mean absolute errors were less accurate in case of Bharadia *et al.* Approximation as compared to the modified Chance model and modified Corrado and Miller model. Massa *et al.* (2007) proposed a comprehensive study of relative accuracy for all available approximations of Black Scholes Implied Volatility. This study used actual daily settlement prices for futures and options contracts for corn and cotton from 1990 to 2005. The large data–set and alternative accuracy measures to ensure reliable results. They found more accurate results with Corrado and Miller's method followed by Bharadia *et al.*'s and Li's method when only call premiums were used. As lesser work has been carried on testing the accuracy of closed-form approximations for implied volatility in Indian market, thus we have considered this topic for the analysis.

OBJECTIVE OF THE STUDY

The objective of the study is to make an analysis regarding the reliability and accuracy of the proxies available for the implied volatility input for the Black Scholes Option Pricing Model in Indian Stock Market. The study tries to find out the best approximation for the implied volatility which can be calculated by using the available variables.

RESEARCH METHODOLOGY

The study considers the options on S&P Nifty Index traded on NSE. The options are European in nature. The time frame for the study includes option contracts till 2012 since inception i.e. June 2001.

Data Sampling

Christensen and Prabhala (1998) pointed out the problem associated with overlapping data which led to inappropriate results in Canina and Figlewiski (1993) work. They suggested the use of one month contracts for better estimation. Moving on the same lines, the sampling of data points to be considered for the study is done on the basis of the following sampling plan :

Step 1 : Options to be considered for the study must be collected on the working day immediately following the expiry date and this option must expire on the next expiry date. This option has approximately a month's period to expiration. Such method avoids overlapping data.

Step 2 : Out of the options considered in Step 1, the options which fall in the range of St / Xt ε (0.95, 1.05) where St is the index level and Xt is the exercise price of the option. The aim is to consider the At-The-Money (ATM) options only as they provide better estimates of the volatility and the range is considered as the definition of ATM option.

Step 3 : Options must satisfy boundary condition i.e . $c > \{(F * e^{(-rr} - X)$. The observation would be included only if it satisfies the boundary condition.

The aim is to capture the most appropriate estimate of volatility. Only ATM options have been considered because it is considered that ATM options provide a better assessment of accurate implied volatility than In-The-Money(ITM) options and Out-Of-The(OTM) money options.

Data

There were initially 20,785 observations in total, but after filtering the data through the above steps, the valid observations were 13702. These observations were considered as valid sample. The valid sample was then considered for the further analysis.

Black Scholes Implied Volatility (BSIV)

It is the value of the volatility that is built into the market's option price. It is referred to as a market price for the holding period of an option.

It reflects the market expectations regarding the market's future volatility. It is based on the assumption of positive relationship between expected risk and expected returns.

$$E(\sigma_t) \sim E(r_t)$$

The Black Scholes Implied Volatility is the unique parameter for which the Black Scholes formula recovers the price of that option.

The options price for a call is computed as per the following Black Scholes formula :

$$C = S * N(d_1) - \{X * e^{-rr} * N(d_2)\}$$

where :

$$d_1 = \frac{\left[\ln\left(\frac{S}{X}\right) + \left(r^2 + \frac{\sigma^2}{2}\right) * r\right]}{\sigma * \sqrt{r}}$$

$$d_2 = \frac{\left[\ln\left(\frac{S}{X}\right) + \left(r - \frac{\sigma^2}{2}\right) * r\right]}{\sqrt{r}} = d_1 - \sigma\sqrt{r}$$

where

C = price of a call option
P = price of a put option
S = price of the underlying asset
X = Strike price of the option
r = rate of interest
t = time to expiration
σ = volatility of the underlying
N represents a standard normal distribution with mean = 0 and standard deviation = 1

In represents the natural logarithm of a number. Natural logarithms are based on the constant e (2.718).

The limitation of Black Scholes formula for determining implied volatility is that it is solution of a tracing back process, which inculcates computational hassles. Implied volatility as per Black Scholes formula involves an iterative process that equates market determined call price to the known variables in the formula.

Numerical methods are used for calculating the implied volatility in which a dummy value is given initially and then different values are substituted in the formula in order to equate the formula to the observed option price; so as to find out the correct value of the implied volatility. Newton method has been used for finding the correct value of implied volatility.

