IMPACT OF INDEX DERIVATIVES ON INDIAN STOCK MARKET VOLATILITY-AN APPLICATION OF ARCH AND GARCH MODEL

S. V. Ramana Rao*, Naliniprava Tripathy**

Abstract

The present study examined the impact of introduction of index futures derivative and index option derivative on Indian stock market by using ARCH and GARCH model to capture the time varying nature of volatility presence in the data period from October 1995 to July 2006. The results reported that the introduction of index futures and index options on the Nifty has produced no structural changes in the conditional volatility of Nifty but however the market efficiency has been improved after the introduction of the derivative products. The study concludes that financial derivative products are not responsible for increase or decrease in spot market volatility, but there could be other market factors which influenced the market volatility.

Keywords: ARCH, GARCH, option futures, index future and dummy coefficiants

**Assistant Professor (Finance), S.S. Institute of Management, Secunderabad, India*
Email: sindhe_rao@yahoo.co.in
***Associate Professor (Finance), Indian Institute of Management Shillong, India*
Email: nt@iimshillong.in/nalini_prava@yahoo.co.in

1. Introduction

During the last decade, many countries across the world have introduced derivative products in their capital markets. The impact of introduction of derivative products on the underlying stock market volatility received major attention all over the world. Investors in the market make their decisions based on their perceptions of the distribution of future stock returns; therefore, any knowledge about future volatility has an enormous influence on their investment behavior. Hence high level of volatility in capital markets often raises issues related to public policies on the stability of financial markets and the economy as a whole. So the present study examined the impact of derivative products viz., index futures and index options on the spot market (Nifty) volatility. The study also investigates whether volatility is time varying and predictable in the market.

The remaining of this paper is structured as follows: the next section presents a brief survey of the literature, in Section: 3 describe the data used in this study, the methodology and the results of the study are presented in Section: 4 and finally Section: 5 conclude the paper.

2. Review of literature

Mayhew Stewart (2000) focused on how the introduction of derivative securities affects the underlying market. In most cases, the resulting models predicted that speculative trading and derivative markets stabilize the underlying market and make spot markets more liquid and more information ally efficient. Huseyin Gulen and Stewart Mayhew (2000) studied the stock market volatility before and after introduction of index futures in 25 countries. They examined whether spot market volatility after the introduction was related to futures market volume and open interest. They found that futures' trading was related to an increase in conditional volatility in US and Japan, but for the rest of the countries they found no significant effect. It was further found that, except for US and Japan, volatility tended to be lower in periods when open interest was high. Benilde Maria Do Nascimen Oliveira et al (2001) analyzed the impact of futures introduction in the Portuguese stock market. The authors used GARCH model to measure the futures trading impact on the spot market volatility. They found that introduction of the PSI-20 index futures trading increased the Portuguese spot market volatility and that there was no improvement on the market efficiency front. Board John et al (2001) examined the effect of futures market volume on spot market volatility in two parallel markets viz. The equity (spot or cash) market and the market for futures on equity index by using GARCH and stochastic volatility models. They found that there was no evidence that futures trading instantly destabilized the spot market or that an increase in volume in one market, relative to the other, instantly destabilized the other market. The stochastic volatility analysis showed that there is a positive influence on spot market volatility which indicates that spot market volatility has increased. Ali F Darrant, et al (2002)

