# Effect of Return and Volatility Calculation on Option Pricing: Using BANKNIFTY

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***Abstract*—Predictability in the asset return and hence the volatility has remained a topic of great concern among the institutional and private investors. The underlying asset in our case is the Bank NIFTY futures. We have tried to predict the volatility using different methods using time series data which are based on historical approach. Then we applied Black-Scholes Option Pricing Model formulae to calculate the option price of Bank Nifty option. We then compared the prices with the actual market trading data of the Bank Nifty option.**

***Index Terms*—Option pricing, volatality, Black-Scholes formula.**

## I. Introduction

In business, uncertainty is a common thing to occur. One who can identify and manages these uncertainties well, emerges successfully. Failure to manage these risks forces several firms to go out of business despite of their technology, skilled labour and market pre-eminence. As result, in the past three decades financial markets have shown the emergence of many instruments which could help these firms to manage the financial risk. The major principle behind these instruments is the fact that a risk-averse individual is willing to pay a price to transfer the risk and an individual with risk-taking ability is willing to bear the risk for a price. Market players discovered the potential of these risk management tools and developed various innovative tools and based on this, they developed various strategies. The most popular among these products are financial futures and options. They are available for foreign exchange, interest rates, stock indices, equities and commodities. These products are also known as derivatives. The largest derivative markets in the world are in government bonds, stock market indices and in exchange rates [1].

The year 1973 was the most important in the field of options trading. In this year, the creation Chicago Board Options Exchange and the publication of the most popular formula in finance, the option pricing model (i.e., Black Scholes Model) of Fischer Black and Myron Scholes revolutionized the investment world [2].

In India, derivative markets in the late 1980s and were futures-based markets with commodities, primary agricultural commodities, as the underlying assets. In 1952, to prevent speculation on the prices of agricultural commodities, the Government of India came up with a legislation that explicitly banned any kind of futures trading on commodities in India. Derivatives trading over the exchange started in India in June, 2000 with the introduction of index futures trading on the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE) of India. This was followed up in July 2001 by the introduction of the index options, options on individual securities, and futures on individual securities on both the NSE and BSE. The market regulator, Securities and Exchange Board of India (SEBI) has been on both the NSE and BSE taking active steps to increase liquidity in the available contracts to make the market more robust and viable for all kinds of investors.

Option pricing models are based on a set of observed parameters as inputs like spot price of the underlying asset, strike price, time to maturity, risk free interest rate and volatility which determine the price of the option. Out of these five parameters, we have the data for spot price, strike price & time period. The two parameters volatility and risk free rate vary through time and market conditions. At the start of the contract, risk free rate is also an observable variable but volatility is estimated using either historical movements or generated by implication. Volatility estimation is important for several reasons and for different people in the market. Pricing of securities is supposed to be dependent on volatility of each asset [3].

Volatility forecasting is an important role in option pricing, and risk management. In this paper, we conducted a review of some of the methods like Effective Holding Period Yield (HPY), Continuously Compounded HPY, Rule of 16 and High-Low method to estimate the volatility from time-series data of underlying assets traded in Indian derivative market. Then use the calculated volatility in analytical estimation of the option pricing based Black-Scholes Option Pricing Model to find the BANKNIFTY option pricing and then compare the results to actual market trading pricing.

## II. Literature Review

For a long time now, uncertainty has been of great interest to financial economists and practitioners with its scientific findings well accepted and exploited. Usually, the risk of a stock is measured by its volatility. It is commonly argued that an increase in volatility is good news for the holder of standard options, because volatility unambiguously increases option prices. In real option literature, uncertainty is said to create corporate value through options and the opportunities corporations have. Studies on the topic can be divided into two categories: studies considering the effects of volatility on assets priced absolutely [4]−[6] and studies that shows the effect of volatility on derivative assets priced relative to other assets [7]−[9].