This limitation provoked the exploration of alternative approximations which can be used as alternatives for the implied volatility.

Curtis and Carriker Approximation

Curtis and Carriker (1988) proposed a non-iterative method which approximates implied volatility for ATM options. They employed the following equation to solve implied volatility :

$$\sigma \approx \left(\frac{2}{\sqrt{r}}\right)\varphi\frac{(C+S)}{2S}$$

Where $\varphi = N^{-1}$ and this approximation is more correct for ATM options.

Bharadia *et al.* Approximation

Bharadia et al. (1996) developed a simplified volatility approximation as :

$$\sigma \approx \left(\frac{\sqrt{2\pi}}{r}\right)*\left(\frac{(c-(S-K)}{2}\Big/\left(\frac{S-(S-K)}{2}\right)\right)$$

Brenner & Subrahmanyam Approximation

Brenner & Subrahmanyam (1988) proposed a following formula :

$$\sigma \approx \left(\sqrt{\frac{2\pi}{r}}\right)*\left(\frac{C}{S}\right)$$

where C is call premium

S is current underlying asset price

r is time till expiration of option.

The accuracy of formula is based on the assumption that the price is equal to discounted exercise price. In this approximation, an at-the-money option is defined as one whose futures price is equal to discounted strike price $S = Xe^{-rr}$

Corrado and Miller Approximation

Corrado and Miller (1996) proposed the following formula which was the extention of Brenner and Subrahmanyam method to approximate Near-The-Money options :

$$\sigma \approx \sqrt{\frac{2\pi}{r}}\left(\frac{1}{(S+K)}\right)\left[C-\frac{(S-K)}{2}+\sqrt{\left(C-\frac{S-K}{2}\right)^2-\frac{(S-K)^2}{\pi}}\right]$$

The equation uses discounted strike price as well as discounted futures price i.e. K = Xe–rr and $S = Se^{-rr}$

Keber and Schuster Approximation

Keber and Schuster (2003) gave the following formula for approximating implied volatility :

$$\sigma \approx \left(\sqrt{\frac{1}{r}}\right)*\left(\frac{\sqrt{2\pi}}{(S_0+X_0)}\right)*\left(c-\frac{(S_0-X_0)}{2}+\frac{1}{(\pi*(c-r))}\right)$$

$$+\sqrt{\left(c-\left(\frac{(S_0-X_0)}{2}\right)+\left(\left(\frac{(S_0-t-X_0)^2}{2*\pi(2*(S_0-X)+(X_0))}\right)\right)\right)^2-\frac{(S_0-X_0)^2}{\pi}}$$

Li's Approximation

Li (2005) proposed the implied volatility approximation which was an improvement on the Brenner and Subrahmanyam formula.

$$\sigma \approx \frac{2\sqrt{2}}{\sqrt{r}}\tilde{Z}-\frac{1}{\sqrt{r}}\sqrt{8\tilde{Z}^2}-\frac{6\alpha}{\sqrt{2}\tilde{Z}}$$

Where $Z = \text{Cos}\left[\frac{1}{3}\text{Cos}^{-1}\left(\frac{3\alpha}{\sqrt{32}}\right)\right]$ and $\alpha = \frac{\sqrt{2\pi}}{S}C$

Chargoy-Corona and Ibarra Valdez Approximation

Chargoy-Corona and Ibarra Valdez (2006) approximated implied volatility by using mathematical framework, guided by Galios Theory. The following formula assumes that options are exactly at the money :

$$\sigma \approx \left(\frac{2}{\sqrt{r}}\right)\varphi\left(\frac{Ce^{-rr}+X}{2X}\right)$$

Analysis of Accuracy

The estimation efficiency of an approximation can be assessed by regressing Black Scholes Implied Volatility on the implied volatility approximation. The R-squared statistic measures how successful the fit is explaining the variation of the data. R-square is the square of the correlation between the actual response values and the approximations.

$$\text{BSIV} = \beta_0 + \beta_1 \text{ proxy} + \varepsilon$$

If the volatility approximation is accurate, then the value of β_0 and β_1 would be 0 and 1 respectively. The sign and magnitude of the coefficients as well as the adjusted R^2 are interpreted to judge the predictive power of different models.