examined the role of futures trading in spot market fluctuations. The Exponential Generalised AutoRegressive Conditional Heteroscedasticity was used to measure volatility and relationship between volatility in the spot and futures markets for the period November 1987 to November 1997. They concluded that index futures trading could not be blamed for the volatility in the spot market. Pilar Corredor and Rafael Santamania examined the effect of the introduction of derivatives (futures and options) in the Spanish market on the volatility and on the trading volume of the underlying index. The period of analysis covers October 1990 to December 1994 and they used GARCH, EGRCH and GJR models to find out the conditional volatility. The findings of the study are that the level of volatility had decreased when derivative markets were introduced but the trading volume of the Ibex 35 had increased. They concluded that the introduction of derivatives did not present a problem for the spot market because their impact was beneficial and possessing characteristics similar to the Spanish market. Kiran Kumar Kotha and Mukhopadhyay Chiranjit (2003) studied the impact of futures introduction on underlying NSE Nifty volatility by using a CUSUM plot and GARCH family of techniques to capture the time varying nature of volatility and volatility-clustering phenomenon's presence in the data. The results reported that the introduction of index futures trading had no effect on the mean level of returns of Nifty. Nagaraj KS and Kiran Kumar Kotha's (2004) studied the impact of Index Futures trading on the spot market volatility by using GARCH model. The study found that the market had become more efficient in assimilating the information into the market after the introduction of index futures. Furthermore the study indicated that Monday and Friday are significant in terms of day of week effect of the market and also that volatility of the spot market has declined. YPSingh and S. Bhatia (2006) studied the futures trading impact the spot market volatility by using the GARCH (1, 1) model. The study proved that the daily spot market volatility in India has marginally declined since the introduction of futures trading in India. The market efficient has also improved after introduction of derivative products in the Indian capital markets. The study also found that there is a marginal decline in daily volatility on the expiration day of the derivative contracts. These results are quite contrary to the earlier studies results.

3.Time series data &methodology

The present study has been carried out with the three-benchmark indices: S&P CNX Nifty, S&P CNX Nifty Junior and S&P 500 index for studying the volatility behavior. Daily closing prices from June 1999 to July 2006 were obtained from NSE website for Nifty and Nifty Junior; similarly S & P 500 index from Prowess. For the data set daily returns are calculated for Nifty, Nifty Junior and S & P 500 index by using the following formula.

$$R_t = \ln (P_t/P_{t-1})*100$$

P_t and P_{t-1} are the prices at time t, and t-1 respectively and R_t is the return for time t.

Financial time series usually exhibits a characteristic called volatility clustering which means that large changes tend to follow large changes and small changes tend to follow small changes. In either case, the changes from one period to the next period are typically of unpredictable nature. GARCH model accounts for certain characteristics like fat tails and volatility clustering that are commonly associated with financial time series. Volatility of the stock markets is measured by using Standard Deviation or GARCH model. The GARCH model provides for heteroscedasticity in the observed returns. GARCH Model is a time series modeling technique that uses past variance and the past variance forecasts to forecast future variances. It is observed that the model that takes into account the changing variance can make more efficient use of the data. The Generalized Auto Regressive Conditional Heteroscedasticity (GARCH) model is a variation of the Auto Regressive Conditional Heteroscedasticity (ARCH) model developed by Engle in 1982. Bollerslev originally proposed the GARCH model in 1986. A distinguishing feature of this model was that the error variance might be correlated over time because of the phenomenon of volatility clustering. In analyzing the behavior of volatility due to derivative products, it is necessary to eliminate the influences of other factors. This is achieved by regress the return series over its lags, over its exogenous variables and over day-of-the-week. The GARCH (1, 1) framework has been found to have the best specification in both the works. Hence this work has been carried out with GARCH (1, 1) model with necessary modifications.

ARCH

The ARCH (q) process captures the conditional heteroscedasticity of financial returns by assuming that today's conditional variance is a weighted average of past squared unexpected returns:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^{\ 2} + \alpha_2 \varepsilon_{t-2}^{\ 2} + ... + \alpha_q \varepsilon_{t-q}^{\ 2}$$

Where $\alpha_0 > 0, \alpha_1, \alpha_2 ..... \alpha_q \geq$ and e_{t1} I_{t-1} ~ N (0, h_t)

If a major market movement occurred yesterday, the day before or up to q days ago, the effect will be to increase today conditional variance because all parameters are constrained to be non-negative. In fact, the ARCH model with exponentially declining lag coefficients is equivalent to a GARCH (1, 1) model.

