A Study on the Volatility Effects of Listing of Equity Options and Equity Futures in National Stock Exchange of India

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Abstract

Ever since their introduction in various stock exchanges of the world, financial derivatives have been an interesting area of study, a major concern being their impact on the volatility of the underlying securities. Considering the phenomenal growth of the derivatives market in India together with the fact that studies around the world lack in consensus regarding the impact of futures and options on market volatility, an in-depth study of the Indian market was felt necessary. This study aimed to find out whether introduction of options and futures contracts had an effect on the volatility of the underlying equities. The results from the ARMA- GARCH models applied in the study proved that volatility of most of the underlying stocks decreased with the listing of equity options and futures.

Key words: volatility, ARMA, GARCH, equity options, equity futures, NSE

JEL Classification : G12, G14, G18

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Options and futures, the two most commonly traded derivatives were introduced in India in the year 2000 in both the major stock exchanges-Bombay Stock Exchange and National Stock Exchange Ltd. as a move to provide cost efficient hedging facility. Single stock futures contracts were introduced in November 2001 as a substitute for the carry forward system, considering better regulatory provisions for derivatives and options on individual securities were introduced in July 2001. Volatility is the relative rate at which the price of a security moves up and down. There are conflicting views on the impact of listing of options and futures on the underlying securities. A number of theoretical arguments are prevalent as to why options and futures might lead to an increase or decrease in volatility of the underlying asset. Aside from the different theoretical arguments, there is no dearth of empirical literature with regard to effect of derivatives introduction on the volatility of the underlying securities. Most of the studies conducted in the developed markets like U.S. and Europe found evidence of the stabilizing effect on the cash market returns with derivatives listing (Alexakis, 2007 ; Conrad 1989 ; Edwards, 1988). However, some studies reported an increase in market volatility (Harris, 1989 ; Zhong, Darrat, & Otero, 2004). Again, few did not find any significant effect of derivative listing (Spyrou, 2005). Inconsistency prevails even in the findings from the Asian markets.

Objective of the Study

With regard to the dichotomy in theoretical stabilizing/ destabilizing role of derivatives and the inconsistency in

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empirical findings together with the increasing business growth of derivatives in the Indian market, it is necessary to examine the effects of derivative introduction in the Indian context. Therefore, the present study intends to examine whether listing of equity options and equity futures affects the volatility of the underlying equities listed in the National Stock Exchange of India.

Hypothesis

Listing of equity options and equity futures contracts do not have a significant effect on the volatility of the underlying securities listed in the National Stock Exchange of India.

Data and Methodology

The securities on which equity options and futures were listed from the very beginning, that is, July 2001 till December 2011 were identified. However, to analyze the effects of derivatives listing, it is considered necessary to have at least 2 - years closing prices data prior to the date on which derivatives were listed on these securities. Securities with lesser data before the listing of options and futures contracts on these securities were dropped from the study. Equity options and futures listings only till December 2011 were considered so as to have enough post event time series data to draw reliable conclusions. Securities have to meet some eligibility criteria prescribed by SEBI to be continued in the Derivatives Segment. From time to time, securities that fail to meet these criteria are suspended from the Options and Futures Segment. The securities that were excluded from the derivatives segment at any point of time till December 2014 were not taken into account for analysis, that is, only those securities on which options and futures contracts were continuously available once these were introduced in NSE were considered in the study. Daily closing prices of each security from January 1, 1998 to December 31, 2014 were retrieved. If a stock was not listed in NSE in January 1998, data for that stock would commence from the date on which the security was first listed in NSE. So, data for each underlying security would commence from its date of listing on NSE or January 1, 1998, whichever is later. The historical share prices are adjusted for corporate actions like stock splits, bonus issue, and rights issue.

Thereafter, daily returns of each of the securities are computed. Log returns (Y_t) of the series for each security is calculated as :

$$Y_t = \log P_t - \log P_{t-1} \quad (1)$$

where,

P_t and P_{t-1} are the closing prices of the security for successive periods t-1 and t. Augmented Dickey Fuller (ADF) test for presence of unit root is conducted upto lag 12.

One of the most common ways to estimate return volatility is to calculate the sample standard deviation or variance of returns over a given time period. However, it was recognized that asset return volatility is time varying in nature and is not constant over time. Another unique feature of financial time series is that periods of wide swings in prices and periods of relative calm are clustered in time. According to Mandelbrot (1963), large changes tend to be followed by large changes, of either sign, and small changes tend to be followed by small changes. Autoregressive conditional heteroscedasticity (ARCH)/ generalized autoregressive conditional heteroscedasticity (GARCH) models take care of these unique characteristics of financial returns. The GARCH *(p,q)* model given by Bollerslev (1986) suggests that the conditional variance of returns is a linear function of lagged conditional variance and past squared error terms and can be expressed as :

$$R_t = X + \varepsilon_t \text{ where } \varepsilon_t|\psi_{t-1} \sim N(0,h_t) \quad (2)$$

