Volatility Index - A new tool for Risk Management

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ABSTRACT

Volatility index is introduced in India on March 2008, which captures the behavioural and psychological aspects of traders. The ultimate purpose of introducing is to avail new instrument for trading on it and hedge through it. It can also be used to predict the change in near month. The primary objective of the research is to find the extent of relationship prevailing between market and volatility indices. The data collected from NSE, from November 2007 to February 2009, is analysed using correlation and it resulted in -0.677 which infers 3 VIX contract is necessary to hedge two Nifty contracts.

Introduction

VIX is an emerging concept in Indian stock market. This was first introduced by Chicago Board Options Exchange (CBOE) with underlying S&P 500 index in the year 1993[1]. SEBI had recommended that VIX & derivatives on VIX should be introduced in domestic financial markets. Based on this recommendation National Stock Exchange (NSE) of India introduced VIX on 3rd March 2008 with underlying index as S&P CNX Nifty 50 index. VIX is thus an indicator available today, which captures behavioural and psychological aspects of traders.

Volatility is "A statistical measure of the dispersion of returns" for a given security or market index. For measuring volatility we can use the standard deviation or variance between returns from the same security or market index. The higher the volatility, the riskier the security.

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In simple terms Volatility Index means measure of volatility with the underlying Index in terms of percentage (e.g. 20%, 30%). Investor perception about the index in near term can be indicated using this Index. Volatility Index will increase when market price of the index moves abruptly up or down. If there is no abrupt change in the price of market index eventually option prices decreases which results in decrease in volatility index. If VIX is greater than 40 percent investors increased perception to uncertainty leads to hefty amount of volatility. In case VIX lies between 20 percent to 40 percent is reflects that volatility is not very high or not very low, Similarly when VIX is below 20 percent it is usually related to optimistic view, and the investors are satisfied in change in price.

History of VIX

VIX was discussed for the first time in paper by Prof. Robert E Whaley of Duke University, US in 1993[2] and it was introduced in CBOE in the same year. In 2003, the methodology in VIX was modified i.e. from implied volatility to option pricing model. In the year 2004, the asset class of volatility index futures commenced for trading in CBOE. In February 2006 options on VIX was launched. In India, VIX was launched in the year 2008 based on underlying S&P CNX Nifty 50 index.

Index Volatility Vs Volatility Index

It is necessary to differentiate between volatility index and index volatility to understand the concept. Index volatility, is also termed as market risk, is a market volatility which is measure of dispersion. Market index has a base year and provides periodic absolute value and changes; it gives market players a clear image of the market. VIX is a measure of the amount by which underlying index is expected to fluctuate in the near term on the basis of price of options on underlying index. VIX is expressed in percentage value. VIX quantifies them to market condition in near term.

Example

Nifty Index	VIX Index
1000, 2000, etc...	20%, 30%, etc...

Objectives

1. To find the extent of relationship prevailing between market and volatility indices.
2. To find the scope of hedging.
3. To forecast the market change in near term using VIX.

Computation Methodology

VIX is computed using the underlying S&P CNX Nifty 50 Index using the methodology which was adopted from CBOE. This method does not use any option pricing theory like Black and Scholes model which is used for computing option prices. In VIX computation, the values of implied volatility and

expected volatility are taken from the near and mid month option bid and ask prices of Nifty 50 index options. From the near month option contract bid & ask prices an indicator can be derived as to what is the volatility the investors are expecting in market. The VIX is derived using the bid and ask price of near month so by taking into account of the investors perception about market movement.

India's Computation Methodology

Formula Used

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_o} - 1\right]^2$$

Where

σ	VIX / 100
T	Time of Expiration
F	Forward index level is derived from index option prices
K_i	Strike price of out-of-the-money option; a call is $K_i > F$ and put if $K_i < F$
ΔK_i	Interval between the strike price half the distance between the strike on either side of K_i $\Delta K_i = \frac{K_{(i+1)} - K_{(i-1)}}{2}$ (Note: ΔK for the lowest strike is simply between the lowest strike and the next higher strike. Likewise, ΔK for the highest strike is the difference between the higher strike and the next lowest strike)
K_o	First strike below the forward index level, F
R_o	Risk free interest rate to expiration (MIBOR rate is considered)
$Q(K_i)$	The mid-point of bid-ask spread for each option with strike K_i

Hypotherical Example

Computation of time to expiry

Indian Volatility Index in the main uses put and call options in the two consecutive month expiration in order to band a 30 day calendar period. On the other hand, with 8 days left to expiry of that contract, Indian VIX alters to mid and far month. The time to expiration, T in VIX is calculated in minutes rather than days. In this case a hypothetical example with 20 days and 45 days of expiration, have been taken.