Black is among the first to consider the relationship between volatility and the current price [10]. According to

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him, "If there is more risk to be borne, assuming that expected payoffs from business investment do not change, then stock prices must fall so that investors will continue to hold the existing stocks. A fall in stock prices means an increase in expected returns from stocks". Conditions have been established under which the call's price can be maximized or minimized with respect to volatility, and showed that the call price can also be monotone decreasing with volatility. Studies have addressed the net effect of volatility on derivative assets by assuming that volatility increases the risk premium [11]. It has been observed that the longer term options overreact to the changes in the implied volatility of short maturity options which is the reason behind the inefficiency of the S&P 100 index option market [12]. There is a significant difference in the average implied volatility from the put and call options. Also the ratio of average daily call open interest to average call volume is much lower than the same ratio for put options [13]. It is also found that the information content and estimation error of the high-low estimates were not always superior to the close-to-close variance [14], and that price discreteness caused the extreme-value method to be significantly downward biased relative to the close-to-close method [15]. It is found that among historical method, improved extreme value method i.e. ARCH and GARCH models and the exponentially weighted moving average of the volatility, the expected forecasting ability is not clearly ranked [16].

## III. Research Methodology

### A. Data Collection

There are several options being traded at the NSE such as NIFTY, NIFTYMINI, S&P 500, BANKNIFTY, etc. We have selected the data for BANKNIFTY from the several options available in the NSE market. BANKNIFTY is selected for the short duration pricing as it is expiring within the month. We collected the data of corresponding futures which is also the underlying asset for previous few years from 1st Jan, 2002 to 16th Jan, 2012. Also we have taken the current date prices of the selected option for the comparison purpose [17]. The data of future prices is collected from website of NSE [18]. The study uses the closing prices along with the high and low prices of the selected futures to measure the volatility.

### B. Methodology of Study

Our study involves use of few techniques to calculate the expected return from the given set of data for the future's closing price series. The simplest one includes the difference in the prices of the successive days. This method is also known as effective Holding Period Yield [19].

$$r(t) = \frac{\text{Price}(t+1) - \text{Price}(t)}{\text{Price}(t)} = \frac{\text{Price}(t+1)}{\text{Price}(t)} - 1 \tag{1}$$

Here, $r(t)$ represent the return series which is being calculated from the price series Price($t$). The expected return $\mu$ is calculated from the return series as:

$$\mu = \frac{\sum r(t)}{n} \tag{2}$$

Variance $\sigma^2$ is calculated by using the return series and the mean (expected return, $\mu$) as follows:

$$\sigma^2 = \frac{\sum (r(t) - \mu)^2}{n-1} \tag{3}$$

From here we can calculate the standard deviation or in other words the volatility for the daily return. Another method of calculating returns uses the logarithmic difference of the prices also known continuously compounded Holding Period Yield [19], i.e.

$$r(t) = \ln\left(\frac{\text{Price}(t)}{\text{Price}(t-1)}\right) \tag{4}$$

Another method uses the high and low of the daily future prices [3]. It uses (High - Low) / (High + Low) as the daily high-low return. The origin of this method is probably that (H-L)/2 is half the price range, and (H+L)/2 is the "average" price, between the two extremes. It calculates the percent of its average price by which the stock deviated above and below its average price, computed by the only method that is possible if only the High and Low prices for the period are known, which was common when historical stock price data was expensive to get [20]. Volatilities from all the above methods are then annualized by multiplying it with $\sqrt{T}$ where $T$ is the number of trading days in a year and is taken here as 252. Another rule of 16 says to annualize the daily volatilities by multiplying it with 16 instead of $\sqrt{T}$ [20]. The average magnitude (absolute value) percentage price change per day which is calculated arithmetically and not log normally, multiplied by 16.