$$h_t = \alpha_0 + \Sigma^{q}_{j=1}\, \alpha_j \varepsilon^2_{t-j} + \Sigma^{p}_{i=1}\, \beta_i\, h_{t-1} \quad (3)$$

where $p \geq 0, q > 0$, $\alpha_0 > 0$, $\alpha_j \geq 0, \beta_i \geq 0$

$i = 1,2,....p$
$j = 1,2,......q$

Equation (2) is the conditional mean equation and equation (3) is the conditional variance equation. R_t is the dependent variable that refers to the return calculated as the log returns of the closing price of the underlying securities at time t, and X is a set of independent variables, ψ_{t-1} is the information set available at time t -1, ε_t is the innovation of the series with variance h_t . The GARCH model starts with the specification of the conditional mean equation (Enders , 2010).

In order to take into account the market wide factors, S&P CNX Nifty log returns were incorporated in the conditional mean equation :

$$R_t = \theta + \delta\, \text{Nifty}_t + \varepsilon_t \quad (4)$$

An important property of time series data is the existence of correlation across observations (Koop, 2005). Therefore, besides the market wide factors, returns of a security R_t might be explained by its lagged return R_{t-i} .

$$R_t = \theta + \delta\, \text{Nifty}_t + \Sigma^{m}_{i=1}\, \varphi_i\, R_{t-i} + \varepsilon_t \quad (5)$$

Such a model, where the explanatory variables are lags of the dependent variable is called autoregressive (AR) model. Likewise,

$$R_t = \theta + \delta\, \text{Nifty}_t + \Sigma^{n}_{i=1} \Upsilon_{\text{i}}\, \varepsilon_{t-i} + \varepsilon_t \quad (6)$$

An MA process is simply a linear combination of white noise error terms. The series :

$$R_t = \theta + \delta\, \text{Nifty}_t + \Sigma^{m}_{i=1} \varphi_i R_{t-i} + \Sigma^{n}_{i=1} \Upsilon_{\text{i}}\, \varepsilon_{t-i} + \varepsilon_t \quad (7)$$

The residuals from the ARMA *(m,n)* model were verified for serial correlation to confirm the goodness of fit of the model. Breusch Godfrey Lagrange Multiplier test was used to test the significance of residual serial correlation. Equation (7) can be used to find the effects of derivatives introduction if there is no evidence of autoregressive conditional heteroskedasticity (ARCH) in the residuals. Therefore, ARCH Lagrange Multiplier test was conducted to look for autoregressive conditional heteroskedasticity in the residuals. Also, for robustness, the Ljung Box test on the squared residuals was applied to look into the ARCH effects. Significance of the LM test and Ljung Box test on the squared residuals implies the necessity of use of ARCH/GARCH models. The GARCH (1,1) specification can be used to describe the volatility dynamics of almost any financial return series, both in developed as well as emerging markets (Engle, 2004) and the same has been used to describe the volatility dynamics of the underlying securities in the study. The conditional variance in GARCH (1,1) process is given by :

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1\, h_{t-1} \quad (8)$$

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

h_t is the conditional variance in period t, α_1 represents the short run persistence of shock, and β_1 represents the contribution of older shocks on return variance. If GARCH (1,1) is found to be a poor fit as per the goodness of fit tests, the higher order GARCH model or ARCH*(q)* is applied. The conditional variance in ARCH *(q)* process is given by :

$$h_t = \alpha_0 + \Sigma^q_{j=1}\alpha_j\varepsilon^2_{t-j} \quad (9)$$

To determine whether the conditional volatility of the stock returns has been affected by the introduction of options and futures, a dummy variable *D* is introduced in the conditional variance equation. The dummy takes the value of 0 (zero) prior to listing of derivative contracts and 1(one) after these derivative contracts are introduced. The conditional variance equation is thus specified as :

$$h_t = \alpha_0 + \Sigma^q_{j=1}\alpha_j\,\varepsilon^2_{t-j} + \Sigma^p_{i=1}\beta_i h_{t-i} + \lambda D \quad (10)$$

or

$$h_t = \alpha_0 + \Sigma^q_{j=1}\alpha_j\varepsilon^2_{t-j} + \lambda D \quad (11)$$

depending on whether GARCH *(p,q)* or ARCH*(q)* model is used.

If the coefficient of the dummy variable λ is found to be significant, it can be concluded that initiating derivative trading in the market has had an impact on the volatility of the underlying securities. If λ is found to be negative and significant, it can be said that volatility has decreased post derivative introduction, and if λ is found to be positive and significant, it can be concluded that volatility has increased with the introduction of equity options and futures.

