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Ramita
Assistant Professor,
Department of Commerce,
Maitreyi College, University of Delhi, New Delhi, India

Correspondence
Ramita
Assistant Professor,
Department of Commerce,
Maitreyi College, University of Delhi, New Delhi, India

Forecasting of Maruti Suzuki returns using ARCH/GARCH model

Ramita

Abstract
Time Series Modelling has been used to forecast the returns of Maruti Suzuki Ltd. The order of the best ARIMA Model has been found (1,0,2) for estimating the Mean Equation. After estimating it, it has been found that heteroskedasticity effect was present and Hence, Variance equation has been estimated using ARCH/GARCH Model. The graphs of returns of Maruti Suzuki Ltd has been compared with forecasted Maruti Suzuki returnsand data has been showed.

Keywords: Forecasting, ARIMA, Maruti Suzuki Ltd., ARCH/GARCH, India

Introduction
Maruti Suzuki India Ltd. is an automobile company in India, established in February 1981. Its headquarter is in New Delhi, India. Its a leading automobile company producing popular cars as Ertiga, Wagon R, Ciaz, Alto, Swift Dezire, Swift, Baleno. The company is listed on MCX Stock Exchange, The Stock Exchange (Mumbai) and National Stock Exchange of India Ltd. Return forecasting is helpful for investment strategies. Forecasting is a technique that use the estimators to predict the future trend by using the historical data and in time series analysis the past returns of the data series are used to predict the future returns also called the lagged returns.

Literature Review
Dr. Jiban Chandra Paul in his paper "Selection of Best ARIMA Model for Forecasting Average Daily Share Price Index of Pharmaceutical Companies in Bangladesh : A case study on Square Pharmaceutical Ltd.", Global Journal Of Management And Business Research Finance-Volume 13, forecasted the share price by using best ARIMA model. Kumar Manoj in his paper "An Application of Time Series ARIMA Forecasting Model for Predicting Sugarcane Production in India"-Studies in Business and Economics used Box-Jenkins' ARIMA Model to forecast the sugarcane production. But volatility clustering problem was not there in both the above cases.
Robert Engle in his article "The use of ARCH/GARCH Models in Applied Econometrics" Journal of Economic Perspectives-Volume 15, stated that for asset pricing and portfolio analysis, risk measurement is very important as financial decisions are trade off between risk and return. And for time series financial data ARCH/GARCH has shown successful results by forecasting the risk component depicted by volatilty clustering in the financial time series data graph.
Kenneth R. French in his paper "Expected Stock Returns and Volatility" Journal of Financial Economics 19(1987) 3-29, examines the relation between expected stock returns and stock market volatility. He compared the ARIMA and GARCH model and concluded that although both the models have similar capacity to predict volatility, the GARCH-in-mean model implies greater variability of expected risk premiums.
And this study also used ARCH/GARCH Model to forecast the returns based on time series data as this method encompasses greater variability.

Objective
- To forecast the Maruti Suzuki Returns by forecasting the:

A) Mean Equation
B) Variance Equation

Data Analysis

Study used Maruti Suzuki Ltd. Daily Closing Prices for approx last 5 years. (from 1st Jan 2013 to 13th July 2018). Data has been divided into two categories one is estimation period ie. 1st Jan 2014 - 31st mar 2016 and the other is validation period ie. 1st aril 2016- 13th July 2018. Prices are converted into log returns to make the price series a stationary series and Box-jenkins approach is being used for modeling the mean equation. However return series shows evidence of ARCH effects as noticed by the autocorrelations of the squared residuals. They all were significant resulting in rejecting the “No ARCH” null hypothesis. Further it is assured by Heteroskedasticity test (ARCH). Hence variance equation has been estimated. And the volatility is measured by ARCH/GARCH Modelling.

Mean Equation

Time Series Analysis and Building ARIMA

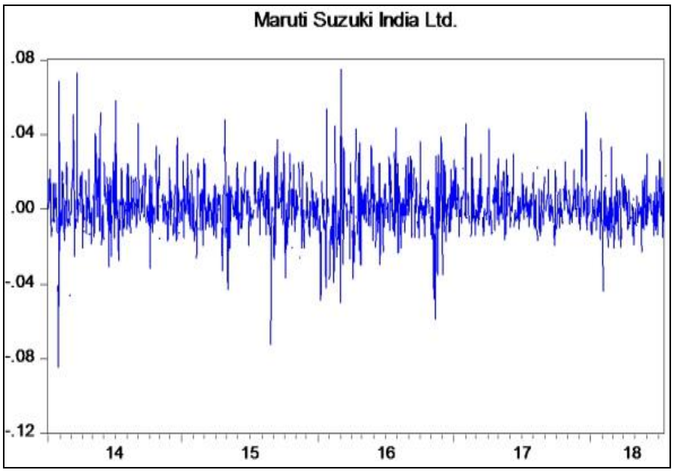
The Maruti Suzuki Prices data is used to develop forecasting model. The graph below represents the line plot of prices in BSE.

