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RESEARCH ARTICLE

EXAMINATION OF GARCH MODEL FOR DETERMINANTS OF INFOSYS STOCK RETURNS

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ABSTRACT

The research on asset volatility in financial market is the foundation of finance. To measure and predict asset volatility accurately, Bollerslev built a generalised ARCH (GARCH) model based on the ARCH model. The GARCH process is often preferred by financial modeling professionals because it provides a more real-world context than other forms when trying to predict the prices and returns of financial instruments. It is the general process for a GARCH model involves three steps. The first is to estimate a best-fitting autoregressive model; secondly, compute autocorrelations of the error term and lastly, test for significance. The objective of the study is to GARCH (1,1) model for the volatility of Infosys stock returns and factors influencing the volatility in the returns of Infosys stock returns. The study covers monthly data ranging from Sept. 2009 to Nov.2015 having 98 observations. The empirical investigation considers returns of closing prices of all variables namely Infosys Stock Return as dependent and S&P CNX Nifty and Dow Jones Industrial Average as independent variables. Data for all variables are collected from the official websites of nseindia.com and yahoofinance.com. E-Views is used to analyze the data. It is concluded that despite there is a weakness of this student's t distribution model about its non-normality of residuals, many suggest that non-normality in the residuals may not be that serious problem for estimation. Hence this model will be used for forecasting.

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INTRODUCTION

The research on asset volatility in financial market is the foundation of finance, such as capital assets pricing, financial derivatives pricing, and financial risk measurement. The premise of quantitative financial analysis is to accurately measure and predict asset quality. Therefore, the measurement and prediction of asset volatility are a hotspot of research all the time. To measure and predict asset volatility accurately, Bollerslev built a generalised ARCH (GARCH) model based on the ARCH model. Then, GARCH model was extended. The GARCH process is often preferred by financial modelling professionals because it provides a more real-world context than other forms when trying to predict the prices and returns of financial instruments. It is the general process for a GARCH model involves three steps. The first is to estimate a best-fitting autoregressive model; secondly, compute autocorrelations of the error term and lastly, test for significance.

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Admittedly, GARCH- type models have fairly strong predictive power, but there is a room for improvement, as the accuracy pursuit for future volatility prediction is endless in financial operation such as capital assets pricing, financial derivatives pricing, and financial risk measurement. Therefore, it is necessary to improve the predictive power of the models.

Objectives

To study GARCH (1,1) model for the volatility of Infosys stock returns and factors influencing the volatility in the returns of Infosys stock returns.

Data and Methodology

The empirical investigation was carried out based on monthly data ranging from Sept. 2009 to Nov.2015 which covers 98 observations. The study has selected two stock indices variables namely S&P CNX Nifty and Dow Jones Industrial Average which may have influence on the Infosys stock Returns.
The empirical investigation considers returns of closing prices of all variables. Infosys Stock Return as dependent variable of Indian stock market. Data for all variables are collected from

the official websites of nseindia.com and yahoofinance.com. E-Views is used to analyze the data.

Hypothesis Testing

The hypotheses of this research are given below:

H01: There is unit root of Infosys Stock Returns, S&P CNX Nifty Returns and Dow Jones Industrial Average Returns.
H02: There is no ARCH Effect.
H03: The residuals/ Error Term of Infosys Stock Returns are normally distributed.
H04: The residuals of Infosys Stock Returns are not serially correlated.
H05: The residuals of Infosys Stock Returns have no ARCH effect.

Unit Root Test

The foundation of time series analysis is stationarity. A stationary process is a stochastic process whose joint probability distribution does not change when shifted in time or space. If the variable is not stationary, we can obtain a high regression although there is no meaningful relation between variables i.e. spurious regression between totally unrelated variables. Therefore before estimating regression augmented Dickey Fuller test (Hamilton, J., 1994) was conducted to check the stationarity of the data. The test for a unit root is conducted on the coefficient of y_{t-1} in the regression. Where Y_t is the variable in period t, T denotes a time trend, is the difference operator, et is pure white noise error term disturbance with mean zero and variance deviation 2, k represents the no. of lags of the differences in the ADF equation and $Y_{t1} = (Y_{t-1} - Y_{t-2})$.

