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Testing Volatility for selected Indian Indices

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Abstract

Volatility can be estimated in two ways viz., historical and implied, whereas historical volatility shows the past and the implied volatility shows the future movements of the market. Estimation of implied volatility (IV) will be helpful for the market participants including hedgers, arbitrageurs and speculators. The study attempts to approximate IV of Index options of National stock exchange of India using three different models viz. the Corrado-Miller's Model (1996), Brenner-Subrahmanyam's Model (1988) and Bharadia-Christopher-Salkin's Model (1996) and to estimate the market behaviour by comparing calculated IV with the India VIX on four option index namely S&P CNX Nifty options, Nifty Midcap 50 options, Bank Nifty options and CNX IT options. Near month At-the-money contract were chosen for the period of five years and ten months from 2nd March 2009 to 31st December 2014 for all the four indices. The findings of the study reveal that in most of the contracts the calculated IV is different from the India VIX. The market participants could make their investment strategies based on the calculated volatility appropriately (whether underpriced or overpriced). The speculators especially are interested in the volatility trading this could help them in a big way to position them-self in the market movement.

Keywords: Implied volatility (IV), India Volatility Index (VIX), Corrado-Miller's Model, Brenner-Subrahmanyam's Model, Bharadia-Christopher-Salkin's Model

Introduction

The capital market is an incorrigibly uncertain. This uncertainty makes the investors in blues. There are few adept investors who win even in the sudden mishap of capital market. The adept investors do hedge, arbitrage and speculates by measuring volatility. The investors' guard their securities from the volatility through the help of derivative instruments such as Futures, Options, Forward and SWAPS. In the derivatives market future price can be revealed due to the estimation of expected increase in the price level of stock or index or commodity. The derivatives provide the investor to anticipate the short-term risk. Among the derivative instruments, Options provide leverage and right to execute according to the will of writer and holder, apart from these Options market allows estimating implied volatility. The volatility is of two types historical and implied. Whereas, historical volatility deals with standard deviation of historical return of index return or stock return. The implied volatility is the market's assessment of underlying asset's volatility, as reflected in the Options pricing. Through the implied volatility probability of gauge in near future movement is possible. We can see the difference between the historical and implied volatility, historical volatility provides the historical volatile and the implied volatility provides exact pulse of the capital market but measuring the implied volatility is little complicated, actually by reversing the famous benchmark model so called Black-Scholes-Merton (1973) Options pricing model (B-S-M) is used to estimate the implied volatility because of its complicated calculations the academicians tried to provide the simple calculation to estimate the implied volatility. There are several other models exists which approximates the implied volatility among them the Corrado-Miller's Model (1996), Brenner-Subrahmanyam's Model (1988) and Bharadia-Christopher-Salkin's Model (1996) were used to approximate implied volatility for at-the-money contract. Similar to this study the B-Su Model (1988) used at-the money contract to estimate the implied volatility, to an extension of the B-Su approach the B-C-S model deals with in-or out-of the money and C-M Model is also an extension of B-Su approach. All these three models provide simplified volatility approximation approach for the investors and the academicians.

Generally Volatility Index (VIX) is known as fear index. In India it is called as India VIX, it is based on Nifty Index Options Prices, calculated for 30 days of best bid-ask prices (Put) of Nifty Options. If more Put options purchased on Nifty the VIX will increase. Basically the Put Options were purchased by the investor when the market is in turmoil. VIX measures the behavioural pattern of the investors. When the VIX is sky-scraping buy the Nifty, when VIX is near to the ground sell the Nifty or components of Nifty. The VIX act inverse to the market, there is always lead lag or lag lead relationship between the VIX and the S&P CNX Nifty. The VIX is calculated using out-of-the money contract.

For further understanding, IV means Implied Volatility, VIX is Volatility Index, C-M Model is Corrado-Miller Model, B-Su Model is Brenner-Subrahmanyam Model and B-C-S Model is Bharadia and Christopher and Salkin Model.