$T = \{M_{\text{Current day}} + M_{\text{Settlement day}} + M_{\text{Other days}}\}$/ Minutes in a year

Where,

$M_{\text{Current day}}$ = Number of minutes remaining until midnight of the current day

$M_{\text{Settlement day}}$ = Number of minutes from midnight until 15:30 on expiry day

$M_{\text{other days}}$ = Total number of minutes in the days between current day and expiry day. Time to expiration for the near month and next month options, T1 and T2 respectively, is:

T_1 = For 20 days

= {(8.5 hrs *60 min) + (15.5 hrs *60 min) + (19 days * 24 hrs * 60 min)} / 365 days * 24 hrs * 60min

= {510+930+23360}/525600=0.04718

T_2 = For 45 days

= {(8.5 hrs *60 min) + (15.5 hrs *60 min) + (44 days * 24hrs * 60 min)} / 365 days * 24 hrs * 60 min

=> {510+930+63360}/525600= 0.12328

Computation of Forward Index Level, F

For Near contract month

Forward index level is determined based on 'At the money' option prices. The minimal difference between mid call and mid put prices is considered as 'At the money' strike. In this case, the difference between mid call and mid put prices is smallest at the **2800** strike in the near month. Where mid call and put price is an average price between bid and ask price of that respective strikes.

The formula used to calculate the forward index level is

F = Strike Price + e^{RT} (Mid call price- Mid put price)

Nifty 50 Near Month Option							
	Call			Put			
Strike Index	Bid	Ask	Mid Price	Bid	Ask	Mid Price	Difference
2450	355.15	366	360.575	55	88	71.5	289.075
2500	318	335	326.5	56.25	63	59.625	266.875
2550	280	288	284	65	80	72.5	211.5
2600	206.2	280	243.1	73	89.9	81.45	161.65
2650	215	299.8	257.4	83	92	87.5	169.9
2700	183.55	199.35	191.45	114	127.95	120.975	70.475
2750	186	196	191	132	144	138	53
2800	128	138	133	143.1	179.95	161.525	28.525
2850	125	140	132.5	180	242.2	211.1	78.6
2900	110	121.9	115.95	190	286.95	238.475	122.525
2950	84	95	89.5	230	260	245	155.5
3000	60	62	61	213	386	299.5	238.5
3050	45	50	47.5	296.15	365	330.575	283.075

Using the 'At the money' call and put mid prices above, F_1 for the near month option is computed.

$$F_1 = 2800 + 2.718281828^{(0.075 * 0.04718)} (133 - 161.525)$$

$$= 2800 + 1.003 * -28.525$$

$$= 2800 - 28.610575 = 2771.3894$$

R is taken as 7.5 percent as the benchmark of MIBOR for the near month and 8.5 percent for the next month.

Computation of K_0

In order to determine K_0 – the strike price must be lesser than forward index and it must be immediately followed by the forward index level, F_1 = 2771.3894. In this case, **K_0 = 2750** for the near month expiry.

Selection of Options to be used in the calculation

Sort all strike prices of option contracts in ascending order. Strike prices greater than K_0 is selected along with non-zero bid price. Similarly, the put options that have strike prices less than K_0 and non-zero bid price is selected. After two consecutive call / put option with a bid price of zero, further no call/ put option is selected.

Nifty 50 Near Month Option			
Strike Index	Mid Call Price	Mid Put Price	Q(K)
2450		71.5	71.5
2500		59.625	59.625
2550		72.5	72.5
2600		81.45	81.45
2650		87.5	87.5
2700		120.975	120.975
2750	**191**	**138**	**164.5**
2800	133		133
2850	132.5		132.5
2900	115.95		115.95
2950	89.5		89.5
3000	61		61
3050	47.5		47.5

Select both the put and call with strike price K_0. Then average the quoted mid-call prices for selected strike price.

