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A Study on the Behaviour of Volatility of Nifty Index Options

Nidhin Mathew

Assistant Professor, St. Pius X College Rajapuram, Kasaragod (India)

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***Corresponding Author**
Email: nidhinkmathew857[at]gmail.com

ABSTRACT

An option is a financial derivative that gives the holder the right, but not the obligation, to buy or sell a basket of stocks at an agreed-upon price on or before a certain date. Index options are similar to other options contracts, where the underlying instruments are stock market indices. This study is an attempt to analyse the relationship between spot and options markets in order to find out whether there exists any lead-lag relationship between these two. The study focuses on the relationship between the NIFTY Index Options and the underlying stock index - NIFTY 50. The study mainly focuses on analysing the dynamic relationship between options and spot market volatilities in the NIFTY. The relationships such as long term, short term and causality between spot and options market volatilities are analysed with the help of various econometric models. This study intrepidly says that the relationship between the options and spot markets is so dynamic. It is seen that there is a very smooth way of passing information from the options market to spot market and both are highly linked.

1. Introduction

An option is a financial derivative that gives the holder the right, but not the obligation, to buy or sell a basket of stocks at an agreed-upon price on or before a certain date. A call option is an option that gives the holder the right, but not the obligation, to buy underlying assets at an agreed-upon price on or before a specific future date. A put option is an option that gives the holder the right, but not the obligation, to sell underlying assets at an agreed-upon price on or before a specific future date. Index options are similar to other options contracts, where the underlying instruments are stock market indices. Index options deliver the investor a chance either to capitalize on an expected market move or to protect holdings in the underlying assets. The degree of exposure changes with the specific index option. The risk associated with the index option is limited and it is known to buyers in advance. If the index does not move as anticipated, the buyer's risk is limited to the premium paid, which is the price of the option. An index call option is said to be 'in-the-money' when its strike price is less than the underlying index. An index call option is said to be 'at-the-money' when its strike price is the same as the underlying index and 'out-of-the-money' when its strike price is greater than that underlying index. An index put option is said to be in-the-money when its strike price is greater than the reported level of the underlying index. It is 'at-the-money' when its strike price is the same as the underlying index and 'out-of-the-money', when its strike price is less than the underlying index.

The efficiency of the financial markets can be analysed different models, tests or by exploring arbitrage pricing relationships. According to Brunetti and Torricelli, if there is an absence of arbitrage, two assets providing identical future profits must trade at the same price in an efficient market. If there is any possibility for arbitrages, there will be an immediate reaction from market participants resulting in withdrawal arbitrage opportunities. The efficiency of the Options market can be analysed in two ways - Cross markets efficiency and Internal option market efficiency. Cross market efficiency is based on tests of the joint efficiency of the option and the underlying market and internal option market efficiency aims at assessing the existence of arbitrage opportunities within the very same option market.

The National Stock Exchange of India Ltd. (NSE), which is the leading stock exchange in India, was established in 1992 as a tax paying company in Mumbai. NSE has provided a number of financial services such as listings of securities, trading, clearing and settlement services, indices, market data, financial education, etc. The NIFTY 50 is the flagship index of NSE, which was launched on 3rd November 1995 with a base value of 1000. The index itself covers all the major sectors of the Indian economy and it includes 50 stocks. The derivatives trading at India's National Stock Exchange (NSE) commenced on 12thJune 2000 with futures trading on NIFTY Index. National Stock Exchange (NSE) introduced trading in index options on 4th June 2001. The options contracts are European style and cash settled and are based on the popular market benchmark NIFTY Index.

This study is an attempt to analyse the relationship between spot and options markets in order to find out whether there exists any lead-lag relationship between these two. The study focuses on the relationship between the NIFTY Index Options and the underlying stock index - NIFTY 50. The study mainly focuses on analysing the dynamic relationship between options and spot market volatilities in the NIFTY. The relationships such as long term, short term and causality between spot and options market volatilities are analysed with the help of various econometric models.

2. Review of literature

Fleming, Ostdiek and Whaley (1996) examine the interactions between the S&P500 index, options and futures contracts on this index. They conclude that the derivatives markets lead systematically the spot market, while the futures market precedes the options market, in particular, due to more

important liquidity, and therefore to less high transaction costs on the former.