The following four alternative accuracy measures evaluate the accuracy of alternative estimates relative to Black Scholes Implied Volatility estimates out of which two measures are based on percentage errors and two on absolute error values :

Percentage errors can be calculated as follows :

$$Pt = [\ (At - Bt) / Bt] * 100$$

And errors values can be calculated as follows :

$$Et = At - Bt$$

Where B is Black Scholes Implied Volatility and A is volatility approximation and t denotes the point of time.

The measures of errors to be used in the study are as follows :

Mean Error : $ME = \frac{1}{T}\sum_{t=1}^{T} e_t$

Mean Squared Error : $MSE = \frac{1}{T}\sum_{t=1}^{T} e_t^2$

Mean Absolute Error : $MAE = \frac{1}{T}\sum_{t=1}^{T} |e_t|$

Mean Percentage Error : $RMSE = \frac{1}{T}\sum_{t=1}^{T} p_t^2$

RESULTS AND ANALYSIS

Table 1 showcases the descriptive statistics for the Black Scholes Implied Volatility and the other seven approximations for the implied volatility. It can be observed that the mean value of all the approximations is bit higher than Black Scholes Implied Volatility (BSIV). Only the KEBER_IV has lower standard deviation than BSIV.

Table 1

Descriptive Statistics for the Implied Volatility Approximations

	BSIV	Curtis_ IV	Brenner_ IV	Bhardia_ IV	Chargoy_ IV	Corrado_ IV	LI_ IV	Keber_ IV
Mean	0.24212	0.29970	0.29438	0.29845	0.29820	0.26184	0.29164	0.26309
Std. Er.	0.00086	0.00201	0.00192	0.00108	0.00200	0.00101	0.00188	0.00101
Std. Dev.	0.10106	0.23505	0.22525	0.12671	0.23428	0.10087	0.22051	0.10091
Kurtosis	17.06304	4.32070	4.16430	14.42336	4.39728	20.78742	4.11691	20.89488
Skewness	2.20718	1.37752	1.33068	1.94281	1.38973	2.86332	1.31067	2.86742
Range	1.72100	2.66836	2.54356	2.92645	2.66701	1.70540	2.48842	1.70017
Minimum	0.00000	0.00000	0.00000	-1.09754	0.00000	0.01292	0.00000	0.02413
Maximum	1.72100	2.66836	2.54356	1.82892	2.66701	1.71832	2.48842	1.72430
Count	13702	13702	13702	13702	13702	10054	13702	10055
Confidence Level (95.0%)	0.00169	0.00394	0.00377	0.00212	0.00392	0.00197	0.00369	0.00197

The results for the regression equation :

$$BSIV = \beta_0 + \beta_1 proxy + \varepsilon$$

are given in Table 2. The regression equation is tested for each of the approximation. For being an unbiased estimator of implied volatility, the coefficients of regression equation must be equal of 0 and 1 respectively. It can be observed that the Adjusted R^2 and values of coefficients are satisfactory only in case of CORRADO_IV and KEBER_IV.

Table 2

Regression Results for different Approximations with Complete Sample

	Coefficient	Std.Er.	t-statistic	p-value	Adj. R^2	Std.Er.	N
$BSIV = \beta_0 + \beta_1$ CURTIS_IV							
β_0	0.18198	0.00124	147.07236	0.00000	0.21775	0.08938	13702
β_1	0.20066	0.00325	61.76441	0.00000			
$BSIV = \beta_0 + \beta_1$ BRENNER_IV							
β_0	0.17884	0.00125	143.39834	0.00000	0.22943	0.08871	13702
β_1	0.21493	0.00336	63.87788	0.00000			
$BSIV = \beta_0 + \beta_1$ BHARADIA_IV							
β_0	0.09718	0.00175	55.45071	0.00000	0.37074	0.08017	13702
β_1	0.48565	0.00541	89.85169	0.00000			
$BSIV = \beta_0 + \beta_1$ CHARGOY_IV							
β_0	0.18221	0.00124	147.32778	0.00000	0.21686	0.08943	13702
β_1	0.20091	0.00326	61.60264	0.00000			
$BSIV = \beta_0 + \beta_1$ CORRADO_IV							
β_0	0.00410	0.00016	26.41758	0.00000	0.99690	0.00559	10054
β_1	0.99357	0.00055	1796.72539	0.00000			
$BSIV = \beta_0 + \beta_1$ LI_IV							
β_0	0.17740	0.00125	141.62731	0.00000	0.23441	0.08843	13702
β_1	0.22192	0.00343	64.77582	0.00000			
$BSIV = \beta_0 + \beta_1$ KEBER_IV							
β_0	0.00321	0.00013	24.20205	0.00000	0.99775	0.00476	10055
β_1	0.99325	0.00047	2110.95343	0.00000			