When equity derivatives were introduced for the first time in NSE in 2001, equity options were listed on July 2, 2001 and equity futures on the same securities were listed on November 9, 2001. For these stocks, to separate the effects of options and futures, two dummy variables were specified, one to account for the effects of equity options listing and the other to account for the effects of equity futures introduction. Thus, Equations (10) and (11) take the following forms, respectively if the stocks had derivatives listed on them in 2001.

$$h_t = \alpha_0 + \Sigma^q_{j=1}\alpha_j\varepsilon^2_{t-j} + \Sigma^p_{i=1}\beta_i h_{t-i} + \lambda_0 DO_t + \lambda_1 DF_t \quad (12)$$

Or

$$h_t = \alpha_0 + \Sigma^q_{j=1}\alpha_j\varepsilon^2_{t-j} + \lambda_0 DO_t + \lambda_1 DF_t \quad (13)$$

The dummy variables DO_t and DF_t take the value of 0 (zero) prior to listing of equity options and equity futures , respectively and 1(one) after their introduction.

Some diagnostics tests were conducted to verify if the model specified is good fit for the return series. The squared residuals of the estimated models should not be serially correlated, and there should not remain any ARCH effects in the residuals. For this, the Ljung Box test was conducted on the squared residual series and the ARCH Lagrange Multiplier test was also applied.

Findings and Discussion

On the basis of the criteria prescribed above, 83 stocks were identified for analysis. Daily closing prices of each security from January 1, 1998 to December 31, 2014 were retrieved and adjusted for corporate actions. Returns of the securities were computed through log transformation. Descriptive statistics, that is, mean, standard deviation, skewness and kurtosis of the 83 log return series are reported in the Table 1. The return series depict fat tails, as is evident from the kurtosis, exceeding 3 in all the cases. This is in confirmation to the widely documented findings

Table 1. Summary Statistics, Test Statistics for Shapiro Francia Test for Normality, and Augmented Dickey Fuller Test of the Log Returns of Securities Identified for GARCH Analysis

Sl No	Securities	Mean	Std Deviation	Skewness	Kurtosis	W' #	ADF ^
1	ACC	5.43E-04	0.0254388	-0.1483053	6.478152	0.95544*	-46.62724 * (1)
2	ADANIENT	0.0009907	0.0323588	0.131313	9.186175	0.91433*	-17.7549 * (9)
3	ADANIPORTS	0.000287	0.0297675	0.2717088	7.349278	0.95484*	-16.64966 * (6)
4	ALBK	0.0008526	0.0279302	-0.0007085	6.980137	0.96033*	-24.7181 * (4)
5	AMBUJACEM	5.92E-04	0.024469	0.0738352	5.506435	0.96784*	-48.40553 * (1)
6	ANDHRABANK	6.90E-04	0.0270938	-0.0134564	7.541756	0.95191*	-40.50993 * (1)
7	APOLLOTYRE	7.82E-04	0.0318922	0.2894359	7.575889	0.95146*	-28.39076 * (4)
8	ASHOKLEY	0.0007618	0.0315307	0.1974565	5.817647	0.96789*	-45.3857 * (1)
9	ASIANPAINT	9.61E-04	0.0183796	0.2343687	7.690233	0.93617*	-29.15156 * (4)
10	AUROPHARMA	1.43E-03	0.0318084	-0.0446681	7.15257	0.94646*	-16.41509 * (12)
11	AXISBANK	1.24E-03	0.0307036	0.4621311	8.041253	0.94463*	-18.40762 * (10)
12	BANKBARODA	5.36E-04	0.0294819	0.0533376	7.176979	0.9594*	-19.51627 * (1)
13	BANKINDIA	0.0004735	0.0313464	0.1380414	5.871801	0.96863*	-19.39783 * (11)
14	BHARATFORG	1.01E-03	0.0295388	0.2167327	6.077239	0.95792*	-28.3787 * (4)
15	BHARTIARTL	0.0008616	0.0252629	0.4425015	7.466232	0.9611*	-35.43867 * (2)
16	BHEL	4.76E-04	0.0283104	-0.1270946	7.038013	0.95883*	-24.71407 * (6)
17	BIOCON	0.000211	0.0235703	0.4427802	11.17838	0.9167*	-15.074 * (10)
18	BPCL	4.30E-04	0.028474	0.0669742	6.207046	0.9652*	-29.5445 * (4)
19	CENTURYTEX	4.69E-04	0.035316	0.0348648	5.452319	0.97392*	-27.17144 * (4)
20	CESC	7.08E-04	0.031829	0.5099587	6.693159	0.95346*	-28.6515 * (4)
21	CIPLA	8.51E-04	0.0224828	-0.0229682	6.928636	0.9445*	-28.54677 * (5)
22	CROMPGREAV	1.01E-03	0.0341925	0.2075035	5.432562	0.97031*	-46.96157 * (1)
23	DABUR	0.0009834	0.0242572	0.1454597	7.556535	0.93952*	-19.21852 * (11)
24	DIVISLAB	1.56E-03	0.0251328	0.3398943	7.17393	0.94091*	-23.5862 * (4)
25	DRREDDY	8.69E-04	0.0239718	-0.0400264	8.013233	0.93223*	-47.34301 * (1)
26	EXIDEIND	0.0008076	0.0267141	0.4294446	6.595566	0.95506*	-33.53292 * (3)
27	FEDERAKBNK	9.30E-04	0.0294076	0.1494652	7.757657	0.94561*	-18.51998 * (9)
28	GAIL	4.24E-04	0.0248169	0.0082434	13.25955	0.92361*	-19.92999 * (11)
29	GODREJIND	1.61E-03	0.0332568	0.7612344	7.853756	0.93581*	-27.56249 * (2)
30	HCLTECH	0.0003782	0.0331094	-0.3679397	7.941329	0.93378*	-25.17898 * (6)
31	HDFC	8.43E-04	0.0241711	0.3433467	7.365769	0.95163*	-29.43677 * (6)
32	HDFCBANK	9.60E-04	0.0235514	0.2809256	9.963675	0.93307*	-28.83451 * (5)
33	HEROMOTOCO	8.25E-04	0.0240461	0.3984485	8.165126	0.95466*	-41.43276 * (2)
34	HEXAWARE	0.0010257	0.034078	1.356882	22.66331	0.89856*	-20.89567 * (6)
35	HINDLACO	1.74E-04	0.0273525	-0.0813561	6.331147	0.9645*	-20.17022 * (10)
36	HINDPETRO	2.72E-05	0.0290481	-0.536523	15.20612	0.93343*	-30.0924 * (4)
37	HINDUNILVR	3.98E-04	0.0201831	0.2625263	7.393854	0.95465*	-27.13088 * (6)
38	ICICIBANK	8.74E-04	0.0304762	0.0752165	6.843908	0.95236*	-28.44944 * (5)
39	IDBI	-5.77E-05	0.0325734	-0.4201494	15.73303	0.91795*	-18.86056 * (10)