Hemler and Miller (1997) in their study examined the efficiency of European style S&P 500 Index options traded on the Chicago Board Options Exchange (CBOE). From their study, Hemler and Miller found significant arbitrage opportunities for S&P 500 European options. However, they warned that some quotes might not have been executed, due to stale prices, indicating some arbitrage profits may have been virtually impossible to achieve.

De Jong and Donders (1998) examined the relationship between the Dutch options market and the spot market. They found that the futures contracts lead both the options and the index by about 10 minutes. Their results proved that the relationship between the options market and the spot market is not unidirectional.

Booth and Tse (1999), examining the relationship between the German derivative markets and the DAX index, find cross linkages among the three markets. In particular, they conclude that the spot market lead the options market. In the case of French markets, Capelle-Blancard and Vandelanoite (2002), using Granger linear and non-linear causality tests between European options and the CAC40 index, find that the spot market leads the options market.

Fung (2004) in his study examined the pricing efficiency of the Hang Seng Index options market in Hong Kong, by making use of the Box spread Strategy. It was found that there were very few arbitrage opportunities and upon further examination based on the reporting time of quotes, it was found that all the apparent mispricing were deceptive and they could be explained by stale quotes. The absence of real arbitrage opportunities confirmed the efficiency of the Hong Kong options market.

Benzion(2005) in his study examined the efficiency of the Israeli options market by examining the box spread strategy. They made use of a real-time computer program to find Arbitrage gain opportunities by considering the sample of index options traded on the Tel-Aviv Stock Exchange. It was found that only a few arbitrage opportunities were possible which disappeared rapidly and substantiated the efficiency of the Israeli options market.

Vipul (2009) examined themarket efficiency for the European style Nifty index options of the National Stock Exchange (NSE) India, by making use of a box-spread strategy. Time-stamped transaction data provided by NSE between 1 January 2002 and 31 December 2003 was used for this study. It was found that profit opportunities, after accounting and incorporating for transaction cost, was quite frequent, but, they did not persist even for 2 minutes. The fact that the arbitrage opportunities do not persist even for two minutes, indicates that the arbitrageurs do not ignore the mispricing for a long time..

3. Objectives of the study

1. To examine whether there exists any lead-lag relationship between the spot and options market in NSE.
2. To analyses the pricing efficiency of the NIFTY Index Options by comparing the linkage in volatilities between the spot and options market.

4. Data and methodology

For the present study, NIFTY 50 Index is the underlying index and NIFTY Index options are considered to test the internal market efficiency of NSE India.In order to assess the relationship between spot and options market, the daily at the money implied volatility of the options price along with the daily historical volatility of the underlying asset have been collected from the BLOOMBERG database and NSE website for NIFTY 50 indices for five years from 1st January 2014 to 31st December 2018. The historic volatility (HVol) is based on the standard deviation of daily price movements. On the other hand, the implied volatility (IVol) is found by using the Black-Scholes model on the at the money option prices.

The analysis of the study is done with the help of the econometrics software E-Views through the following steps:

1. The preliminary analysis is done through descriptive statistics.
2. The unit root test has been adopted in order to ensure that the variables HVol and IVol are stationary, which is a pre-requisite for determining the short-term as well as the long-term relationship among the variables.
3. Long term relationship between the spot and options market is determined by using the Johansen co-integration model.
4. Short-term relationship and lead-lag between the spot and options market are defined through the Vector Error Correction model.
5. The causality of the spot and options volatility series is established by employing the Granger Causality/ Block Exogeneity Test on the variables included in the study.

Using the above mentioned models/tests, the following null hypotheses can be tested to accomplish the objectives of the study.

H_{01}: There is no significant relationship between the spot and options market in a long and short period.

H_{02}: The option price has no information to pass on to spot market

H_{03}: There is no significant lead-lag effect between the spot and options market.

5. Limitations of the study

The study is based on secondary data and therefore errors in the collection, compilation of data, etc. are dependent on the process and perfection decided by others. Daily volatilities, both historic and implied volatilities are directly obtained from Bloomberg database. Seasonality effect, Monday effect, expiration effects, cyclical effects and celebration effects effect are not taken into consideration in the study. Microeconomic factors like GDP, interest rate, inflation rate and other country-specific factors are not included here.

6. Analysis and interpretations

Identifying the established relationship among the spot market and options market for a long period is important to explain the efficiency of the market to predict the movement of another market. Long run relationship between the options market and its underlying market has an important effect on forecasting and hedging models to reduce the risk involved in the underlying asset.