Table 3

Regression Results for Implied Volatility Approximations with Sub-Samples on the Basis of Risk Free Interest Rate

	Less than 6%					More than 6%				
	BSIV = $\beta_0 + \beta_1$ CURTIS_IV									
	β_0	β_1	Adj. R^2	Std. Er.	N	β_0	β_1	Adj. R^2	Std. Er.	N
value	0.1917	0.2781	0.2931	0.0841	3597	0.1739	0.2661	0.3052	0.0834	6457
Std. Er.	0.0026	0.0072				0.0019	0.0050			
t-statistic	74.2366	38.6288				91.9812	53.2562			
p-value	0.0000	0.0000				0.0000	0.0000			
	BSIV = $\beta_0 + \beta_1$ BRENNER_IV									
value	0.1864	0.2994	0.3111	0.0830	3597	0.1694	0.2847	0.3197	0.0825	6457
Std. Er.	0.0026	0.0074				0.0019	0.0052			
t-statistic	71.4984	40.3114				88.7801	55.0941			
p-value	0.0000	0.0000				0.0000	0.0000			
	BSIV = $\beta_0 + \beta_1$ BHARADIA_IV									
value	-0.0048	0.9246	0.9125	0.0296	3597	0.0011	0.8911	0.9086	0.0303	6457
Std. Er.	0.0015	0.0048				0.0011	0.0035			
t-statistic	-3.1600	193.6989				1.0264	253.2942			
p-value	0.0016	0.0000				0.3047	0.0000			

Contd.

Contd. Table 3

BSIV = β_0 + β_1 CHARGOY_IV										
value	0.1920	0.2791	0.2910	0.0842	3597	0.1740	0.2669	0.3053	0.0834	6457
Std. Er.	0.0026	0.0073				0.0019	0.0050			
t-statistic	74.2890	38.4306				92.1000	53.2777			
p-value	0.0000	0.0000				0.0000	0.0000			
BSIV = β_0 + β_1 CORRADO_IV										
value	0.0041	0.9927	0.9973	0.0052	3597	0.0040	0.9942	0.9966	0.0058	6457
Std. Er.	0.0002	0.0009				0.0002	0.0007			
t-statistic	16.6059	1157.1774				20.4161	1381.4004			
p-value	0.0000	0.0000				0.0000	0.0000			
BSIV = β_0 + β_1 LI_IV										
β_0	0.1837	0.3104	0.3205	0.0825	3597	0.1674	0.2940	0.3255	0.0822	6457
Std. Er.	0.0026	0.0075				0.0019	0.0053			
t-statistic	70.2101	41.1931				87.2622	55.8301			
p-value	0.0000	0.0000				0.0000	0.0000			
BSIV = β_0 + β_1 KEBER_IV										
value	0.0025	0.9942	0.9989	0.0034	3597	0.0026	0.9950	0.9985	0.0038	6457
Std. Er.	0.0002	0.0006				0.0001	0.0005			
t-statistic	15.5062	1772.7558				19.5994	2107.8035			
p-value	0.0000	0.0000				0.0000	0.0000			

It the second phase of regression-based analysis, the complete sample is further divided on the basis of interest rate, time to expiry and differential returns. Table 3 shows the results for the sample divided on the basis of interest rate. MIBOR is considered as proxy for the risk free interest rate. The total sample is further sub-divided into two sub samples. The first sub-sample considers the regression analysis for those observations in which MIBOR rate is less than 6% and the second sub-sample consists of those observations in which the MIBOR rate is more than 6%.