All these different volatilities are used to calculate the option prices based on different strike prices toward a fixed maturity time. The prices are calculated by using the Black-Scholes formula for the option pricing. The Black-Scholes equation [5]:

$$c_t + rSc_s + \frac{1}{2}\sigma^2 S^2 c_{ss} = rc \tag{5}$$

where ct represent rate of change of call option price with time, $c_s$ is the rate of change in c with respect to change in underlying stock price and $c_{ss}$ is the double differential of $c$ with respect to stock price. $\sigma$ is the volatility in the underlying asset price. The analytical solution for the above differential equation is the Black-Scholes formulae:

$$c = S_0 N(d_1) - Ke^{-rT} N(d_2) \tag{6}$$

$$p = Ke^{-rT} N(-d_2) - S_0 N(-d_1) \tag{7}$$

where, $c$ is the price of the call option and $p$ represents the put option price. $S_0$ is the underlying asset price, $K$ is the strike price of the asset, $r$ is the risk-free interest rate and $T$ is the time to expiration of the option. $N$(.) represents the cumulative normal distribution of $d_1$ and $d_2$ which are obtained as follows

$$d_1 = \frac{\ln(S_0 / K) + (r + \sigma^2 / 2)T}{\sigma\sqrt{T}} \quad (8)$$

$$d_2 = \frac{\ln(S_0 / K) + (r - \sigma^2 / 2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} \quad (9)$$

The model is based on a normal distribution of underlying asset returns which is the same thing as saying that the underlying asset prices themselves are log-normally distributed. The main advantage of the Black-Scholes model is speed - it lets you calculate a very large number of option prices in a very short time. The Black-Scholes model has one major limitation: it cannot be used to accurately price options with an American-style exercise as it only calculates the option price at one point in time at expiration (European-style Options). Then, based on different volatility calculation methods, the option prices are compared with each other and with the option prices collected from the daily newspaper.

## IV. Results and Discussions

The results of volatility calculation using four different methods are given in Table 1. The calculated values are all annualized. Daily volatility derived by Simple method (effective HPY), log method and high-low method are annualized by multiplying them with $\sqrt{252}$ . Other hand by rule of 16, the daily volatilities is annualized by multiplying it with 16. The future's price data for the 2002 – 2004 does not contain the high and low prices. The volatility calculated using the high-low method of return have considerably low values than the other 3 methods. Fig. 1 shows the comparison of the annualized volatilities calculated using different methods from 2002 to 2012. It is shown that trends of changing the volatility with respect to every years are same in different methods but magnitude wise in high-low volatility method is less with respect other three methods.

TABLE I: Volatility Calculation

| Year | Effective HPY | Log Method | Rule of 16 | High-Low |
|---|---|---|---|---|
| 2005 | 0.25014462 | 0.2504207 | 0.2521220 | 0.078584 |
| 2006 | 0.29729362 | 0.2980122 | 0.2996438 | 0.123058 |
| 2007 | 0.33739749 | 0.3369723 | 0.3400647 | 0.107946 |
| 2008 | 0.55277468 | 0.5524785 | 0.5571445 | 0.172376 |
| 2009 | 0.44148004 | 0.4362460 | 0.4449700 | 0.135793 |
| 2010 | 0.21838432 | 0.2186564 | 0.2201107 | 0.068119 |
| 2011 | 0.27385299 | 0.2736197 | 0.2760178 | 0.076597 |
| 2012 | 0.20316747 | 0.2026557 | 0.2047735 | 0.065040 |

Table II shows the option price calculated using the volatility values of the year 2012 only. At this time the risk free rate of interest is 8% approximately. We have calculated the option prices corresponding to different strike prices and compared it with the given closing prices of the call options [17] on these strike prices. Fig. 2 displays the comparison results of option prices based on different volatility methods.