GARCH

If an autoregressive moving average model (ARMA model) is assumed for the error variance, the model is a generalized autoregressive conditional heteroskedasticity (GARCH), Bollerslev (1986)) model. In that case, the GARCH (*p*, *q*) model (where *p* is the order of the GARCH terms σ^2 and *q* is the order of the ARCH terms ϵ^2), following the notation of original paper is given by

$$y_t = x_t'b + \epsilon_t$$
$$\epsilon_t|\psi_t \sim \mathcal{N}(0,\sigma_t^2)$$
$$\sigma_t^2 = \omega + \alpha_1\epsilon_{t-1}^2 + \cdots + \alpha_q\epsilon_{t-q}^2 + \beta_1\sigma_{t-1}^2 + \cdots + \beta_p\sigma_{t-p}^2 = \omega + \sum_{i=1}^{q}\alpha_i\epsilon_{t-i}^2 + \sum_{i=1}^{p}\beta_i\sigma_{t-i}^2$$

Generally, when testing for heteroskedasticity in econometric models, the best test is the White test. However, when dealing with time series data, this means to test for ARCH errors (as described above) and GARCH errors (below). Exponentially weighted moving average (EWMA) is an alternative model in a separate class of exponential smoothing models. It can be an alternative to GARCH modeling as it has some attractive properties such as a greater weight upon more recent observations but also some drawbacks such as an arbitrary decay factor that introduce subjectivity into the estimation.
GARCH (p, q) model specification

The lag length *p* of a GARCH (*p*, *q*) process is established in three steps:

- Estimate the best fitting AR(*q*) model

$$y_t = a_0 + a_1y_{t-1} + \cdots + a_qy_{t-q} + \epsilon_t = a_0 + \sum_{i=1}^{q} a_iy_{t-i} + \epsilon_t$$

- Compute and plot the autocorrelations of ϵ^2 by

$$\rho = \frac{\sum_{t-i+1}^{T}(\hat{\epsilon}_t^2 - \hat{\sigma}_t^2)(\hat{\epsilon}_{t-1}^2 - \hat{\sigma}_{t-1}^2)}{\sum_{t=1}^{T}(\hat{\epsilon}_t^2 - \hat{\sigma}_t^2)^2}$$

- The asymptotic, that is for large samples, standard deviation of $\rho(i)$ is $1/\sqrt{T}$. Individual values that are larger than this indicate GARCH errors. To estimate the total number of lags, use the Ljung-Box test until the value of these are less than, say, 10% significant. The Ljung-Box Q-statistic follows χ^2 distribution with *n* degrees of freedom if the squared residuals ϵ_t^2 are uncorrelated. It is recommended to consider up to T/4 values of *n*. The null hypothesis states that there are no ARCH or GARCH errors. Rejecting the null thus means that such errors exist in the conditional variance.

RESULTS

Table 1. shows the variables selected for the study namely Infosys Stock Returns, S&P CNX Nifty Index Returns and Dow Jones Industrial Average Index (DJIA) Returns are stationary.

Table 1. ADF- t Statistic

Variables	ADF-t stat. value	ADF-t stat Prob. value
Infosys Stock Returns	-13.2538	0.0001
NSE Nifty index Returns	-9.26493	0
DJIA index Returns	-8.70253	0

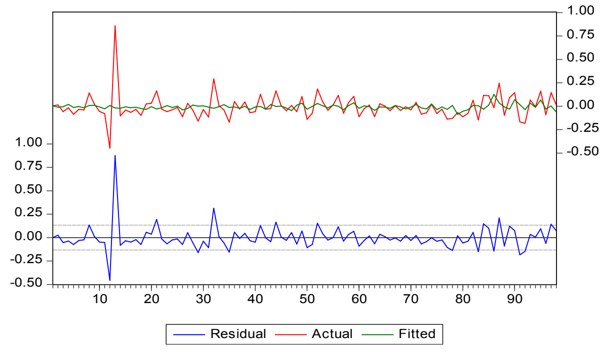


Chart 1. Residuals of Infosys Return

On visual inspection of Chart-t depicts that the residuals of the Infosys returns based on the output regression, there is clustering volatility in the residuals. It means that the periods of low volatility is followed by the periods of low volatility for long period. Again the periods of high volatility is tended to be followed by periods of high volatility. It suggests that residual or error term is conditional and it can be represented by ARCH and GARCH effect.