In this paper an attempt was made to approximate implied volatility using three different models they are C-M Model (1996), B-Su Model (1988), B-C-S Model (1996) and compared the each estimated implied volatility separately with the volatility index (Indian VIX).

Literature Review

The financial engineers and practitioners have been continuously trying to estimate the volatility and it became at most impossible to measure because the variables of volatiles are unobservable. But through the help of variables available in B-S-M Options pricing the implied volatility can be approximated. The relevance of calculating the IV using various models are tested and relevant modes has been suggested. Some of the important studies in this area are discussed below:

A formula was built to find the European option price, the formula has a lognormal process and applied stochastic calculus to calculate Options price. This study gave a significant impulse to the Options trade all over the world, because it developed a generally applicable method to calculate European Options prices. Still now the B-S-M model is popular model to estimate the European Options price (Black, Scholes, Merton, 1973). An attempt is made to develop more realistic Options pricing models. B-S-M formula and also checked with the B-S-M model and founded that the model is better in practical implementation on European Options price (Gurdip Bakshi, Charles Cao, zhiwu Chen, 1997). Strike price biases in B-S Options pricing model with small errors in the risk-free rate and standard deviation proxies found that the small errors in the risk-free rate and standard deviation proxies can produce the same systematic biases that empirical studies of the Black-Scholes Options pricing model report. Using of implied volatility reduces the standard deviation error (Jerry A. Hammer, 1989). Black-Scholes pricing formula can be approximated in closed-form for the strike price equals to the future price of underlying asset. An interesting result is that the derived equation is not only very simple in structure but also that it can be immediately inverted to obtain an explicit formula for implied volatility. The comparison was made on the accuracy of three approximation formulas, through the analysis said that the first order approximations are close only for small maturities, P´olya approximations are remarkably accurate for a very large range of parameters (Paolo Pianca, 2005). The solution for investors' problem of Options pricing with classic B-S-M model was found by finding the Gamma, strike price with time-to-maturity, spot prices of Options and using B-S-M model an exact expression of implied volatility can be calculated (Philippe Jacquinot and Nikolay Sukhomlin, 2010). Testing the accuracy of these approximation methods (B-S Model) using call only and put-call average elicitation of an implied volatility estimate and the results of the analysis conducted for approximations using averages from implied volatilities derived from calls and puts were remarkably different (Olga Isengildina-Massa et al., 2007). However having analysed the three different models (Chance's (1993, 1996) model, Corrado and Miller's (1996) model and Bharadia, Christofides and Salkin's (1996) model for approximating implied volatility, Corrado and Miller's (1996) model is the best model even without an additional information. But, Chance's model, especially as extended in study, has relatively simple and accurate for most cases (Donald R.

Chambers and Sanjay K. Nawalkha, 2001). Identifying the implied volatility errors in B-S formula, when the Options price is away from the money, to measure the implied volatility errors the GLS (Generalized Least Squares) estimator used to reduce the noise and bias in implied volatility calculation (Ludger Hentschel, 2003). The study on empirical performance of GARCH model for Options pricing and comparing with volatility index (VIX)found that non-affine models clearly outperform affine models (Juho Kanniainen et al., 2014). There are studies justified that the Corrado & Miller (1996) model is the best alternative to estimating the implied volatility using B-S-M framework, may be in the future improvements can be done (Winfried G. Hallerbach, 2004). The efficiency of S&P CNX Nifty index Options in Indian securities market, reveal that implied volatilities do not hold all the information available in the past returns so these are indicative of the violation of efficient market hypothesis in the case of S&P CNX Nifty index Options market in India (Alok Dixit et al., 2010). Understanding the implied volatility with respect to macroeconomic announcements were examined and found that in-the-money and out-of-the money Options have different characteristics in their responses, leading to the conclusion that heterogeneity in investor beliefs and preferences affect Options implied volatility through the state price density (SPD) function (Hassan Tanha et al., 2014). Testing the volatility smile with the core assumption of the Black–Scholes Options pricing model with the Options data gives a classical U-shaped volatility. Indeed, there is some evidence that the "volatility smirk" which pertains to 30-day Options and also implied volatility remain higher for the shorter maturity Options and decrease as the time-to-expiration increases. The results lead us to believe that in-the-money calls and out-of-the-money puts are of higher volatility than at-the-money Options (Imlak Shaikh and Puja Padhi, 2014). Therefore the study intends to approximate the IV with three different models viz. C-M Model (1996), B-Su Model (1988) and B-C-S Model (1996) for the every near month at-the-money contract of Options index. The calculated IV is individually compared with the India VIX to identify the best possible implied volatility measure.