40	IFCI	3.05E-05	0.0401226	0.4682081	8.663608	0.91662*	-28.8385 * (4)
41	IGL	0.0004864	0.0250344	-1.062684	38.95882	0.84793*	-22.92252 * (6)
42	INDIACEM	4.15E-05	0.0342994	0.1200515	5.591213	0.96698*	-47.39128 * (1)
43	INFY	1.09E-03	0.0271304	-0.5138671	12.04821	0.91371*	-18.99897 * (10)
44	IOB	5.24E-04	0.0283431	-0.0844322	7.340714	0.95656*	-41.11533 * (1)
45	IOC	0.0002511	0.0246203	0.1748796	9.053695	0.93318*	-26.99961 * (5)
46	ITC	6.76E-04	0.0211629	0.0429253	6.177258	0.95515*	-47.87572 * (1)
47	JINDALSTEL	1.07E-03	0.0331726	0.0457009	8.580846	0.94442*	-19.45649 * (10
48	JISLJALEQS	0.001052	0.0327954	0.2507462	5.500344	0.97029*	-17.51805 * (10)
49	JPASSOCIAT	0.0001954	0.0385171	-0.4617788	7.89144	0.95769*	-36.35262 * (1)
50	KOTAKBANK	0.0017926	0.0337976	0.4391488	8.215656	0.9308*	-26.09486 * (5)
51	LICHSGFIN	0.0006191	0.0302902	0.3277652	7.783105	0.94663*	-19.92374 * (11)
52	LT	9.70E-04	0.0290913	0.2698089	9.263235	0.93444*	-36.36367 * (1)
53	KTKBANK	0.0010096	0.0241453	0.3628434	7.153691	0.96659*	-18.19745 * (10)
54	LUPIN	0.0016206	0.0243952	1.070733	17.68835	0.9187*	-24.71256 * (5)
55	M&M	6.42E-04	0.027847	0.0352429	7.03962	0.9592*	-30.5558* (4)
56	MCLEODRUSS	6.59E-04	0.0318695	0.5554848	7.674439	0.94252*	-16.93945 * (6)
57	NMDC	-0.0005503	0.0287171	0.864549	8.720832	0.92408*	-13.634 * (7)
58	ONGC	4.65E-04	0.02477	0.1764147	7.300832	0.95276*	-19.63441 * (10)
59	ORIENTBANK	3.91E-04	0.0289262	-0.0948529	8.168113	0.9592*	-21.10394 * (8)
60	PETRONET	9.90E-04	0.026842	0.2557603	12.23799	0.91064*	-30.91008 * (2)
61	PTC	0.0002792	0.0293451	0.323629	7.743454	0.94602*	-26.64312 * (3)
62	RANBAXY	4.10E-04	0.0268987	-0.5936753	17.40483	0.90526*	-28.3445 * (4)
63	RELCAPITAL	4.84E-04	0.0349806	-0.0213546	6.597965	0.95976*	-35.32749 * (2)
64	SAIL	4.73E-04	0.0362707	0.5644355	10.28952	0.91653*	-19.12743 * (9)
65	SBIN	5.98E-04	0.0247464	0.0373243	5.961666	0.96991*	-20.75354 * (8)
66	SESAGOA	8.11E-04	0.034053	0.2706992	5.600856	0.96965*	-19.72071 * (8)
67	SIEMENS	8.91E-04	0.0271476	0.1021432	6.676592	0.94957*	-19.306 * (10)
68	SRTRANSFIN	1.17E-03	0.0536072	0.1508094	23.16648	0.73236*	-18.52761 * (12)
69	SUNPHARMA	1.42E-03	0.0255718	0.2132943	6.919168	0.93971*	-20.42539 * (11)
70	SYNDIBANK	6.24E-04	0.0282166	0.0882661	8.936731	0.9383*	-29.40385 * (3)
71	TATACHEM	2.52E-04	0.0258258	-0.0529255	7.099856	0.94607*	-18.92954 * (11)
72	TATAGLOBAL	2.97E-04	0.0240531	0.1901283	6.01054	0.96022*	-46.82435 * (1)
73	TATAMOTORS	4.97E-04	0.0296876	-0.1018663	5.479503	0.97466*	-19.03519 * (9)
74	TATAPOWER	4.73E-04	0.0266794	-0.0711865	8.946318	0.93988*	-20.18507 * (10
75	TATASTEEL	3.50E-04	0.0289591	-0.1772374	5.73894	0.96995*	-19.63218 * (8)
76	TITAN	1.11E-03	0.032525	0.4102418	6.449112	0.95647*	-46.68972 * (1)
77	UCOBANK	5.22E-04	0.0293351	0.3870059	7.163309	0.9468*	-23.7651 * (4)
78	ULTRACEMCO	0.0009047	0.0222479	0.2795477	5.950641	0.96159*	-21.78188 * (4)
79	UPL	8.91E-04	0.0390378	-1.062697	28.73705	0.92197*	-19.14335 * (7)
80	UNITECH	0.0006735	0.0272311	0.3358285	9.025015	0.94943*	-19.74605 * (8)
81	VOLTAS	1.04E-03	0.0326125	0.4301571	5.704821	0.96521*	-19.09117 * (9)