To remove the error of double counting, the mid put and mid call prices are averaged and computed in to a single value. However, in all the other option strikes only one call/put prices is considered. This is done to centre the loop of options around K_0.

The price used for 2750 strike in the near term is therefore, (191+138)/2 = 164.50. When option strike for computation is not available then the previous value of VIX will be taken in to consideration.

Repeat step 2 to 4 for next month

Nifty 50 Next Month Options							
	Call			Put			
Strike Index	Bid	Ask	Mid Price	Bid	Ask	Mid Price	Difference
2550	365	568.9	466.95	181.2	202.9	192.05	274.9
2600	311.1	476.55	393.825	90	160	125	268.825
2650	300	341	320.5	216.2	245	230.6	89.9
2700	244.7	481.95	363.325	162.6	251	206.8	156.525
2750	261	276.75	268.875	215.05	280	247.525	21.35
2800	197	432	314.5	200	220	210	104.5
2850	215.3	221	218.15	299	360	329.5	111.35
2900	170.5	258.65	214.575	210	232	221	6.425
2950	167	180	173.5	258.2	732	495.1	321.6
3000	120	211	165.5	275	796	535.5	370
3050	135.3	143.5	139.4	301	689.5	495.25	355.85

F_2 = $2900 + 2.718281828^{(0.085 * 0.12328)} (214.575 - 221)$

= $2900 + 1.010 - 6.425$

= 2894.585

Computation of K_0

K_0 = 2850 for the near month expiry.

Selection of Options to be used in the calculation

Nifty 50 Near Month Option			
Strike Index	Mid Call Price	Mid Put Price	Q(K)
2550		192.05	192.05
2600		125	125
2650		230.6	230.6
2700		206.8	206.8
2750		247.525	247.525
2800		210	210
2850	**218.15**	**329.5**	**273.825**
2900	214.575		214.575
2950	173.5		173.5
3000	165.5		165.5
3050	139.4		139.4

Calculate volatility for both near month and next month options

Calculating Indian VIX to the near month and next month options with time to expiration of T_1 and T_2, respectively using the formula,

$$\sigma_1^2 = \frac{2}{T_1}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT_1} Q(K_i) - \frac{1}{T_1}\left[\frac{F_1}{K_o} - 1\right]^2$$

$$\sigma_2^2 = \frac{2}{T_2}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT_2} Q(K_i) - \frac{1}{T_2}\left[\frac{F_2}{K_o} - 1\right]^2$$

Indian VIX uses the information reflected in the prices of all the options. The contribution of a single VIX value is proportional to the price of the options and inversely proportion to the option's strike prices. For example, the contribution of the near month 2450 is given by

$$\frac{\Delta K_{2450PUT}}{K^2_{2450\,PUT}} e^{RT} Q(2450\ PUT)$$

In general, ΔK_i is simply the difference between K_i and adjacent strike price. In this case 2450 is the lowest strike price in the strop of near month options and 2500 happens to be the adjacent strike. Therefore,

$\Delta K_{2450\ PUT} = 50$(i.e. 2500-2450) and

$$\frac{\Delta K_{2450PUT}}{K^2_{2450\,PUT}} e^{RT} Q(2450\ PUT) = \frac{50}{2450^2} * e^{(0.075 * 0.04718)} * 71.5$$

Ki	Option Type	Q(K)	ΔKi	Ki^2	$\Delta Ki / Ki^2$	e^{RT}	Contribution by Strike
2450	Put	71.5	50	6002500	8.32986E-06	1.003	0.000597
2500	Put	59.625	50	6250000	0.000008	1.003	0.000478
2550	Put	72.5	50	6502500	7.68935E-06	1.003	0.000559
2600	Put	81.45	50	6760000	7.39645E-06	1.003	0.000604
2650	Put	87.5	50	7022500	7.11997E-06	1.003	0.000625
2700	Put	120.975	50	7290000	6.85871-E-06	1.003	0.000832
2750	Put / Call Average	164.5	50	7562500	6.61157E-06	1.003	0.001091
2800	Call	133	50	7840000	6.37755E-06	1.003	0.000851
2850	Call	132.5	50	8122500	6.15574E-06	1.003	0.000818
2900	Call	115.95	50	8410000	5.9453E-06	1.003	0.000691
2950	Call	89.5	50	8702500	5.74548E-06	1.003	0.000516
3000	Call	61	50	9000000	5.55556E-06	1.003	0.00034
3050	Call	47.5	50	9302500	5.3749E-06	1.003	0.000256
						$\sum_i \frac{\Delta K_i}{\Delta K_i^2} e^{RT_2} Q(K_i)$	0.008259