TABLE II: Option Price Calculation for Bank Nifty CNX

| Strike Price | Effective HPY | Log Method | Return16 | High-Low | Actual Price |
|---|---|---|---|---|---|
| 8000 | 1020.499528 | 1020.495452 | 1020.51292 | 1020.357 | 990 |
| 8100 | 921.0791426 | 921.0693672 | 921.110977 | 920.6735 | 869.6 |
| 8200 | 822.039301 | 822.0181704 | 822.107587 | 820.9905 | 777 |
| 8300 | 723.791103 | 723.749754 | 723.923776 | 721.3074 | 684.35 |
| 8400 | 627.0369679 | 626.9635012 | 627.271302 | 621.6244 | 607 |
| 8500 | 532.8496277 | 532.7306936 | 533.227122 | 521.9414 | 510 |
| 8600 | 442.6891878 | 442.5131898 | 443.245572 | 422.2611 | 425.5 |
| 8700 | 358.3152103 | 358.0764218 | 359.067760 | 322.6566 | 363.55 |
| 8800 | 281.5786685 | 281.2807610 | 282.515442 | 224.045 | 292.6 |
| 8900 | 214.1265643 | 213.7838556 | 215.202718 | 131.7122 | 232.55 |
| 9000 | 157.0996989 | 156.7351754 | 158.243690 | 59.11962 | 176.9 |
| 9100 | 110.9116017 | 110.5521954 | 112.039763 | 18.14446 | 133.15 |
| 9200 | 75.18480237 | 74.85550056 | 76.2194612 | 3.486973 | 99.15 |
| 9300 | 48.85058283 | 48.56953719 | 49.7351204 | 0.396710 | 74.95 |
| 9400 | 30.38254453 | 30.15861113 | 31.0890304 | 0.025923 | 45 |
| 9500 | 18.07139244 | 17.90444494 | 18.5997267 | 0.000961 | 34.15 |
| 9600 | 10.27344765 | 10.15674429 | 10.6441681 | 2.02E-05 | 23.45 |
| 10000 | 0.68085205 | 0.665625524 | 0.73026501 | 1.56E-14 | 9.1 |

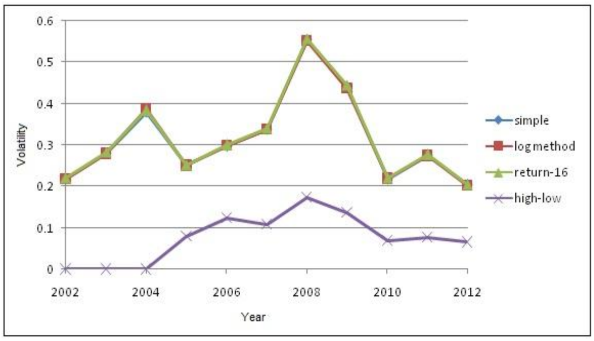


Fig. 1. Volatility for different methods.

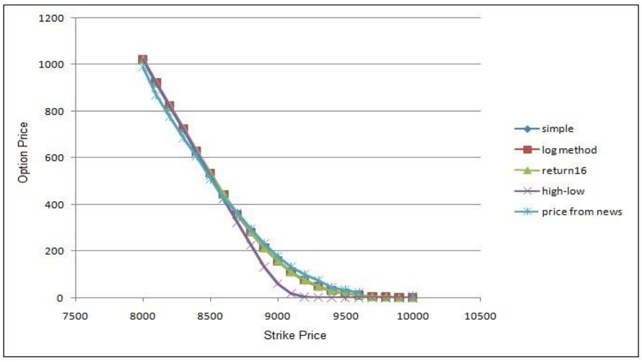


Fig. 2. Comparison of option prices.

## V. Conclusion

In this paper, we have used different simple methods to calculate the expected return and to interpret the annualized volatility. We have seen from the results that the same set of data gives variations in expected returns and affects the volatility. The simple method (effective Holding Period Yield, HPY), log method (continuously compounded HPY) annualized with an approximated 252 trading day and simple method i.e. effective HPY with rule of 16 gives very close results with respect to return and volatility. The daily high-low method gives a lower value in comparison to other methods we have used. The rule of 16 is just used to annualizing the daily volatility to 256 trading days ($16 \approx 252^{1/2} = 15.8745$) which is very close to the assumption of 252 days. Moreover, options prices are also considerably varying for the different methods and changing strike prices. Our analysis shows that approximation value of option prices derived by different methods are very closed to the data of option price mentioned in Derivatives Options Trading at NSE [17].

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