It can be observed that the approximations given by Bharadia *et al.* (BHARADIA-IV), Corrado (CORRADO-IV) and Keber (KEBER-IV) are satisfactory in terms of performance.

Now the total sample is again sub-divided into 8 sub-samples which are categorised on the basis of time to expiry i.e. 3, 5, 10, 15, 20, 25, 30 days to expiry and more than 30 days. It is evident that the KEBER-IV has shown the persistent performance along with the CORRADO-IV. The regression based performance for the sub-samples is shown below in Table 4.

It can be observed that as the time to expiry has a horizon of one month, the accuracy of the KEBER_IV increases a lot. Similarly the performance of CORRADO_IV also showcases the best fit. It can also be observed that the results shown by BHARADIA_IV are also satisfactory.

Table 4

Regression Results for Implied Volatility Approximations for the Sub-Samples on the Basis of Time to Expiry

	CURTIS_IV	BRENNER_IV	BHARADIA_IV	CHARGOY_IV	CORRADO_IV	LI_IV	KEBER_IV
r : less than 3 days							
Adj. R^2	0.7290	0.7248	0.9599	0.7291	0.9971	0.7234	0.9984
Std. Er.	0.1159	0.1168	0.0446	0.1159	0.0121	0.1171	0.0090
N	155	155	155	155	155	155	155
r : more than 3 days but less than 5 days							
Adj. R^2	0.4445	0.4496	0.9268	0.4445	0.9951	0.4520	0.9977
Std. Er.	0.1080	0.1075	0.0392	0.1080	0.0102	0.1073	0.0069
N	596	596	596	596	596	596	596
r : more than 5 days but less than 10 days							
Adj. R^2	0.2458	0.2566	0.8865	0.2458	0.9942	0.2613	0.9976
Std. Er.	0.0920	0.0913	0.0357	0.0920	0.0081	0.0910	0.0052
N	1441	1441	1441	1441	1441	1441	1441
r : more than 10 days but less than 15 days							
Adj. R^2	0.2047	0.2188	0.8927	0.2044	0.9969	0.2248	0.9988
Std. Er.	0.0798	0.0791	0.0293	0.0798	0.0050	0.0788	0.0031
N	2863	2863	2863	2863	2863	2863	2863
r : more than 15 days but less than 20 days							
Adj. R^2	0.2428	0.2628	0.9204	0.2427	0.9983	0.2707	0.9994
Std. Er.	0.0761	0.0750	0.0247	0.0761	0.0036	0.0746	0.0021
N	2440	2440	2440	2440	2440	2440	2440
r : more than 20 days but less than 25 days							
Adj. R^2	0.3343	0.3621	0.9501	0.3329	0.9993	0.3754	0.9998
Std. Er.	0.0794	0.0777	0.0217	0.0795	0.0025	0.0769	0.0014
N	1489	1489	1489	1489	1489	1489	1489
r : more than 25 days but less than 30 days							
Adj. R^2	0.4429	0.4720	0.9673	0.4408	0.9997	0.4872	0.9999
Std. Er.	0.0695	0.0677	0.0168	0.0696	0.0017	0.0667	0.0010
N	801	801	801	801	801	801	801
r : more than 30 days							
Adj. R^2	0.4162	0.4450	0.9643	0.4142	0.9999	0.4588	1.0000
Std. Er.	0.0586	0.0572	0.0145	0.0587	0.0008	0.0565	0.0004
N	269	269	269	269	269	269	269

Table 5

Regression Results for Implied Volatility Approximations for Samples Based on the Difference Between Discounted Futures Value and Discounted Strike Price of Options

