SPOT VOLATILITY PREDICTION BY FUTURES AND OPTIONS: AN INDIAN SCENARIO

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Abstract

There are a plethora of studies on the determinants of the spot volatility. The issue of determining spot volatility becomes more convoluted and esoteric when the security concerned also trade-in options and futures markets as its derivative instrument. Most of the research seems to inadequately address the issue of a determinant of spot volatility using only options market and leaves futures market unaccounted for. This paper is an attempt to fill the gap and includes both the markets to determine the spot volatility. Spot volatility measures are regressed on options volume and futures volume using multiple regression analysis. Both the acceptable and popular measures of volatility, GARCH (1,1) estimates, and implied volatility, are used to represent spot volatility. The regression results for options volume as well as futures volume are statistically significant in both the regressions of GARCH (1,1) estimates and implied volatility. This result adds value to the existing lode of knowledge that not only options volume but also the futures volume determines the spot volatility. This is the unique contribution of the present study. Informed investors and equity researchers can reasonably use the findings of this paper to value the shares and predict the future share price, which are the major implications of the study. However, diagnostic testing and model specification is not consistent which are the limitations of the present study. A further study with the improved model specification can be the future scope of the study on the topic.

Key Word: Options; Futures; Volatility; Markets; Volatility Spillover

1. Introduction

The securities which have their futures and options contracts as well, practically are traded in the three markets together (Rastogi and Athaley, 2019). This is obvious that the volatility in the three markets also gets affected and therefore there are evidences that the volatility of one market impacts the volatility of the other markets (Rastogi and Agarwal, 2020). It becomes perplexing to see that there are many theories and findings of different papers discussing volatility at their center stage (Andersen and Bollerslev, 1998, Arouri et al., 2012, Bansal et al., 2014, Baykut and Kula, 2019). There are another set of studies which provide different findings to corroborate the idea that options market, the trading volume in the options market impact the spot volatility (Augustin et al., 2016, Black and Scholes, 1973, Bollen, 1998, Chen and Wang, 2017, Sarwar, 2003, Sarwar, 2004, Sarwar, 2005). In addition to this there are some studies which deal with spot volatility and futures market as well (Bae et al., 2004, Bessembinder and Seguin, 1992, Bologna, 2000, Darrat and Rahman, 1995, Edwards, 1988, Grossman, 1988).

Despite all the clamour on the role of options market and futures markets to impact the spot volatility, there is practically a void when it comes to a possible discussion on spot volatility due both the markets (options and futures market) together. The discussion of Sarwar (2005) and Shenbagaraman (2003) aptly talks how options volume impacts the spot volatility but without an obvious discussion on futures volume and its role on the spot volatility determinations. This paper is an attempt to figure out how both the markets (futures and options market) impact the spot volatility. Objective of this paper is to investigate the impact of options and futures markets on the spot volatility.

The remaining parts of the paper is divided into six more sections. A review of the literature section discusses the relevant literature on the topic. The theoretical model section presents the theoretical model applied in the paper for empirical investigation. The fourth section on data and methodology provides the details about the source of data, time period of the data and methodology used in the paper. The results are discussed in the fifth section. Discussion on the findings of the paper, its contribution and implication are covered in the sixth section of the paper. The paper is concluded in the seventh section.

2. Review of Literature

The extant literature on volatility is spread across a very wide spectrum. The relevant literature on the
determinants of volatility is mainly concentrated into three main categories or themes.

A good number of literature uses options as a determinant for spot volatility. As a matter of fact, in the estimation of the price of options, volatility is an important variable (Rastogi et al., 2018). Therefore, in all likelihood, options finds its mention in the discussion of spot volatility (Ni et al., 2008,Pan and Poteshman, 2006,Pathak, 2015, Sarwar, 2003, Sarwar, 2005, Srinivasan, 2010). Options volume are usually found in having the endogenous association between them (Sarwar, 2005). The endogeneity is addressed by 2SLS or GMM methods in most of the studies. Some studies have also taken into account the moneyeness issues along with put and call options as part of their discussion and have related them with the spot volatility. The options volume and spot volatility studies are also talking in term of directional traders and hedgers (Baillie and Myers, 1991, Pan and Poteshman, 2006).

There are many studies which takes into account the role of futures for determining spot volatility (Agnolucci, 2009, Bae et al., 2004, Bessembinder and Seguin, 1992, Bologna, 2000, Chang et al., 2000, Chernov, 2001, Thenmozhi, 2002, Sarkar and Rastogi, 2011, Rastogi, 2011a, Rastogi, 2016). It is really surprising to see that studies relating the futures market and its volume to spot volatility are there but whenever options volume is in the discussion, researchers prefer to ignore the futures as a determinant for spot volatility (Chen and Wang, 2017, Sarwar, 2005). It is a fact that in the option pricing formula (both continuous option pricing and binomial option pricing) spot volatility is one of the important inputs. Therefore, it seems the obvious reason for the preference of options volume to determine the spot volatility. However, the surprising element is that there are enough studies to relate the futures with the spot volatility, but in isolation not with the options volume (Hodgson and Nicholls, 1991, Malhotra and Sharma, 2016).