GARCH

The full GARCH (p, q) model adds p auto regressive turns to the ARCH (q) specification and the conditional variance equation take in the form as follows:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^{\ 2} + \alpha_2 \varepsilon_{t-2}^{\ 2} + \alpha_q \varepsilon_{t-q}^{\ 2} + \beta_1 h_{t-1} + \beta_2 h_{t-2} + ...+ \beta_p h_{t-p} ....$$

$$\alpha_0 > 0, \alpha_1, \alpha_2, ...\alpha_q \geq 0,\ \beta_1 \beta_2 .....\beta_p \geq 0$$

In the ARCH (q) process the conditional variance is specified as a linear function of past squared observations only, whereas the GARCH (p, q) process allows lagged conditional variances to enter as well. The GARCH (p, q) process defined above is stationary when –

$$(\alpha_1 + \alpha_2 + ... + \alpha_q) + (\beta_1 + \beta_2 + ...\beta_p)$$

GARCH (1, 1) process model given by

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^{\ 2} + \beta_1 h_{t-1} + \beta_2 D_t$$

$$\alpha_0 > 0, \alpha_1 \geq 0\ \ \beta_1 \geq 0$$

Where D_t is a dummy variable that takes a value of zero before introduction of derivative and value of 1 after introduction of derivative

The stationary condition for GARCH (1, 1) is

$$\alpha_1 + \beta_1 <_1$$

The GARCH (1, 1) model is represented as given below.

$$R_{Nifty} = \alpha_0 + \alpha_1 R_{Nifty,t-1} + \alpha_2 R_{Nifty\ junior,t} + \alpha_3 R_{S\&P500,t-1} + \sum_{J=4}^{\prime} \alpha_j Day_j + u_t$$

Where $R_{Nifty,\ t}$ is the daily return on the S&P CNX Nifty index calculated as the first difference of the log of the index, $R_{Nifty,\ t-1}$ is the lagged Nifty return, $R_{NiftyJunior,t}$ is the return of Nifty Junior, $R_{SP500,t-1}$ is the lagged S & P 500 index return, and DAY_j are day-of-the-week dummy variables for Monday to Friday except Thursday. It is essential to remove domestic market wide factors influence on Nifty returns to isolate the impact of derivative products introduction into the Indian capital market. In order to do this Nifty Junior, a proxy variable which does not have derivative products and which captures market wide influence of domestic markets in India has been included in the above conditional mean equation. In GARCH, the residuals (u_t) from the conditional mean equation assumed to be distributed in N ($0,h_t$) where the conditional volatility h_t is given by the following equation:

$$h_t = y_0 + y_1 \in_{t-1}^{2} + y_2 h_{t-1} + y_3 D_t$$

Where D_t is a dummy variable that takes a value of zero before introduction of index options, index futures, stock options and stock futures period and value of one in the post introduction period. y_1 reflects the impact of recent news (shocks), y_2 reflects the impact of old news (persistence volatility). For a GARCH process to be stable, it is necessary that y_0 and y_1 and y_2 are greater than zero and for $y_1+y_2<1$. y_3 would indicate the impact of introduction of derivative products on the underlying stock market volatility. A significant negative value for y_3 would indicate that derivatives introduction decreases the volatility. Similarly, a positive value suggests increase of volatility.

4. Empirical analysis

The study tried to find out whether the nature of the GARCH process was changed as a result of the derivative products introduction. The Indian stock markets have witnessed changes like rolling settlement system, electronic trading system, and creation of futures and options segment etc. These changes could have contributed to improve the efficiency of the market operations. Hence, to explore this, the GARCH (1, 1) model is estimated separately for the pre index futures and post index futures, pre index options and post index options. This facilitates obtaining more information about the effect of the introduction of index derivative products in the Indian stock market. The conditional mean and variance equations are similar except that the dummy variable for derivative products would not be there in conditional variance equation. The results of these two equations are helpful in analyzing the information efficiency in the pre and post derivative products period, examining the persistence of volatility and the changes in the day-of-week effect.