	In case of $F.e^{(-r*t)} < X.e^{(-r*t)}$					In case of $F.e^{(-r*t)} > X.e^{(-r*t)}$				
	$BSIV = \beta_0 + \beta_1$ CURTIS_IV									
	β_0	β_1	Adj. R^2	Std. Er.	N	β_0	β_1	Adj. R^2	Std. Er.	N
Value	0.1327	0.7965	0.6272	0.0583	4670	0.0846	0.4137	0.5239	0.0720	5384
Std. Er.	0.0017	0.0090				0.0026	0.0054			
t Stat	78.7446	88.6419				33.0059	76.9656			
P-value	0.0000	0.0000				0.0000	0.0000			
	$BSIV = \beta_0 + \beta_1$ BRENNER_IV									
Value	0.1299	0.8002	0.6465	0.0568	4670	0.0770	0.4420	0.5391	0.0708	5384
Std. Er.	0.0016	0.0087				0.0026	0.0056			
t Stat	78.7675	92.4036				29.8434	79.3589			
P-value	0.0000	0.0000				0.0000	0.0000			
	$BSIV = \beta_0 + \beta_1$ BHARADIA_IV									
Value	-0.0002	0.9054	0.9067	0.0292	4670	-0.0022	0.9034	0.9125	0.0309	5384
Std. Er.	0.0013	0.0042				0.0012	0.0038			
t Stat	-0.1621	213.0663				-1.8095	236.8825			
P-value	0.8712	0.0000				0.0704	0.0000			

Contd.

Contd. Table 5

BSIV = $\beta_0 + \beta_1$ CHARGOY_IV										
Value	0.1325	0.8021	0.6274	0.0583	4670	0.0853	0.4141	0.5216	0.0722	5384
Std. Er.	0.0017	0.0090				0.0026	0.0054			
t Stat	78.5973	88.6650				33.2695	76.6188			
P-value	0.0000	0.0000				0.0000	0.0000			
BSIV = $\beta_0 + \beta_1$ CORRADO_IV										
Value	0.0041	0.9927	0.9969	0.0053	4670	0.0041	0.9941	0.9969	0.0058	5384
Std. Er.	0.0002	0.0008				0.0002	0.0008			
t Stat	18.4279	1224.1960				19.1762	1315.3542			
P-value	0.0000	0.0000				0.0000	0.0000			
BSIV = $\beta_0 + \beta_1$ LI_IV										
Value	0.1285	0.8037	0.6545	0.0562	4670	0.0734	0.4563	0.5457	0.0703	5384
Std. Er.	0.0016	0.0085				0.0026	0.0057			
t Stat	78.6088	94.0541				28.3623	80.4210			
P-value	0.0000	0.0000				0.0000	0.0000			
BSIV = $\beta_0 + \beta_1$ KEBER_IV										
Value	0.0023	0.9946	0.9988	0.0033	4670	0.0028	0.9945	0.9986	0.0039	5384
Std. Er.	0.0001	0.0005				0.0001	0.0005			
t Stat	16.5615	1962.7741				19.2094	1949.0423			
P-value	0.0000	0.0000				0.0000	0.0000			

In this we have tried to distribute the sample into two categories on the basis of difference between futures value discounted for risk free rate for the time to expiry and strike price of the option being discounted with the same risk free rate and time to expiry. The difference between the two represents whether the options are In-The-Money or Out-Of-The money. The values are discounted in order to include the present value of dividends given by the stocks comprising the underlying asset i.e. the Nifty Index. Observing the results in Table 5, it can be interpreted that the CORRADO_IV approximation and KEBER_IV approximation are the best estimates for the implied volatility.

ANALYSIS OF ERRORS

The analysis of errors is important in order to find out the loss functions and express the accuracy of the method for constructing fitted values in the model. The results for the errors have been shown below for all the samples created on the basis of different criteria.

The results for the mean errors are shown in the Table 6 below. It is the most simple definition of loss function. It is the amount of physical error in an approximation. It is a common measure to forecast error in time series analysis. The results shown below clearly show that the errors related to CORRADO_IV AND KEBER_IV have the least error. The errors further reduce when the time to expiry is more than 25 days.