Table 2. Heteroskedasticity Test: ARCH

Heteroskedasticity Test: ARCH				
F-statistic	5.158177	Prob. F(1,95)		0.0254
Obs*R-squared	4.99553	Prob. Chi-Square(1)		0.0254
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 11/22/15 Time: 11:00				
Sample (adjusted): 2 98				
Included observations: 97 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013475	0.008192	1.644826	0.1033
RESID^2(-1)	0.226908	0.099908	2.271162	0.0254
R-squared	0.0515	Mean dependent var		0.017414
Adjusted R-squared	0.041516	S.D. dependent var		0.080545
S.E. of regression	0.078856	Akaike info criterion		-2.22199
Sum squared resid	0.59073	Schwarz criterion		-2.16891
Log likelihood	109.7666	Hannan-Quinn criter.		-2.20053
F-statistic	5.158177	Durbin-Watson stat		1.960497
Prob(F-statistic)	0.025395			

Table 3. GARCH (1,1) Student's t distribution

Dependent Variable: INFO				
Method: ML - ARCH (Marquardt) - Student's t distribution				
Date: 11/22/15 Time: 11:10				
Sample: 1 98				
Included observations: 98				
Failure to improve Likelihood after 48 iterations				
Presample variance: backcast (parameter = 0.7)				
t-distribution degree of freedom parameter fixed at 10				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*DJIA				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.01213	0.009221	-1.31556	0.1883
NSE	0.525798	0.119743	4.391067	0
Variance Equation				
C	0.006658	0.002177	3.058061	0.0022
RESID(-1)^2	0.371288	0.141018	2.632912	0.0085
GARCH(-1)	-0.02223	0.186309	-0.11932	0.905
DJIA	0.029491	0.039651	0.74378	0.457
R-squared	0.032317	Mean dependent var		-0.0063
Adjusted R-squared	0.022237	S.D. dependent var		0.13485
S.E. of regression	0.133338	Akaike info criterion		-1.72428
Sum squared resid	1.706773	Schwarz criterion		-1.56602
Log likelihood	90.4897	Hannan-Quinn criter.		-1.66027
Durbin-Watson stat	2.643059			

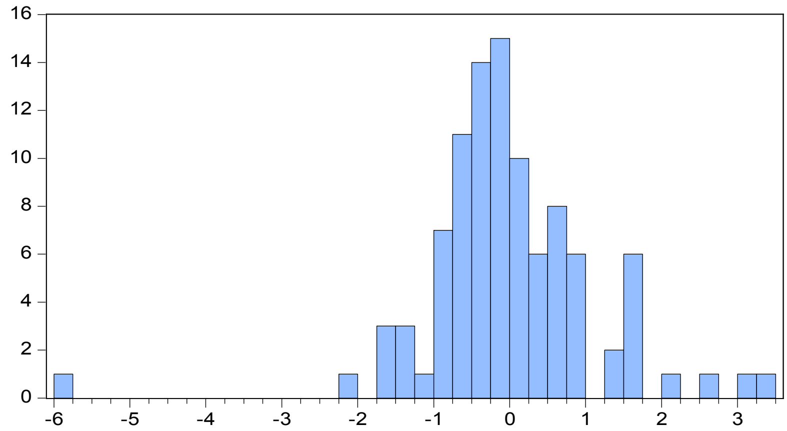
Table 4. Serial Correlation of Residuals of Infosys Stock Returns

Date: 11/22/15 Time: 11:17						
Sample: 1 98						
Included observations: 98						
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|* |	.|* |	1	0.161	0.161	2.6177	0.106
.|. |	*|. |	2	-0.059	-0.087	2.9753	0.226
.|. |	.|. |	3	-0.004	0.021	2.9772	0.395
.|. |	.|. |	4	-0.014	-0.023	2.9983	0.558
.|. |	.|. |	5	-0.057	-0.051	3.3365	0.648
.|. |	.|. |	6	-0.038	-0.023	3.4891	0.745
.|. |	.|. |	7	-0.058	-0.058	3.8502	0.797
.|. |	.|. |	8	0.008	0.024	3.8565	0.87
.|* |	.|* |	9	0.136	0.126	5.8803	0.752
*|. |	*|. |	10	-0.073	-0.125	6.4804	0.773
.|. |	.|. |	11	-0.003	0.051	6.4814	0.839
.|. |	.|. |	12	-0.011	-0.045	6.4959	0.889
.|. |	.|. |	13	-0.021	-0.007	6.545	0.924
.|. |	.|. |	14	-0.017	-0.004	6.5768	0.95
.|. |	.|. |	15	-0.019	-0.023	6.6174	0.967
.|. |	.|. |	16	-0.016	0.002	6.6491	0.979
.|. |	.|. |	17	0.032	0.021	6.7743	0.986
.|. |	*|. |	18	-0.035	-0.072	6.9236	0.991
.|. |	.|* |	19	0.069	0.129	7.5157	0.991
.|** |	.|** |	20	0.267	0.22	16.445	0.689