Methodology

In order to study the best measure for Implied Volatility with the three classic models viz. C-M Model (1996), B-Su Model (1988) and B-C-S Model (1996) secondary data comprises of four Options indices such as CNX Nifty, Midcap-50, Bank Nifty and IT index Options for both call and put Options for the period of 6 years from January 2009 to December 2014 daily options price data of near-month at-the-money contract of European Options includes S&P CNX Nifty, CNX Midcap 50, Bank Nifty and IT index for the study. The implied volatility (IV) depends on several inputs from B-S-M Options pricing model. Mumbai Inter-Bank Offer Rate (MIBOR) is used as proxy for risk-free rate. The IV is calculated using three different models on daily Options price, they are Corrado-Miller's Model (1996), Brenner-Subrahmanyam's Model (1988) and Bharadia-Christopher-Salkin's Model (1996). The data source for The Volatility Index (VIX) and other data required for the IV are downloaded from the NSE website (www.nseindia.com). MIBOR is downloaded from debt segment of NSE. The calculated IV prices of three models are individually compared with the VIX using Independent sample t-test to identify which model is best model to estimate VIX.

Models and formula used to calculate the implied volatility (IV)

- The Corrado-Miller's (C-M) Model (1996) is

$$\sigma\sqrt{t} = \left[\sqrt{2*\frac{\pi}{A}}\right]*\left\{c-\left[\frac{B}{2}\right]+\sqrt{\left(c-\left[\frac{B}{2}\right]\right)^{2}-\frac{(B^{2})}{\pi}}\right\}$$

Where, $A = s + (k * e^{-rt})$; $B = s - (k * e^{-rt})$;

$$C = [S * N(d_1)] - [Ke^{-rt} * N(d_2)];\ d1 = \frac{ln\left(\frac{S}{K}\right)+(r+0.5^2)*t}{\sigma\sqrt{t}},\ d2 = d1 - \sigma\sqrt{t}$$

- The Brenner-Subrahmanyam's (B-Su) Model (1988) is

$$\sigma = \frac{c * \sqrt{2\pi}}{s * \sqrt{t}} \approx \sqrt{\frac{2\pi}{t}} * \frac{c}{s}$$

- The Bharadia-Christopher-Salkin's (B-C-S) Model (1996) is

$$\sigma = \sqrt{\frac{2\pi}{t}} * \frac{c * \delta}{s * \delta}$$

Where, $\delta = \frac{s - (k * e^{-rt})}{2}$

The implied volatility (IV) depends on several inputs from B-S-M Options pricing model like Ln = Natural Logarithm, S = Spot price of the underlying asset, K = Exercise or Strike price of the Options, r = Annual Risk free rate of return, t = Time to expiry of the Options, N = Cumulative standard normal Distribution, e = Exponential term (2.7183), σ = Standard deviation of the continuously compounded annual rate of return of the underlying asset, P = Theoretical price of Put option, C = Theoretical price of Option Price/ Call Price/ Premium Price. In the above formulas 2 refers to α. The C-M Model (1996) had originally suggested the value of α = 1.88 would be optimal, for simplicity settled on α = 2 in their equation.