Table 6

Results for the Mean Errors

	CURTIS_IV	BRENNER_IV	BHARADIA_IV	CHARGOY_IV	CORRADO_IV	LI_IV	KEBER_IV	N
Samples on the basis of Time to Expiry								
Upto 3 days	0.0935	0.0876	0.0479	0.0932	-0.0066	0.0849	-0.0045	155
3 to 5 days	0.0705	0.0658	0.0452	0.0701	-0.0054	0.0637	-0.0034	596
5 to 10 days	0.0695	0.0640	0.0429	0.0687	-0.0045	0.0611	-0.0026	1441
10 to 15 days	0.0611	0.0558	0.0319	0.0599	-0.0025	0.0526	-0.0012	2863
15 to 20 days	0.0415	0.0371	0.0246	0.0399	-0.0016	0.0344	-0.0006	2440
20 to 25 days	0.0158	0.0126	0.0209	0.0136	-0.0012	0.0107	-0.0003	1489
25 to 30 days	0.0112	0.0082	0.0159	0.0082	-0.0007	0.0067	0.0000	801
More than 30 days	0.0105	0.0075	0.0140	0.0067	-0.0005	0.0061	0.0001	269
Samples on the basis of MIBOR								
More than 6.5%	0.0256	0.0219	0.0277	0.0234	-0.0022	0.0200	-0.0010	3597
Less than 6.5%	0.0583	0.0532	0.0303	0.0571	-0.0026	0.0503	-0.0013	6457
Samples on the basis of Difference between Discounted Futures Value and Discounted Strike Price								
$F.e^{(-r^*t)} < X.e^{(-r^*t)}$	-0.0998	-0.0970	0.0275	-0.1007	-0.0022	-0.0960	-0.0009	4670
$F.e^{(-r^*t)} > X.e^{(-r^*t)}$	0.1735	0.1626	0.0309	0.1714	-0.0026	0.1569	-0.0013	5384

The Table 7 showcases the error square of the simple errors between the BSIV and the Volatility approximation. The error square provides a quadratic loss function and also measures the uncertainty in forecasting. Mean Error square places more emphasis on the magnitude of the error rather than the direction of the error. It can be clearly observed that the mean square error for the CORRADO_IV and KEBER_IV presents the minimum loss functions in almost all the sub- samples. But the approximation BHARADIA_IV also showcases some improvement in few cases.

The Table 8 presents the results for the percentage errors. The percentage error has positive value if the approximation is greater than the true value. So, it can be said that the negative values of the percentage errors are more preferred one. The results of percentage errors are also aligned with the previous results showing the better performance of approximations CORRADO_IV and KEBER_IV in determining the true value for BSIV.

Absolute error refers to just the magnitude of simple errors and not the direction. Mean absolute errors for the approximations are shown in Table 9. It clearly indicates that KEBER_IV approximation is one of the most appropriate proxy for BSIV.

CONCLUSION

The results of the study clearly show that the approximations provided by Corrado and Miller, and Keber and Schuster are the most appropriate proxy for the implied volatility. Thus, these closed-form solutions for implied volatility can be used as an input for the implied volatility in Black Scholes Option Pricing Model rather than back solving the implied volatility. Thus, the use of the closed form proxy would enhance the forecasting power of the Black Scholes Option Pricing Model.

Table 7

Results for the Error Square

	CURTIS_IV	BRENNER_IV	BHARADIA_IV	CHARGOY_IV	CORRADO_IV	LI_IV	KEBER_IV	N
Samples on the basis of Time to Expiry								
Upto 3 days	0.0774	0.0690	0.0052	0.0772	0.0002	0.0653	0.0001	155
3 to 5days	0.0537	0.0489	0.0040	0.0535	0.0001	0.0468	0.0001	596
5 to 10 days	0.0481	0.0433	0.0035	0.0477	0.0001	0.0411	0.0000	1441
10 to 15 days	0.0347	0.0308	0.0020	0.0343	0.0000	0.0289	0.0000	2863
15 to 20days	0.0245	0.0215	0.0012	0.0241	0.0000	0.0201	0.0000	2440
20 to 25days	0.0189	0.0165	0.0009	0.0186	0.0000	0.0155	0.0000	1489
25 to 30days	0.0148	0.0127	0.0005	0.0145	0.0000	0.0118	0.0000	801
More than 30days	0.0129	0.0110	0.0004	0.0125	0.0000	0.0102	0.0000	269
Samples on the basis of MIBOR								
More than 6.5%	0.0275	0.0244	0.0017	0.0271	0.0000	0.0230	0.0000	3597
Less than 6.5%	0.0336	0.0298	0.0020	0.0333	0.0000	0.0281	0.0000	6457
Samples on the basis of Difference between Discounted Futures Value and Discounted Strike Price								
$F.e^{(-r*t)} < X.e^{(-r*t)}$	0.0137	0.0130	0.0017	0.0139	0.0000	0.0127	0.0000	4670
$F.e^{(-r*t)} > X.e^{(-r*t)}$	0.0467	0.0408	0.0020	0.0459	0.0000	0.0380	0.0000	5384