There are a few studies which move across futures and options both and deal with spot volatility (Bae et al., 2009, Bandivadekar and Ghosh, 2003, Bhauimik et al., 2008, Singh and Kansal, 2011, Srinivasan, 2010). The presence of both, futures volume and options volume to impact the spot volatility is justified as well. But this is an area which is quite less researched (Rastogi and Athaley, 2019, Rastogi and Agarwal, 2020). It is quite common to see in literature the isolated cases of options or futures market impacting the spot volatility, but the number of studies which cover both is quite less. Rather, the literature is lopsided with the options market and its impact on the spot volatility.

There are varied studies on volatility which talks about many interactions of different markets across the same securities as well as different securities (Rastogi, 2010, Rastogi and Srivastava, 2011, Rastogi, 2013, Rastogi, 2014). Volatility spill over is also another phenomenon which is quite evident in the literature of spot volatility (Baele, 2005, Christiansen, 2007, Dedi and Yavas, 2016, Erten et al., 2012, Hong, 2001, KIRKULAK ULUDAG and EZZAT, 2017, Liu, 2016). Most of the studies uses bivariate tool to figure out volatility spill over and there is strong evidence for the same. But most of the studies do not talk about integration of the volatility among the three markets except a few studies (Rastogi and Athaley, 2019, Rastogi and Agarwal, 2020). It is different thing to have options volume and futures volume driving the spot volatility, it is reasonable to have a few studies to integrate the three markets.

3. Theoretical Model

The proposed model applied in the paper is as follows:

\[ GARCH_t = \alpha + \beta_1 LOGFV + \beta_2 LOGPV \]  
\[ IV_t = + \beta_1 LOGFV + \beta_2 LOGPV \]

Equation 1 explains the association of GARCH (historical spot volatility measured by GARCH 1,1) mode and its association with futures volume and options volume. Bollerslev (1986) argued that GARCH (1,1) model is a good model to estimate volatility and the same is done in the paper to estimate the volatility. Equation 2 talks about the association of implied volatility (IV) with options and futures volume. It is discussed in the literature that IV can also be another good measure of the volatility of the stock prices (Imlak and Puja, 2014, Ryu, 2012). This paper has used both the popular measure of volatility to explore the determinants of volatility. Based on the above-mentioned discussion, following directional hypothesis is formulated:

**Hypothesis:** spot volatility is associated with both options volume and futures volume.

4. Data and Methodology

Daily stock prices of the NIFTY 50 index are pulled out from the CMIE Prowess database from January 2016 to September 2017. Option volume and futures volume of Nifty 50 options and futures are used in the paper. Both the volume series have also been pulled out for the same time period. Log transformation is used for volume
data of both the time series to bring the better consistency in the application of optimum least square based estimator to estimate the coefficients of Equation 1 and 2 (Wooldridge, 2016). Log transformed values of the variables have higher probability of unbiased and consistent estimates of the coefficients. Therefore, the same is applied in the estimation of the model (Table 2).

Table 1 reports the descriptive of the variables used in the paper. The GARCH estimate of the annual volatility of the stock indices (NIFTY 50) has mean, minimum and maximum values of 12.30%, 8.09, and 20.17% respectively. The standard deviation of GARCH estimate of volatility is 3.13%. The same descriptive statistics of IV are 24.61%, 12.61%, 58.09% and 7.31% respectively. The similar values of LOGFV and LOGOV are also reported in Table 1.

Table 1. Descriptive Statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GARCH</td>
<td>8.09%</td>
<td>20.17%</td>
<td>12.30%</td>
<td>3.13%</td>
</tr>
<tr>
<td>IV</td>
<td>12.61%</td>
<td>58.09%</td>
<td>24.61%</td>
<td>7.31%</td>
</tr>
<tr>
<td>LOGFV</td>
<td>10.12%</td>
<td>15.13%</td>
<td>13.59%</td>
<td>.83</td>
</tr>
<tr>
<td>LOGOV</td>
<td>9.64%</td>
<td>18.88%</td>
<td>15.71%</td>
<td>1.32</td>
</tr>
</tbody>
</table>

Note: LOGFV and LOGOV are natural logs of future volume and option volume respectively. GARCH is historical volatility estimated by GARCH (1,1) model and IV is implied volatility. GARCH and IV are annual volatilities estimated in percentages.