Hypothesis of the Study

H_0^1: The means of the NIFTY's IV and VIX are not significantly different.

H_0^2: The means of the Midcap-50's IV and VIX are not significantly different.

H_0^3: The means of the BANK's IV and VIX are not significantly different.

H_0^4: The means of the IT's IV and VIX are not significantly different.

Analysis And Interpretation

In the study, IV is estimated through C-M Model (1996), B-Su Model (1988) and B-C-S Model (1996) for the every near month contract over a period of 6 years for 4 Options index and at-the-money contracts is chosen. The calculated IV is compared individually and with the Indian VIX using independent sample t-test.

INDEPENDENT SAMPLES T-TEST OF CNX NIFTY, MIDCAP-50, BANK, IT FOR THE YEAR 2009 TO 2014

Table – 1A Group Statistics of CNX Nifty

	Mode	N	Mean	Std. Deviation	Std. Error Mean
IV & C-M Model	VIX	1442	22.5319	7.83084	.20622
	IV	1442	20.4541	13.55058	.35684
IV & B-Su Model	VIX	1442	22.5319	7.83084	.20622
	IV	1442	24.4929	17.89648	.47129
IV & B-C-S Model	VIX	1442	22.5319	7.83084	.20622
	IV	1442	25.0637	30.88056	.81321

Source: computed as per data taken from NSE

Table – 1B Independent Samples t-Test of CNX Nifty

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
IV & C-M Model	Equal variances assumed	50.422	.000	5.041	2882	.000	2.07778	.41214	1.26965	2.88590
	Equal variances not assumed			5.041	2306.911	.000	2.07778	.41214	1.26957	2.88598
IV & B-Su Model	Equal variances assumed	149.487	.000	-3.812	2882	.000	-1.96108	.51443	-2.96977	-.95240
	Equal variances not assumed			-3.812	1973.280	.000	-1.96108	.51443	-2.96996	-.95220
IV & B-C-S Model	Equal variances assumed	280.154	.000	-3.018	2882	.003	-2.53187	.83895	-4.17687	-.88687
	Equal variances not assumed			-3.018	1625.565	.003	-2.53187	.83895	-4.17741	-.88634

Source: computed as per data taken from NSE

Table – 1A shows the C-M Model mean of VIX is 22.5319 and the mean of IV is 20.4541, with the mean difference of 2.07778 which is insignificant. As per table – 1B the significant value is 0.000 which is lesser than 0.05. Hence, the null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

In B-Su Model the mean of VIX is 22.5319 and the mean of IV is 24.4929 (as per table – 1A) with the mean difference of -1.96108 which is significant. As per table – 1B the significance value is 0.000 which is lesser than 0.05. Hence, the Null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

In B-C-S Model the mean of VIX is 22.5319 and the mean of IV is 25.0637 (as per table –1A) with the mean difference of -2.53187 which is insignificant. As per table – 1B the significant value is 0.003 which is lesser than 0.05. Hence, the Null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

Table – 1B shows the Levene's Test for Equality of Variances. The result shows that the significant value for all the three models is 0.00 which means both group (VIX and IV) are homogenous. Thus the t-test for equal variance not assumed is considered.

The following Table – 2A pre–highlights the C-M Model mean of VIX is 22.4521and the mean of IV is 26.4508, with the mean difference of -3.99862 which is insignificant. As per table – 2B the significant value is 0.000 which is lesser than 0.05. Hence, the null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

In B-Su Model the mean of VIX is 22.4521 and the mean of IV is 32.1177 (as per table – 2A) with the mean difference of -9.66552 which is significant. As per table – 2B the significant value is 0.000 which is lesser than 0.05. Hence, the Null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

In B-C-S Model the mean of VIX is 22.4521 and the mean of IV is 33.2083 (as per table –2A) with the mean difference of -10.75621 which is insignificant. As per table – 2B the significance value is 0.000 which is lesser than 0.05. Hence, the Null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

Table – 2B shows the Levene's Test for Equality of Variances. The result shows that the significant value for all the three models is 0.00 which means both group (VIX and IV) are homogenous. Thus the t-test for equal variance not assumed is considered.