82	WIPRO	9.62E-04	0.0310206	-0.0991058	8.212276	0.92839*	-16.30069 * (10)
83	YESBANK	0.0011359	0.0329669	-3.554226	88.30104	0.82515*	-27.46427 * (3)

Shapiro Francia test statistic for normality

^ Augmented Dickey Fuller test statistic for unit root at lag 12

*Statistically significance at 1% level

Figures in parenthesis under the ADF column indicates the lag chosen on the basis of AIC at which the ADF test statistic is reported.

of Mandelbrot (1963) and Fama (1965) that financial returns follow a leptokurtic distribution that is characterized by fat tails and a narrow peak around the mean when compared with normal distribution.

The Shapiro Francia test for normality is conducted. The hypothesis that the return series is normally distributed is rejected at the 1% significance level in all the 83 cases analyzed. The test statistic W' is reported in Table 1. The Augmented Dickey Fuller (ADF) test was conducted upto lag 12 to test for stationarity. The ADF test statistics for the 83 securities are reported at the chosen lag based on Akaike Information Criteria (AIC). The test statistics along with the lag in parenthesis are reported in Table 1. The null hypothesis of presence of unit root is rejected at the 1% significance level in each of the return series of the 83 securities.

The regression models with autoregressive (AR) terms and moving average (MA) terms (where necessary) are specified for the mean equation of the 83 return series. To verify the goodness of fit of the models, Breusch Godfrey LM test was applied to test for serial correlation in the residuals. The presence of ARCH effect is detected in all the 83 series through the Ljung Box test and ARCH LM test. This necessitates the use of ARCH/GARCH type models to capture the volatility dynamics. For most of the return series, GARCH (1,1) specification, that is,

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 h_{t-1} + \lambda D_t \quad (14)$$

was found to be a good fit. In GARCH (1,1) it is important to ensure that $\alpha_0 > 0$, $\alpha_1 \geq 0$, $\beta_1 \geq 0$. Also, the model is covariance stationary only if $\alpha_1 + \beta_1 < 1$. If the model is able to capture the time varying volatility, there should not be serial correlation in squared residuals of the model. Ljung Box test was conducted to test for serial correlation in the squared residuals and ARCH LM test was conducted to ensure that there is no presence of ARCH effects in the squared residuals. If GARCH (1,1) is found to be inadequate, GARCH (2,1), that is :

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 h_{t-1} + \beta_2 h_{t-2} + \lambda D_t \quad (15)$$

is used to model the return series. In case of the security SUNPHARMA, GARCH(3,1) was applied :

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 h_{t-1} + \beta_2 h_{t-2} + \beta_3 h_{t-3} + \lambda D_t \quad (16)$$

For AXISBANK return series, ARCH(9) model is used that is expressed as :

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \varepsilon^2_{t-2} + \alpha_3 \varepsilon^2_{t-3} + \alpha_4 \varepsilon^2_{t-4} + \alpha_5 \varepsilon^2_{t-5} + \alpha_6 \varepsilon^2_{t-6} + \alpha_7 \varepsilon^2_{t-7} + \alpha 8_8 \varepsilon^2_{t-8} + \alpha_9 \varepsilon^2_{t-9} + \lambda D_t \quad (17)$$

For KOTAKBANK return series, the ARCH(5) model is used :

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \varepsilon^2_{t-2} + \alpha_3 \varepsilon^2_{t-3} + \alpha_4 \varepsilon^2_{t-4} + \alpha_5 \varepsilon^2_{t-5} + \lambda D_t \quad (18)$$

If the volatility of a return series could be explained by both a higher order GARCH model like GARCH (2,1) and ARCH*(q)* model, Akaike Information Criteria was used to make the model selection.