Table 8

Results for the Percentage Error

	CURTIS_IV	BRENNER_IV	BHARADIA_IV	CHARGOY_IV	CORRADO_IV	LI_IV	KEBER_IV	N
Samples on the basis of Time to Expiry								
Upto 3 days	0.2809	0.2674	0.2028	0.2799	-0.0273	0.2615	-0.0188	155
3 to 5days	0.2576	0.2423	0.1859	0.2559	-0.0225	0.2358	-0.0117	596
5 to 10 days	0.2708	0.2510	0.1727	0.2677	-0.0186	0.2407	-0.0110	1441
10 to 15 days	0.2497	0.2291	0.1319	0.2447	-0.0113	0.2173	-0.0057	2863
15 to 20days	0.1725	0.1550	0.1054	0.1661	-0.0077	0.1448	-0.0031	2440
20 to 25days	0.0617	0.0495	0.0885	0.0537	-0.0054	0.0423	-0.0016	1489
25 to 30days	0.0257	0.0157	0.0647	0.0156	-0.0031	0.0104	-0.0003	801
More than 30days	0.0226	0.0127	0.0571	0.0096	-0.0021	0.0080	0.0003	269
Samples on the basis of MIBOR								
More than 6.5%	0.0984	0.0853	0.1124	0.0905	-0.0094	0.0785	-0.0046	3597
Less than 6.5%	0.2304	0.2114	0.1271	0.2256	-0.0113	0.2004	-0.0056	6457
Samples on the basis of Difference between Discounted Futures Value and Discounted Strike Price								
$F.e^{(-r^*t)} < X.e^{(-r^*t)}$	-0.3988	-0.3893	0.1163	-0.4022	-0.0100	-0.3857	-0.0041	4670
$F.e^{(-r^*t)} > X.e^{(-r^*t)}$	0.6880	0.6481	0.1267	0.6800	-0.0111	0.6274	-0.0062	5384

Table 9

Results for the Absolute Errors

	CURTIS_IV	BRENNER_IV	BHARADIA_IV	CHARGOY_IV	CORRADO_IV	LI_IV	KEBER_IV	N
Samples on the basis of Time to Expiry								
Upto 3 days	0.1854	0.1788	0.0479	0.1852	0.0066	0.1758	0.0050	155
3 to 5days	0.1781	0.1720	0.0452	0.1778	0.0054	0.1692	0.0038	596
5 to 10 days	0.1749	0.1676	0.0429	0.1744	0.0045	0.1638	0.0028	1441
10 to 15 days	0.1500	0.1423	0.0319	0.1492	0.0025	0.1385	0.0014	2863
15 to 20days	0.1265	0.1195	0.0246	0.1257	0.0016	0.1160	0.0008	2440
20 to 25days	0.1132	0.1065	0.0209	0.1125	0.0012	0.1033	0.0006	1489
25 to 30days	0.1012	0.0944	0.0159	0.1003	0.0007	0.0913	0.0003	801
More than 30days	0.0949	0.0881	0.0140	0.0937	0.0005	0.0851	0.0003	269
Samples on the basis of MIBOR								
More than 6.5%	0.1318	0.1249	0.0277	0.1309	0.0022	0.1217	0.0012	3597
Less than 6.5%	0.1434	0.1362	0.0303	0.1428	0.0026	0.1325	0.0015	6457
Samples on the basis of Difference between Discounted Futures Value and Discounted Strike Price								
$F.e^{(-r^*t)} < X.e^{(-r^*t)}$	0.0998	0.0970	0.0275	0.1007	0.0022	0.0960	0.0013	4670
$F.e^{(-r^*t)} > X.e^{(-r^*t)}$	0.1735	0.1626	0.0309	0.1714	0.0026	0.1569	0.0015	5384

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