6.1 Results from Summary Statistics

Table -1
Summary Statistics for NIFTY Index

VARIABLES	OPTION	SPOT
Mean	27.64493	30.43304
Median	23.47200	25.68300
Std. Dev.	13.51401	15.52703
Skewness	1.640008	1.784281
Kurtosis	6.249030	6.739794

Table No.1 shows the descriptive statistics of spot and option variables for the NIFTY options market. In order to understand the behaviour of raw data series included in the study, mean, median, standard deviation, skewness, kurtosis and Jarque-Bera measured and presented. During the period of study, the options and spot variables show the coefficients of variation of 0.4887 and 0.51025 respectively for the NIFTY index. It indicates that the options market shows comparatively lower variation. Also, the average volatility in the option prices is lower than that of the spot market volatility. The skewness for both the market shows values around 2 which indicate that most values are concentrated on the left of the mean with extreme values to the right. Kurtosis is above 3 for both HVol and IVol and it should be said that the series is leptokurtic which means that the distribution is sharper than a normal distribution with values clustered around the mean. This means a high probability for extreme values.

6.2 Result of Stationary Test

Table -2 Results of Stationary Tests

INDEX	VARIABLES	LEVEL	
		ADF	PP
NIFTY	OPTION	-2.92874**	-3.78437***
	SPOT	-2.60406*	-3.74055***
*, **,*** indicates the significance at 10%,5%, and 1% level.			

Stationary is the important property of time series data which shows the ability of the data series to explain the long and short term information. As a preliminary test, it is necessary to test the stationarity of the time series variables such as HVol and IVol by applying Augmented Dickey-Fuller (ADF) and Philip Perron (PP) Unit Root Test. Table no. 2 shows the results of the ADF and PP test for HVol and IVol. HVol and IVol variables are stationary in its level form. It indicates that HVol and IVol are capable to test the role of one variable on the other. The significance of these statistical results says that there is no possibility of accepting the null hypothesis that there is a unit root in the variable. While rejecting the null hypothesis, it is absolutely confirmed that the data series are losing their long-term informational content.

6.3 Result of VAR Criteria for the Lag Selection Procedure

Table -3 Result of VAR Criteria Adopted for Selection of Lag Length for Model

Index	Lag	LogL	LR	FPE	AIC	SC	HQ
NIFTY	0	-9268.61	NA	10687.68	14.95260	14.96086	14.95571
	1	-6204.11	6114.184	76.74950	10.01630	10.04109	10.02562
	2	-6189.35	29.40235*	75.42894*	9.998945*	10.04026*	10.01448*
* indicates lag order selected by the criterion at 5% level. LR-sequential modified LR test statistic, FPE- Financial Prediction Error, AIC-Akaike Information Criterion, SC- Schwarz information Criterion, HQ- Hannan-Quinn information criterion.							

Table no. 3 shows the result of VAR criteria adopted for the selection of optimal lag length for the statistical methodology used to determine the relationship between option and spot market. As per the Likelihood Ratio (LR), final protection error and Akaike Information Criterion (AIC), HQ, SC and FPE the optimal lag length for NIFTY is 2. The error term of each variable is stationary at this point. The optimal lag length helps to avoid the auto correlation problem from the time series data set up to an extent.

6.4 Long Term Relationship Between Option and Spot Markets

Table -4 Results of Unrestricted Co-integration Rank Test applied through Johansen Co-integration Methodology

Index	Hypothesis	Eigen Value	Trace Statistics	Critical Value at 5%	Max- Eigen Statistic	Critical Value at 5%
NIFTY	r=0	0.064351	91.08453**	15.49471	82.41228**	14.26460
	r≤1	0.006975	8.672250	3.841466	8.672250	3.841466
**denotes the rejection of the hypothesis at a 5% level. Trace test indicates one cointegration equation at a 5% level. Max-Eigenvalue test indicates 1 cointegrating equation at the 5% level.						