For the sake of brevity, the coefficients of ARMA equations, the ACFs and PACFs, the coefficients of the mean equation, the results of the diagnostics tests of the 83 series are not shown in this paper. Only the coefficients of the

Table 2. Coefficients of GARCH (p,q) Variance Equation and the Dummy Variables

$$h_t = \alpha_0 + \Sigma^{q}_{j=1}\alpha_j\varepsilon^2_{t-j} + \Sigma^{p}_{i=1}\beta_i h_{t-i} + \lambda D/ \quad h_t = \alpha_0 + \Sigma^{q}_{j=1}\alpha_j\varepsilon^2_{t-j} + \Sigma^{p}_{i=1}\beta_i h_{t-i} + \lambda_0 DO_t + \lambda_1 DF_t$$

Sl No©	α_0	α_1	β_1	β_2	β_3	λ	λ_0	λ_1
1	5.83E-05*	0.104385*	0.857596*				-2.62E-05**	-1.40E-05ˆ
2	0.000142*	0.238691*	0.62441*			2.71E-05*		
3	0.000206*	0.101114*	0.759296*			-0.00012*		
4	6.75E-05*	0.127383*	7.90E-01*			-1.82E-05*		
5	2.91E-05*	0.058988*	0.903614*				-1.48E-05*	-3.01E-07ˆ
6	6.19E-05*	0.147723*	0.76396*			-7.50E-06**		
7	1.66E-05*	0.051195*	0.930698*			3.64E-06*		
8	2.05E-05*	0.061955*	0.468545*	0.451138*		-8.94E-06*		
9	2.69E-05*	0.141986*	0.409822*	0.362353*		2.31E-06ˆ		
10	3.05E-05*	0.11502*	0.859658*			-4.36E-07ˆ		
12	3.78E-05*	0.091768*	0.471087*	0.392833*		-1.28E-05*		
13	6.65E-05*	0.124232*	0.78743*			1.69E-06ˆ		
14	9.50E-06 *	0.070045 *	0.572412 *	0.346715 *		-2.17E-06 *		
15	0.000111*	0.126281*	0.761943*			-5.15E-05*		
16	2.34E-05*	0.073067*	0.910072*				7.15E-06ˆ	-2.31E-05*
17	9.37E-06*	0.047652*	0.920567*			6.73E-06*		
18	2.39E-05*	0.055099*	0.926482*				-3.06E-06ˆ	-8.04E-06ˆ
19	3.21E-05*	0.070116*	0.905372*			-1.65E-05*		
20	0.000146*	0.103553*	0.78252*			-8.10E-05*		
21	7.40E-05*	0.09183*	0.799563*				2.33E-06ˆ	-4.08E-05*
22	0.000119*	0.13979*	0.229793*	0.518881*		-3.16E-05*		
23	3.87E-05*	0.123499*	0.205953*	0.608046*		-1.40E-05*		
24	7.83E-07*	0.030605*	0.030910*	0.934029*		1.07E-06ˆ		
25	9.30E-06*	0.032763*	0.956867*				2.89E-06ˆ	-8.19E-06**
26	9.37E-05*	0.137006*	0.747355*			-3.62E-05*		
27	9.41E-05*	0.136174*	0.784257*			-4.41E-05*		
28	2.54E-05*	0.120108*	0.844589*			-4.28E-06**		
29	0.000145*	0.116174*	0.777741*			-8.34E-05*		
30	4.03E-05*	0.082367*	0.897857*			-2.91E-05*		
31	2.03E-05*	0.086315*	0.88121*				-5.78E-06ˆ	-2.02E-06ˆ
32	2.71E-05*	0.120785*	0.392288*	0.440113*		-1.22E-05*		
33	8.09E-05*	0.124993*	0.508663*	0.248685*		-3.27E-05*		
34	8.27E-05*	0.061327*	0.883949*			-4.37E-05*		
35	1.99E-05*	0.067047*	0.90991*				-5.45E-06ˆ	-2.82E-06ˆ
36	4.34E-05*	0.072323*	0.897928*				-1.44E-05ˆ	-7.74E-06ˆ
37	5.15E-05*	0.14172*	0.440869*	0.288279*			-3.26E-06ˆ	-1.01E-05ˆ
38	4.09E-05*	0.106079*	0.85435*			-2.24E-05*		
39	0.000177*	0.119594*	0.730802*			-8.98E-05*		
40	9.39E-05*	0.118599*	0.818930*			-8.21E-06**		