Table 2. Result of Regression Analysis

<table>
<thead>
<tr>
<th>PART A. GARCH</th>
<th>Coefficients</th>
<th>SE</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unstd.</td>
<td>Std.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>.0541</td>
<td>.0302</td>
<td>1.79</td>
<td>.0740</td>
</tr>
<tr>
<td>LOGFV</td>
<td>.0104</td>
<td>.2614</td>
<td>.0019</td>
<td>5.60</td>
</tr>
<tr>
<td>LOGOV</td>
<td>-.0046</td>
<td>-.1823</td>
<td>.0012</td>
<td>-3.91</td>
</tr>
<tr>
<td>F-test (Model)</td>
<td>21.99</td>
<td>(.0000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Square (Adjusted)</td>
<td>9.54%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE of Regression</td>
<td>.0316</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DF</td>
<td>417</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: No of observations (n) = 420

Test for Heteroscedasticity1 62.27 (.0000)
RESET Test2 9.43 (.0000)
Test of Autocorrelation3 337.21 (.0000)

<table>
<thead>
<tr>
<th>PART B. Implied Volatility (IV)</th>
<th>Coefficients</th>
<th>SE</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unstd.</td>
<td>Std.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-.4006</td>
<td>.0626</td>
<td>-6.40</td>
<td>.0000</td>
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<tr>
<td>LOGFV</td>
<td>.0318</td>
<td>.3632</td>
<td>.0038</td>
<td>8.30</td>
</tr>
<tr>
<td>LOGOV</td>
<td>.0137</td>
<td>.2460</td>
<td>.0024</td>
<td>5.62</td>
</tr>
<tr>
<td>F-test (Model)</td>
<td>53.43</td>
<td>(.0000)</td>
<td></td>
<td></td>
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<tr>
<td>R-Square (Adjusted)</td>
<td>20.41</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE of Regression</td>
<td>.0654</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DF</td>
<td>417</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: No of observations (n) = 420

Test for Heteroscedasticity4 23.50 (.0000)
RESET Test4 7.38 (.0000)
Test of Autocorrelation3 241.313 (.0000)

Note: 1 Test of heteroscedasticity has the null of no heteroscedasticity. 2RESET test has null of correctly specified model. 3Test of autocorrelation has the null of no autocorrelation. P-value are in parentheses.

Multiple regression analysis is applied to estimate both the equations using OLS (Optimum Least Square) estimators. STATA 15 is used to estimate the coefficients and other values. We have also tested both the models for OLS assumptions (Heteroscedasticity, Perfect Collinearity and Autocorrelation) and for model
specification. The results for the same are reported in Table 2.

5. Results

The estimation of both the theoretical models is reported in Table 2. Equation 1 is reported in the former part and equation 2 in the latter part of Table 2. Both the proxy of volatility is regressed on futures volume and options volume as per the equation 1 and 2. The results of the regressions are significant in both the cases for both the variables. Options volume as well as futures volume are significantly associated with both the definitions of spot volatility. R-square of GARCH definition of volatility is less as compared to the IV definition of the volatility (they are 9.54% and 20.5% respectively). The RESET test of model specification is also significant which explains the low values of R-squares in both the estimated regression analysis. In addition to this, Heteroscedasticity as well autocorrelation assumptions of OLS are also not holding in both the cases. Despite this, the model is significant and standard error of the model is also at the moderate levels.

6. Discussion

This is a reality that the securities which exist in spot, future and options markets to have higher probability of integration among the three markets. The same results are propounded in this paper. It has been found that the spot volatility is having significant association with both futures and options volume. Therefore, it can be said that the hypothesis of spot volatility having significant association with options volume and futures volume cannot be rejected and due to insufficient evidence.


The main contribution of the paper is that the options volume and futures volume are concurrently and significantly impacting the spot volatility. Moreover, it is observed by the authors that the application of IV and GARCH (1,1) model to use as proxy for variability are also quite less. This knowledge that both options and futures volume are significantly impacting the spot volatility is of immense value for the practical, managerial and policy implications. The findings of the paper will help investors especially informed investors to predict the stock price movement by having an eye on the futures and options transactions.

7. Conclusion

Both options volume and futures volume are significantly impacting the spot volatility. Therefore, it can be concluded that both futures volume and options volume can be used as the determinants of the spot volatility. This result is rare as quite less number of times time there are empirical evidence where both futures and options volume significantly impact the spot volatility. The regression estimates of spot volatility on futures and options volume are having the violations of both the assumptions of homoscedasticity and no autocorrelation. In addition to this, the model specification is also not great. Both are the limitation of the paper. The remedial options like GLS (Generalized Least Square) estimator for heteroscedasticity and robust estimates of standard errors of coefficient estimators are some of the options to overcome the limitation of the paper. These remedial options to overcome limitations are the future scope of the study on this topic.

References