Following is the computation of the volatility for the near month,

$$\sigma_1^2 = \frac{2}{T_1} \sum_i \frac{\Delta K_i}{K_i^2} e^{RT_1} Q(K_i) - \frac{1}{T_1} \left[\frac{F_1}{K_o} - 1\right]^2$$

$$\sigma_1^2 = 42.39084 * 0.008259 - 0.001282 = 0.348831$$

Ki	Option Type	Q(K)	ΔKi	Ki^2	$\Delta Ki / Ki^2$	e^{RT}	Contribution by Strike
2550	Put	192.05	50	6502500	.7.68935E-06	1.01	0.001492
2600	Put	125	50	6760000	7.39645E-06	1.01	0.000934
2650	Put	230.6	50	7022500	7.11997E-06	1.01	0.001658
2700	Put	206.8	50	7290000	6.85871E-06	1.01	0.001433
2750	Put	247.525	50	7562500	6.61157E-06	1.01	0.001653
2800	Put	210	50	7840000	6.37755E-06	1.01	0.001353
2850	Put / Call Average	273.825	50	8122500	6.15574E-06	1.01	0.001702
2900	Call	214.575	50	8410000	5.9453E-06	1.01	0.001288
2950	Call	173.5	50	8702500	5.74548E-06	1.01	0.001007
3000	Call	165.5	50	9000000	5.55556E-06	1.01	0.000929
3050	Call	139.4	50	9302500	5.3749E-06	1.01	0.000757
						$\sum_i \frac{\Delta K_i}{\Delta K_i^2} e^{RT_2} Q(K_i)$	0.014205

$$\sigma_2^2 = \frac{2}{T_2}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT_2} Q(K_i) - \frac{1}{T_2}\left[\frac{F_2}{K_0} - 1\right]^2$$

$$\sigma_2^2 = 0.228463$$

Interrupt

σ_1 to σ_2 arrive at a single value with a constant maturity of 30 days to expiration. Then take the square root of that value and multiply by 100 to get India VIX

$$\sigma = \sqrt{\left\{T_1\sigma_1^2\left[\frac{M_{T_2} - M_{30}}{M_{T_2} - M_{T_1}}\right] + T_2\sigma_2^2\left[\frac{M_{30} - M_{T_1}}{M_{T_2} - M_{T_1}}\right]\right\} * \frac{M_{365}}{M_{30}}}$$