41	0.000125*	0.318086*	0.525149*			-2.87E-05*		
42	3.04E-05*	0.074094*	0.897347*			-6.40E-06*		
43	6.29E-05*	0.141608*	0.796967*				1.68E-06^	-3.28E-05^
44	3.95E-05*	0.097954*	0.840789*			1.52E-06^		
45	3.34E-05*	0.194989*	0.407457*	0.361855*		-6.01E-06**		
46	2.34E-05*	0.063983*	0.884105*				1.46E-05**	-2.38E-05*
47	1.63E-05*	0.084704*	0.904571*			-6.70E-06*		
48	7.71E-05*	0.120225*	0.818493*			-1.98E-05*		
49	1.49E-05*	0.071443*	0.917959*			-1.62E-06^		
51	2.99E-05*	0.100656*	0.855509*			5.06E-08*		
52	1.57E-05*	0.103705*	0.867309*			9.73E-07^		
53	0.000139*	0.140161*	0.739566*			-3.82E-05^		
54	2.46E-05*	0.11015*	0.864095*			-1.16E-05*		
55	2.84E-05*	0.065482*	0.906538*				1.32E-06*	-1.88E-05*
56	5.75E-05*	0.075911*	0.876*			-3.27E-05*		
57	2.80E-05*	0.126687*	0.846103*			-8.62E-06*		
58	3.00E-05*	0.134543*	0.417575*	0.420058*		-1.40E-05*		
59	2.07E-05*	0.115839*	0.845527*			1.22E-05*		
60	7.08E-05*	0.121932*	0.775558*			-1.65E-05*		
61	0.000123*	0.174535*	0.662924*			-5.62E-06^		
62	1.55E-05*	0.091748*	0.891518*				3.80E-06^	-7.60E-06^
63	1.17E-05*	0.073571*	0.909448*			4.68E-06*		
64	3.74E-05*	0.130888*	0.169295*	0.669257*		-1.35E-05*		
65	1.18E-05*	0.068885*	0.90376*				1.19E-06^	-3.32E-06^
66	0.000103*	0.170542*	0.449431*	0.313182*		-3.80E-05*		
67	2.37E-05*	0.083658*	0.877817*			-2.10E-06^		
68	4.41E-05*	0.138067*	0.847691*			-2.36E-05*		
69	2.90E-05*	0.191226*	0.113356*	0.372354*	0.285389*	-7.99E-06*		
70	1.74E-05*	0.066934*	0.898505*			6.55E-06*		
71	1.62E-05*	0.057212*	0.916789*			-6.09E-06*		
72	2.17E-05*	0.073612*	0.894428*				1.20E-05^	-2.05E-05*
73	2.19E-05*	0.066719*	0.576253*	0.338567*			1.12E-05^	-2.50E-05^
74	1.56E-05*	0.089464*	0.891589*				2.81E-05*	-3.46E-05*
75	1.19E-05*	0.064831*	0.920968*			-5.09E-06*		
76	0.000134*	0.119863*	0.794832*			-6.98E-05*		
77	1.49E-05*	0.037311*	0.940691*			-2.22E-07^		
78	1.09E-05*	0.044755*	0.937675*			-3.55E-06*		
79	9.15E-05*	0.135085*	0.70082*			1.66E-05*		
80	6.67E-05*	0.107071*	0.838522*			3.14E-05*		
81	1.42E-05*	0.054863*	0.932648*			-1.30E-06^		
82	8.83E-05*	0.164133*	0.793596*			-5.90E-05*		
83	2.79E-05*	0.094112*	0.867976*			-8.34E-07^		

λ indicates the coefficient of the dummy variable for equity options and futures introduction.
λ_0 indicates the coefficient of the dummy variable for equity options introduction.
λ_1 indicates the coefficient of the dummy variable for equity futures introduction.
©Sl no indicates the Serial number of the securities as in Table 1.
*Statistically significant at the 1% level
**Statistically significant at the 5% level
ˆStatistically not significant

Table 3. Coefficients of ARCH(q) Variance Equation and the Dummy Variable

$$h_t = \alpha_0 + \Sigma^q_{j=1} \alpha_j \varepsilon^2_{t-j} + \lambda D$$

Sl no©	α_0	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	α_9	λ
11	4.15E-04*	0.216742*	0.099096*	0.053666*	0.029575**	0.047738*	0.05*	0.034031*	0.033754*	0.034789*	-1.83E-04*
50	0.00055*	0.243781*	0.130959*	0.104833*	0.162399*	0.07303*					-0.00033*

λ indicates the coefficient of the dummy variable for equity options and futures introduction
©Sl no indicates the Serial number of the securities as in Table 1
*Statistically significant at 1% level
**Statistically significant at 5% level

GARCH conditional variance equation along with the dummy variables of all the 83 securities are reported in the Table 2. The coefficients of ARCH*(q)* variance equation are reported in the Table 3. Since for the year 2001, equity options introduction and equity futures on the same securities were introduced in different dates, two dummy variables were introduced, one to account for the effects of equity options and the other to account for the effects of equity futures introduction. The results are mixed for these securities with the coefficients of the dummy variables not being statically significant in most of the cases. In 13 out of 18 securities, the coefficient of the dummy variable for option introduction in 2001 was found to be insignificant, which implies that options introduction did not have a significant effect on the volatility of the underlyings. The coefficient of dummy variable for futures introduction is found to be significant and negative for seven securities, which reveals that equity futures have led to a significant decrease in the volatility of the underlying securities. For derivative listings other than 2001, that is, in 65 out of the 83 securities, only one dummy variable is specified to account for the effects of both options and futures listings. In these securities, the dummy variable is significant in 52 cases. There are eight securities in which introduction of equity options and futures has led to a significant increase in volatility of the underlying stocks, and there are 44 securities where evidence of significant decrease in volatility is found with the introduction of equity futures and options.