The GARCH analysis of before introduction of derivatives products has exhibited in table 1explains that there is an impact of Nifty Junior, Lag S&P 500 and lag Nifty on Nifty. It is observed that Monday coefficient is significant at 5% level. It indicates that before the introduction of index futures, Monday effect was there in the market as it happens to be opening day of the week and there may be weekend effect also. The output of conditional variance equation y_1 and y_2 are related to efficiency of news. y_1 relates to the impact of yesterday's market specific changes today. It can be inferred that recent news has an impact on price changes. y_2 coefficient reflects the impact of old news on yesterday's variance and as such it indicates the level of persistence in the information effect on volatility. Persistence of volatility means that today's volatility due to information arriving today will affect tomorrow's volatility and volatility of the days to come.

Table 1. Estimates of the GARCH (1, 1) model before the Introduction of Index Futures

	Particulars	*Coefficient*	*t-Statistic*	*Prob.*
α_0	Intercept	-0.010343	-0.196482	0.8442
α_1	Lagged Nifty return	-0.03459**	-2.355926	0.0185
α_2	Nifty Junior return	0.862942*	66.5254	0.0000
α_3	Lagged S & P500 return	0.116363*	5.88259	0.0000
α_4	Dummy-Monday	-0.140195**	-1.950164	0.0512
α_5	Dummy-Tuesday	0.018224	0.479469	0.6316
α_6	Dummy-Wednesday	-0.030494	-1.323961	0.1855
α_7	Dummy-Friday	0.015306	0.967904	0.3331
y_o	ARCH (0)	0.018371*	3.309349	0.0000
y_1	ARCH (1)	0.074674*	5.42106	0.0000
y_2	GARCH (1)	0.907286*	57.03493	0.0000

* Statistically Significant at 1% level
** Statistically Significant at 5% level

Table 2. Estimates of the GARCH (1, 1) model after introduction of Index Futures

	Particulars	*Coefficient*	*t-Statistic*	*Prob.*
α_0	Intercept	-0.040276	-0.784469	0.4328
α_1	Lagged Nifty return	-0.014684	-1.020877	0.3073
α_2	Nifty Junior return	0.68205*	66.44498	0.0000
α_3	Lagged S & P500 return	0.068489*	3.843142	0.0001
α_4	Dummy-Monday	0.019376	0.264724	0.7912
α_5	Dummy-Tuesday	0.054594	1.400666	0.1613
α_6	Dummy-Wednesday	-0.020677	-0.823774	0.4101
α_7	Dummy-Friday	0.028116**	1.934983	0.053
y_0	ARCH (0)	0.032364**	2.347624	0.0118
y_1	ARCH (1)	0.040982**	2.781785	0.0054
y_2	GARCH (1)	0.909369*	28.45292	0.0000

* Statistically Significant at 1% level
** Statistically Significant at 5% level

It is observed from the above table 2 that lag Nifty effect has vanished after index futures. In the post index futures period the Monday effect has disappeared and coefficient sign has also changed from negative to positive. The Friday coefficient is statistically significant at 5% level. The conditional variance equation output y_0, y_1 and y_2 coefficients are statistically significant. Hence it can be inferred that there is an impact of old and latest news effect in the market. A close look at the signals indicating the market efficiency as measured by y_1+y_2, signify the persistence of shocks in the market. In the pre index futures period (y_1+y_2) value was 0.98196 and the same has declined to 0.950351 in the post index futures period. This clearly indicates that there is a substantial reduction in persistence of volatility from pre index futures period to post index futures period. This reveals that market efficiency has increased after the introduction of index futures.

Table 3. Estimates of the GARCH (1, 1) model before Introduction of Index Options

	Particulars	*Coefficient*	*t-Statistic*	*Prob.*
α_0	Intercept	-0.022173	-0.446837	0.655
α_1	Lagged Nifty return	-0.029525**	-2.12089	0.0339
α_2	Nifty Junior return	0.786389*	73.24276	0.0000
α_3	Lagged S & P500 return	0.100516*	5.713709	0.0000
α_4	Dummy-Monday	-0.124197***	-1.759886	0.0784
α_5	Dummy-Tuesday	0.019548	0.529053	0.5968
α_6	Dummy-Wednesday	-0.011454	-0.517595	0.6047
α_7	Dummy-Friday	0.022725	1.520238	0.1285
y_0	ARCH (0)	0.020789*	3.828287	0.0001
y_1	ARCH (1)	0.056676*	5.176842	0.0000
y_2	GARCH (1)	0.920994*	65.8113	0.0000