Continue ………………

.|. |	*|. |	21	-0.033	-0.116	16.58	0.736
.|. |	.|. |	22	-0.01	0.062	16.593	0.785
.|. |	.|. |	23	0.042	0.021	16.824	0.818
.|. |	.|. |	24	-0.009	-0.009	16.834	0.856
.|. |	.|. |	25	-0.048	-0.012	17.138	0.877
.|. |	.|. |	26	-0.035	-0.033	17.306	0.9
.|. |	.|. |	27	-0.033	0.023	17.458	0.919
.|. |	.|. |	28	-0.016	-0.056	17.494	0.938
.|. |	.|. |	29	0.025	-0.028	17.583	0.952
.|. |	.|. |	30	-0.048	0.024	17.919	0.96
.|. |	.|. |	31	0.002	-0.021	17.92	0.971
.|. |	.|. |	32	0.062	0.067	18.498	0.973
.|. |	.|. |	33	-0.035	-0.06	18.678	0.979
.|. |	.|. |	34	-0.034	-0.006	18.859	0.983
.|. |	.|. |	35	0	0.02	18.859	0.988
.|. |	.|. |	36	-0.018	-0.042	18.909	0.991

Table 5. Normal Distribution of Residuals of Infosys Stock Return



Series: Standardized Residuals	
Sample 1 98	
Observations 98	
Mean	-0.013803
Median	-0.155419
Maximum	3.429718
Minimum	-5.753206
Std. Dev.	1.137737
Skewness	-0.661431
Kurtosis	9.354149
Jarque-Bera	172.0111
Probability	0.000000

Table 6. Heteroskedasticity Test: ARCH of Residuals of Infosys Stock Returns

Heteroskedasticity Test: ARCH				
F-statistic	2.961708	Prob. F(1,95)		0.0885
Obs*R-squared	2.932632	Prob. Chi-Square(1)		0.0868
Test Equation:				
Dependent Variable: WGT_RESID^2				
Method: Least Squares				
Date: 11/22/15 Time: 11:16				
Sample (adjusted): 2 98				
Included observations: 97 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.899527	0.340818	2.639318	0.0097
WGT_RESID^2(-1)	0.173776	0.100976	1.720961	0.0885
R-squared	0.030233	Mean dependent var		1.08651
Adjusted R-squared	0.020025	S.D. dependent var		3.21388
S.E. of regression	3.181534	Akaike info criterion		5.17301
Sum squared resid	961.6052	Schwarz criterion		5.22609
Log likelihood	-248.891	Hannan-Quinn criter.		5.19447
F-statistic	2.961708	Durbin-Watson stat		1.96912
Prob(F-statistic)	0.088513			

It is evident from Table-2 that there is ARCH effect from the test of Heteroskedasticity ARCH test. Since its Obs*R-squared Prob. Chi-Square (1) is less than 0.05., it denies null hypothesis and accepts alternative hypothesis. So, there is validity to run GARCH (1, 1) model. Table-3 indicates that under Student's t Distribution, ARCH is significant since its Prob. Value is 0.0085. It means that previous month's Infosys's stock Return information can influence today's Infosys's volatility.GARCH is insignificant since its prob. value is 0.905. It means that current month's Infosys's volatility is not influenced by its internal shock previous month's Infosys's stock Return volatility.Dow Jones Industrial Average Index (DJIA) Returns volatility is also insignificant whose prob. Value is 0.457**.** It means that Current month's Infosys volatility is not influenced by external shock volatility of Dow Jones Industrial Average Index (DJIA) Returns.

Diagnostic checking of the Student's t Distribution

Table -4 discloses that there is no serial correlation in the residuals since its all 36 lags prob. value is more than 0.05. Hence, null hypothesis is accepted. Table-5 indicates that Residuals are not normally distributed since Table-6 shows that there is no ARCH effect since Prob. Chi-Square (1) is 0.0868which is more than 0.05. Therefore, null hypothesis is accepted. A weakness of this student's t Distribution model is non-normality of residuals. Many suggest that non-normality in the residuals may not be that serious problem for estimation. Hence this model will be used for forecasting. Other models of Normal Distribution and Generalised Error Distribution of residual of Infosys Stock Returns do not satisfy the requirements under diagnostic checking and hence, they are not useful model for forecasting.

Conclusion

To study GARCH (1,1) model for the volatility of Infosys stock returns and factors influencing the volatility in the returns of Infosys stock returns under three distributions namely Normal Distribution, Students, t Distribution and Generalised Error Distribution. Among these models, the best model is Student's, t Distribution. Under this model, Current month's Infosys's stock Return volatility is influenced by its own internal shock of ARCH but not by another internal shock of GARCH and external shock of Dow Jones Industrial Average Index (DJIA) Returns factors. It satisfies diagnostic tests of no serial Correlation and No ARCH effect but not normality Distribution. Many suggests that this model is still suitable for forecasting.

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