Where,

M_{T_1} = Number of minutes to expiration of the near month options

M_{T_2} = Number of minutes to expiration of the next month options

M_{30} = Number of minutes in 30 days

M_{365} = Number of minutes in 365 days

σ =28.67165

India VIX = 100 * σ = 100 * 0.2708857 = 27.08857%

Inference

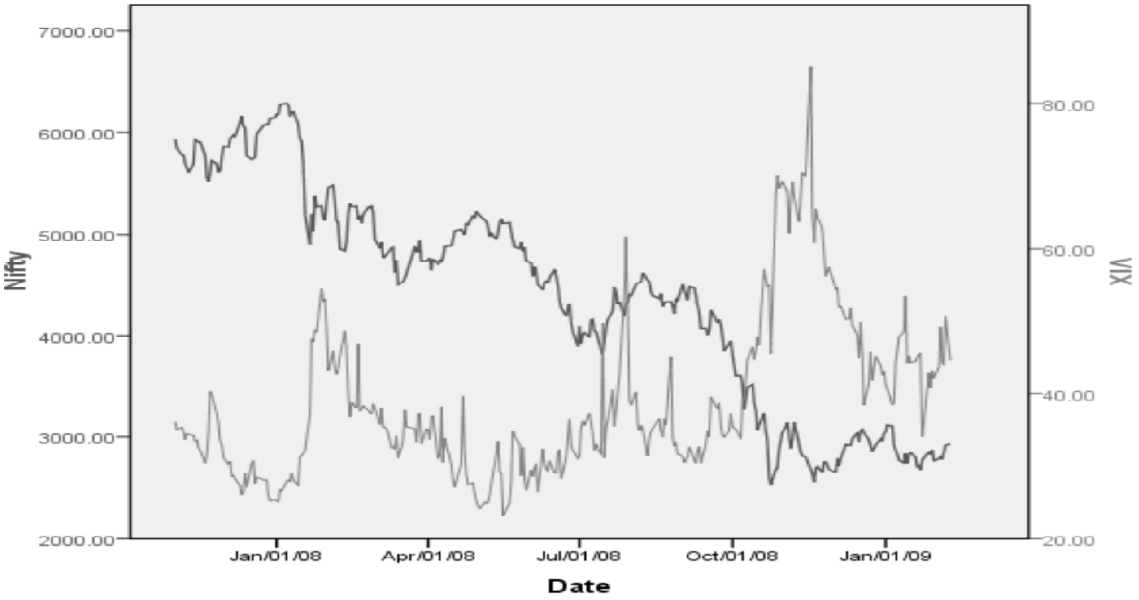
In this case VIX is 27.088%, it can be reasonable forecasted that nifty can change by 2.25 percent (27.088 /12) during next 30 days. In this case there is a normal volatility which lies between 20 to 40 percent. If change in Volatility is greater than 3.33 percent it represents the irrational fear of market and upward trend in near future and very low VIX values. Similarly if change in volatility is less than 1.67 percent it indicates possible downward trend in near future and increase in VIX values.

Application of Volatility Index

VIX is of great advantage in the functions like trading, hedging, analyzing and introducing derivatives products in this Index. Investors can use VIX for purposes mentioned below:

- Investors' portfolios are open to market volatility. To reduce their risk, investors could hedge their portfolio against volatility with an offsetting position in VIX futures or option contracts. This is because VIX is highly negatively correlated with underlying index.
- VIX represents the collective harmony of the market on the expected volatility and being contrarian in nature helps in forecasting the trend. Investors therefore could use this information for taking offsetting positions.
- Investors who took positions in derivatives market have to settle their Mark to Market. Liquidity crunch due to volatility can be avoided by taking another offsetting position in VIX.

Investors who entered into Short sale positions may have directional risk. Derivatives on VIX could help investors in upholding their positions and thus avoid systemic risk in the market.



Although Indian VIX has been in existence only since March 2008 data is available from November 2007. The above chart shows the Index movements of S&P CNX Nifty 50 index and VIX index. For the period from 01/11/2007 to 10/02/2009. The shot term bearishness of nifty is indicated when VIX India < 20% and short term bullishness of nifty can be predicted when VIX > 40%. Relationship of price movement of both the index is calculated using correlation, the results of which is as fallows:

Descriptive Statistics

Variable	Mean	SD	N
VIX	38.6964	10.74641	313
Nifty	4403.3558	1070.92231	313

Variable	Correlation	Significance
VIXNifty	-0.677**	0.000

** Correlation is significant at the 0.01 level (2-tailed)

The correlation is computed using daily closing price of S&P CNX Nifty 50 index and VIX index. All the data are collected from NSE website.

Inference

From the above analysis it is inferred that there is a negative correlation (-0.677) between VIX and Nifty index. It clearly shows the opportunity to hedge using this index. If negative correlation is -1.000, then taking a position in both the markets

will provide complete hedge against volatility. In this case to hedge one contract in Nifty needs 1.5 contracts in VIX, to hedge completely. i.e. for hedging two future contracts it is required to take three VIX offsetting positions.

Conclusion

India is one of the few emerging equity market that has launched VIX. India's VIX as a leading market indicator is questionable at present but existence of Indian VIX cannot be ignored. When Indian option market is effectively traded then the correlation between two indices will improve and it will definitely provide reliable reading of market sentiment in future. In future sector specific volatility indices could be constructed to enable hedging in respective sectors.

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