* Statistically Significant at 1% level
** Statistically Significant at 5% level
*** Statistically Significant at 10% level

Table 3 depicts the GARCH analysis of before introduction of index options explains that there is an impact of lag Nifty returns, Nifty Junior, and Lag S&P 500 on Nifty. It is observed that there is a Monday effect in the market as its coefficient is significant before the introduction of index options. The output of conditional variance equation y_1 and y_2 are related to efficiency of news. y_1 relates to the impact of yesterday's market specific changes today. It is observed that recent news has an impact on price changes. y_2 coefficient reflects the impact of old news on yesterday's variance and as such it indicates the level of persistence in the information effect on volatility

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Table 4. Estimates of the GARCH (1, 1) Model after Introduction of Index Options

	Particulars	*Coefficient*	*t-Statistic*	*Prob.*
α_0	Intercept	-0.047709	-0.859812	0.3899
α_1	Lagged Nifty return	-0.021352	-1.192609	0.2330
α_2	Nifty Junior return	0.717164*	61.39636	0.0000
α_3	Lagged S & P500 return	0.070346*	3.375954	0.0007
α_4	Dummy-Monday	0.028089	0.36258	0.7169
α_5	Dummy-Tuesday	0.039948	0.937569	0.3485
α_6	Dummy-Wednesday	-0.017907	-0.626009	0.5313
α_7	Dummy-Friday	0.026069***	1.658368	0.0972
y_0	ARCH(0)	0.038553**	2.096763	0.036
y_1	ARCH (1)	0.04142**	2.12461	0.0336
y_2	GARCH (1)	0.896665*	20.80725	0.0000

* Statistically Significant at 1% level
** Statistically Significant at 5% level
*** Statistically Significant at 10% level

Table 4 exhibited that lag Nifty effect has vanished after index options. In the post index options period, Monday effect has disappeared. The Friday coefficient is statistically significant at 5% level. The conditional variance equation output y_0, y_1 and y_2 coefficients are statistically significant. Hence it can be concluded that there is an impact of old and latest news effect in the market. The market efficiency, which is measured by y_1+y_2, signifies the persistence of shocks in the market coefficient, shows negative sign. But however, it has become positive in the post index options period but not statistically significant. The y_1 and y_2 coefficients relate to latest and old news respectively. y_1 coefficient is significant hence it can be inferred that recent news has an impact on price changes. Similarly y_2 coefficient suggests that the market has been picking up impact of old news. The market efficiency as a measure of (y_1+y_2) indicates that there is a reduction of persistence of volatility in the post index options period because the value of (y_1+y_2) has come down from 0.97767 to 0.938085. It indicates that the market efficiency has improved after the introduction of index options.

5. Concluding observation

The relationship between financial derivatives such as index futures, index options, stock options and stock futures and corresponding spot market volatility of Nifty has been analyzed by using the GARCH (1, 1) model. The GARCH (1, 1) model included the variables of the day of week effect, domestic market factors, previous day's Nifty effect and worldwide market factors. The analysis of information efficiency through a separate GARCH model for pre and post derivatives period showed that there is a shift in market efficiency due to information flow. There is a Friday effect in the market after introduction of derivative products into the Indian capital market. Apart from this, the result shows that the spot market volatility has not been affected by the introduction of financial derivatives since the dummy coefficients for index futures and index options are not statistically significant. But the findings indicate that the market has become more efficient after introduction of derivative products. However it concludes that financial derivative products are not responsible for increase or decrease in spot market volatility, there could be other market factors which influenced the Nifty volatility. The reasons for increase in volatility could be the enhancement of Foreign Institutional Investors participation in the equity market. Another reason could be the turnover of NSE grew by 69% and also the retail investors' participation in securities markets has increased in the recent years.

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