Table No. 4 provides the result of the unrestricted co-integration rank test applied through Johansen co-integration methodology. The results of Johansen co-integration are explaining through the Trace Statistics and the Max- Eigen test Statistics. For the NIFTY Index options market, the null hypothesis that there is no co-integration equation among Spot and Options is rejected at 5% level of significance. Both test statistics like Trace statistics and Max-Eigen statistics reject

the null hypothesis at a 5% significance level. So the alternative hypothesis that there is atleast one co-integration equation between the options and spot market is accepted. This long-run relationship between options and spot market helps the traders in hedging their portfolio risk and to exploit the arbitrage opportunities. This result reveals that the movement of one market can be predicted by another market during the long term period.

6.5 Short Term Relationship between Spot and Options Market

Table -5 Results of Normalized Co-integration Vector Error Correction Model

Index	Error Correction	D(HVOL)	D(IVOL)
NIFTY	Co-integration Equation-1 [1.00000]	0.00631	0.119247
		[0.63397]	[9.04097]

Table No.5 shows the results of the Vector Error Correction Model applied to determine the short-run relationship between the option and spot markets for various options market during the study period. In NIFTY, the speed of adjustment of the spot market is around 0.6%, at the same time the options market shows around 11%. It indicates that when the options market responds and adjusts around 11% to the new information, the speed of adjustment of the spot market is only 0.6%. From this result, it is proved that the options market is adjusting to the new information very soon than the spot market. The reactions of the spot prices and option prices to the disequilibrium errors captured by the speed of adjustment show that within one time period 11% of disequilibrium errors are corrected in options market, which shows the leading behaviour of the options market. The result shows that the options market responds faster to the previous period's deviation from the long run equilibrium. Thus it should be concluded that the options market is adjusting to the new information faster than spot markets and they are more volatile to the market conditions than the latter.

6.6 Causal Relationship between Spot and Options Markets

Table -6 Results of Normalized Co-integration Vector Error Correction Model

Index	Dependent Variable	Chi-square Value
NIFTY	HVOL	9.418739***
	IVOL	3.646289**

Table-6 shows the result of VAR Granger Causality/ Block Exogeneity Wald Test for a causal relationship between spot and options market in different economies. The Chi-Square values are significant which means that while restricting the lag values of options and residuals of the spot, the null hypothesis of options market does not cause spot volatility is rejected at 5 percentage level of significant and accepted the alternative hypothesis of options market causes spot market for all the options market. Both variables are causing each other, in other sense, there is bidirectional causality between the options market and spot market. This result is supported by the theory and literature that there is bidirectional causality between the options market in India and abroad.

With the help of these empirical results, the null hypotheses of the study such as there are no significant relationship between spot and options market in a long and short period, the option price has no information to pass on to spot market and no significant lead-lag effect between spot and options market are rejected. The study clearly reveals that there is co-integration between the spot and options market. Even though there is a bidirectional relationship between the spot and options market, the options market shows the dominant and leading roll on the spot market.

7. Conclusion

The study mainly focuses on analysing the dynamic relationship between options and spot market volatilities in the NIFTY. The relationships such as long term, short term and causality between spot and options market volatilities are examined in this study. Due to data movement and market trends, the established relationships among markets may be changed. The causal relationship reveals the lead-lag positions between the options and spot markets.

Co-integration results for all the economies under study indicate the possibility of rejection of the null hypothesis that there is no co-integration between options and spot markets. This indicates that there is a long term relationship between both the markets. On the basis of Johansen Co-integration Methodology, the study, thus, proves that there are long term relationship and co-integration between the options market and its underlying market. The speed of adjustment parameters of options and spot markets to the disequilibrium in the co-integration is analysed by using the Vector Error Correction Model. On the basis of the speed of adjustment parameters, it is possible to explain the leading behaviour of the market or the ability of the market to adjust and respond to the new information. It is found that the options market is leading the spot market. It can be said that options markets lead the spot market always and spot markets attract the options market often. The dominant role of the options markets is witnessed through the empirical results of the study. The causality relationships between options and spot markets reveal the position of lead-lag among options and spot markets. Results of the Wald test indicate that there are bidirectional causality relationships between spot and options markets. Both markets are performing like indicators and followers. It can be said that options markets lead the spot markets in most of the cases.

On the basis of empirical results, the null hypothesis such as spot volatility pays a very negligible role in determining options volatility is rejected. It is found that spot market volatility is the key factor that can be considered as the determinant of the options market due to the informational efficiency of the options market. To conclude, this study intrepidly says that the relationship between the options and spot markets is so dynamic. It is seen that there is a very smooth way of passing information from the options market to spot market and both are highly linked.

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