Table – 2A Group Statistics of NIFTY MIDCAP 50

	Mode	N	Mean	Std. Deviation	Std. Error Mean
IV & C-M Model	VIX	1438	22.4521	7.69409	.20290
	IV	1438	26.4508	17.62729	.46484
IV & B-Su Model	VIX	1438	22.4521	7.69409	.20290
	IV	1438	32.1177	23.72926	.62576
IV & B-C-S Model	VIX	1438	22.4521	7.69409	.20290
	IV	1438	33.2083	41.70749	1.09985

Source: computed as per data taken from NSE

Table – 2B Independent Samples t-Test of NIFTY MIDCAP 50

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
IV & C-M Model	Equal variances assumed	115.817	.000	-7.884	2874	.000	-3.99862	.50719	-4.99312	-3.00412
	Equal variances not assumed			-7.884	1965.379	.000	-3.99862	.50719	-4.99332	-3.00393
IV & B-Su Model	Equal variances assumed	216.748	.000	-14.693	2874	.000	-9.66552	.65783	-10.95538	-8.37565
	Equal variances not assumed			-14.693	1735.854	.000	-9.66552	.65783	-10.95573	-8.37530
IV & B-C-S Model	Equal variances assumed	373.750	.000	-9.617	2874	.000	-10.75621	1.11841	-12.94918	-8.56324
	Equal variances not assumed			-9.617	1534.695	.000	-10.75621	1.11841	-12.94998	-8.56243

Source: computed as per data taken from NSE

Table – 3A Group Statistics of CNX BANK

	Mode	N	Mean	Std. Deviation	Std. Error Mean
IV & C-M Model	VIX	1443	22.5289	7.82891	.20610
	IV	1443	30.3405	24.78701	.65252
IV & B-Su Model	VIX	1443	22.5289	7.82891	.20610
	IV	1443	36.3443	32.82095	.86401
IV & B-C-S Model	VIX	1443	22.5289	7.82891	.20610
	IV	1443	38.9515	59.28762	1.56074

Source: computed as per data taken from NSE

Table – 3B Independent Samples t-Test of CNX IT

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
IV & C-M Model	Equal variances assumed	121.361	.000	-11.416	2884	.000	-7.81158	.68429	-9.15332	-6.46983
	Equal variances not assumed			-11.416	1726.871	.000	-7.81158	.68429	-9.15370	-6.46945
IV & B-Su Model	Equal variances assumed	182.623	.000	-15.554	2884	.000	-13.81540	.88825	-15.55706	-12.07373
	Equal variances not assumed			-15.554	1605.565	.000	-13.81540	.88825	-15.55765	-12.07315
IV & B-C-S Model	Equal variances assumed	257.953	.000	-10.432	2884	.000	-16.42255	1.57429	-19.50939	-13.33570
	Equal variances not assumed			-10.432	1492.273	.000	-16.42255	1.57429	-19.51060	-13.33449

Source: computed as per data taken from NSE

Table – 3A shows the C-M Model mean of VIX is 22.5289 and the mean of IV is 30.3405, with the mean difference of -7.81158 which is insignificant. As per table – 3B the significance value is 0.000 which is lesser than 0.05. Hence, the null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

In B-Su Model the mean of VIX is 22.5289 and the mean of IV is 36.3443 (as per table – 3A) with the mean difference of -13.81540 which is significant. As per table – 3B the significance value is 0.000 which is lesser than 0.05. Hence, the Null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

In B-C-S Model the mean of VIX is 22.5289 and the mean of IV is 38.9515 (as per table – 3A) with the mean difference of -16.42255 which is insignificant. As per table – 3B the significance value is 0.000 which is lesser than 0.05. Hence, the Null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

Table – 3B shows the Levene's Test for Equality of Variances. The result shows that the significant value for all the three models is 0.00 which means both group (VIX and IV) are homogenous. Thus the t-test for equal variance not assumed is considered.