Considering the fact that majority of the securities exhibit decrease in volatility with listing of equity futures and equity options, we reject the null hypothesis, and it is inferred that introduction of equity options and equity futures contracts leads a to significant decrease in volatility of the underlying stocks.

Research Implications

At the National Stock Exchange, equity futures turned out to be the most popular product amongst equity derivatives and maintained a dominant position till 2007-08. The press, however, was not kind to this particular product, given its limited circulation in other parts of the world, and the chances of manipulation of futures prices by unscrupulous speculators. Though the worldwide scenario has changed greatly with equity futures introduced in many countries and no debacle in India unveiled in these products in the last 15 years, the success of equity futures in India is still looked upon with scepticism.

Hukeri (2007) compared the worldwide scenario where options accounted for 61% of the total trading volume in derivatives in 2005 with the Indian market, where futures accounted for 86% of the total trading volume in equity derivatives and suggested that the ideal situation would be to ban these products. However, at present, the scenario is much different with index options dominating the equity derivatives market in India. Besides, from time to time, SEBI has refined upon the eligibility criteria to be met for listing of securities in the derivative segment. For instance, the tightening of eligibility norms vide SEBI circular no CIR/DNPD/3/2012 dated July 23, 2012 led to the exclusion of 51 securities from the Derivative segment of NSE. The results from the present study are also reassuring and do not give away any evidence of market instability owing to the introduction of equity futures and options.

The results from the study also conform to previous studies in the Indian market by Sahu (2012), where he found that 90% of the underlying scrips exhibited a decrease in volatility with the introduction of equity derivatives ; Nath (2003) found the volatility of most of the stocks to decrease after listing of equity and equity index derivatives. Nevertheless, enforcing physical delivery of securities would do away with much of the anxiousness associated with derivatives on individual equities, and considering that it has been over a decade and a half that the Indian stock exchanges have been dealing with equity derivatives, it is felt that these exchanges have come of age to achieve physical delivery of derivative contracts successfully.

Conclusion

The importance of the study stems from rapid growth of derivatives all over the world, which poses some major challenges for the regulators and policy makers. One of these is the increase in market volatility. For framing rules related to the derivatives market and to curb its negative effects, the knowledge about its impact on the underlying market is of utmost necessity. At NSE, the turnover from the derivative segment has long surpassed the equity market turnover. Furthermore, NSE is ranked among the top derivative exchanges in the world when it comes to stock futures and index options. ARMA-GARCH (p,q) model is used to determine whether listing of equity options and futures has led to an increase in volatility of the underlying securities in the NSE. A number of goodness of fit tests were conducted to ensure adequacy of the models used. High persistence is noted in all the securities as evident from the sum of α_j and β_i being very close to 1. This is a very common phenomenon observed in daily return series. Though there are few securities that displayed an increase in volatility with the introduction of equity options and futures, most of the securities experienced a decrease in volatility with listing of stock options and futures. Therefore, the study does not find any evidence of derivatives leading to market instability.

Limitations of the Study and Scope for Further Research

There are several other aspects of market quality like liquidity, efficiency, and price of the underlying asset. This study also ignores the effects of derivatives on the volume and price of the underlying securities. There are several other extensions of the GARCH model like APARCH, IGARCH, GARCH-M, EGARCH, GJR-GARCH, FI-GARCH, and so forth. However, the present study has chosen GARCH (p,q)/ ARCH (q) and did not consider other models to maintain a consistency across the 83 return series.

Volatility in financial time series is a mystical phenomenon which has always attracted lots of attention with numerous models designed to capture its characteristics, though the exact reasons for volatility are not yet unveiled. The most convincing reason seems that volatility occurs mainly due to arrival of news and is a natural consequence of trading. A number of fascinating studies can be undertaken in the Indian context. There are vast variants of the GARCH model. It would be a productive exercise to apply these models to the Nifty or/and Sensex and find out which of these models gives a more accurate forecast of the indices. Though there are studies that have been undertaken on the volatility effects of index derivatives on the respective underlying index ; yet, it would be worthwhile to carry out a study with an increased number of observations. There is much enthusiasm generated by artificial neural networks. Determining the predictive accuracy of stock return volatility of the various artificial neural network models vis-a-vis GARCH models would throw new light on the behaviour of financial time series.

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