The following Table – 4A pre-highlights the C-M Model mean of VIX is 22.5289 and the mean of IV is 25.4070, with the mean difference of -2.87810 which is insignificant. As per table – 4B the significance value is 0.000 which is lesser than 0.05. Hence, the null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

In B-Su Model the mean of VIX is 22.5289 and the mean of IV is 30.4572 (as per table – 4A) with the mean difference of -7.92822 which is significant. As per table – 4B the significance value is 0.000 which is lesser than 0.05. Hence, the Null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

In B-C-S Model the mean of VIX is 22.5289 and the mean of IV is 32.2913 (as per table – 4A) with the mean difference of -9.76233 which is insignificant. As per table – 4B the significance value is 0.000 which is lesser than 0.05. Hence, the Null hypothesis cannot be accepted and the mean of VIX and IV is statistically not equal.

Table – 4B shows the Levene's Test for Equality of Variances. The result shows that the significant value for all the three models is 0.00 which means both group (VIX and IV) are homogenous. Thus the t-test for equal variance not assumed is considered.

Table – 4A Group Statistics of CNX IT

	Mode	N	Mean	Std. Deviation	Std. Error Mean
IV & C-M Model	VIX	1443	22.5289	7.82891	.20610
	IV	1443	25.4070	15.80167	.41598
IV & B-Su Model	VIX	1443	22.5289	7.82891	.20610
	IV	1443	30.4572	20.69614	.54482
IV & B-C-S Model	VIX	1443	22.5289	7.82891	.20610
	IV	1443	32.2913	37.89065	.99747

Source: computed as per data taken from NSE

Table – 4B Independent Samples t-Test of CNX IT

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
IV & C-M Model	Equal variances assumed	114.560	.000	-6.200	2884	.000	-2.87810	.46423	-3.78836	-1.96784
	Equal variances not assumed			-6.200	2109.699	.000	-2.87810	.46423	-3.78850	-1.96770
IV & B-Su Model	Equal variances assumed	215.835	.000	-13.611	2884	.000	-7.92822	.58250	-9.07038	-6.78606
	Equal variances not assumed			-13.611	1846.405	.000	-7.92822	.58250	-9.07065	-6.78579
IV & B-C-S Model	Equal variances assumed	413.313	.000	-9.585	2884	.000	-9.76233	1.01854	-11.75946	-7.76519
	Equal variances not assumed			-9.585	1564.897	.000	-9.76233	1.01854	-11.76017	-7.76448

Source: computed as per data taken from NSE

Conclusion

This paper attempts to find out the best model for estimating IV, among selected three models viz. C-M Model (1996), B-Su Model (1988) and B-C-S Model (1996) is calculated for total of 5 year 10 month from 2nd March 2009 to 31st December 2014. For estimating IV, four Options index were chosen they are NIFTY, MIDCAP 50, BANK and IT Options index, the calculated IV are separately compared with the Indian VIX. The previous studies have analysed various implied volatility models under different market conditions. Most studies have accepted the above three selected models under different market conditions because of its implementation and calculation thus, it was used to approximate the IV of NIFTY, MIDCAP-50, BANK and IT Index Options. Whereas calculated IV Index Options and India VIX are significantly different in all the Options Indices in the study period because the IV of Index Options are calculated using at-the-money contract but the India VIX is calculated using out-of-the money contract. The difference in IV can differ with other contracts viz. in-or at-the-money, which are not taken for the study and the results may change accordingly. Hence, the study concludes that the market participants could make their investment strategies based on the calculated volatility appropriately (whether underpriced or overpriced). The speculators especially are interested in the volatility trading this could help them in a big way to position them-self in the market movement

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