To build an ARIMA model for forecasting of a variable requires following steps:

1. Model Identification
2. Parameter Estimation and Selection
3. Diagnostic Checking
4. Use the Model for forecasting.

Model Identification

First stage of ARIMA model building is to identify whether the variable, which is being forecasted, is stationary in time series or not. By stationary we mean, the values of variable over time varies around a constant mean and variance. Time plot of Maruti Suzuki Prices shows that it is not stationary as it is showing an increasing trend in time series. And ARIMA model can’t be used on a non stationary series. So for making this price series stationary, it needs to be converted into log returns. And then test the series for unit root problems.



It can easily be inferred from the above graph that the log returns of Maruti Suzuki time series appears to be stationary both in its mean and variance. But before moving ahead, it should be checked for stationary by using Augmented Dickey-Fuller Test.

Test for stationarity: Augmented Dickey-Fuller (ADF) Test

Our null hypothesis (H_0) in the test is that the time series data is non-stationary while alternative hypothesis (H_a) is that the series is stationary. It is then tested by performing appropriate differencing of the data in d^{th} order and applying the ADF test to differenced time series. However by converting the series into log returns, it needs not to difference. So we tested the log returns series on level for stationarity. The ADF test result, as obtained upon application, is shown below:

Dickey-Fuller= -3.698, Lag order=level, p-value=0.00

We therefore, fail to accept the H_o and accept the alternative hypothesis ie. It is stationary in its mean and variance.

So we move ahead in steps for ARIMA model building and find suitable values of p in AR and q in MA. So by examining the correlogram and partial correlogram we can define the following possible ARMA (auto regressive moving average) models for the log returns of MARUTI SUZUKI LTD. in India:

1. An ARMA(1,0,1) model
2. An ARIMA(1,0,2) model
3. An ARMA(2,0,2) model

ARIMA Model	Coefficients					
	AR(1)	AR(2)	MA(1)	MA(2)		
AR(1,0,1)	-0.27281		0.373234		-5.32196	-5.35317
AR(1,0,2)	0.088496			-0.08327	-5.32561	-5.35682
AR(2,0,2)		-0.15074		0.068881	-5.31796	-5.34917

ARIMA Model (1,0,2) has the lowest AIC and BIC values so this model is the best predictive model for making forecasts for future values of our time series data.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001350	0.000753	1.794073	0.0734
AR(1)	0.088496	0.027157	3.258640	0.0012
MA(2)	-0.083271	0.041407	-2.011048	0.0448
SIGMASQ	0.000272	9.50E-06	28.65861	0.0000

R-squared	0.014439	Mean dependent var	0.001350
Adjusted R-squared	0.009053	S.D. dependent var	0.016632
S.E. of regression	0.016557	Akaike info criterion	-5.356821
Sum squared resid	0.150492	Schwarz criterion	-5.325607
Log likelihood	1485.161	Hannan-Quinn criter.	-5.344626
F-statistic	2.681006	Durbin-Watson stat	1.998586
Prob(F-statistic)	0.046179		

But when this model is checked for heteroskedasticity test it has shown ARCH effect and correlogram of its squared residuals were also significant as shown below:

Autocorrelation of squared residuals

	AC	Q-Stat	Prob
1	0.268	39.908	0.000
2	0.008	39.940	0.000
3	-0.021	40.181	0.000
4	-0.015	40.305	0.000
5	0.002	40.307	0.000
6	0.010	40.367	0.000
7	-0.019	40.570	0.000
8	-0.014	40.684	0.000
9	-0.018	40.867	0.000
10	-0.014	40.981	0.000
11	0.023	41.269	0.000
12	-0.009	41.319	0.000
13	0.002	41.322	0.000
14	-0.020	41.560	0.000
15	-0.011	41.631	0.000
16	-0.014	41.744	0.000
17	-0.017	41.906	0.001
18	-0.020	42.125	0.001
19	-0.022	42.395	0.002
20	-0.011	42.464	0.002

Heteroskedasticity Test: ARCH

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000192	2.95E-05	6.515026	0.0000
RESID^2(-1)	0.295797	0.040732	7.262029	0.0000

For modelling the volatility, Variance equation has been estimated.

Variance Equation

Dependent Variable: MARUTI_SUZUKI_INDIA_LTD_
Sample: 1/01/2014 3/31/2016
Included observations: 553
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

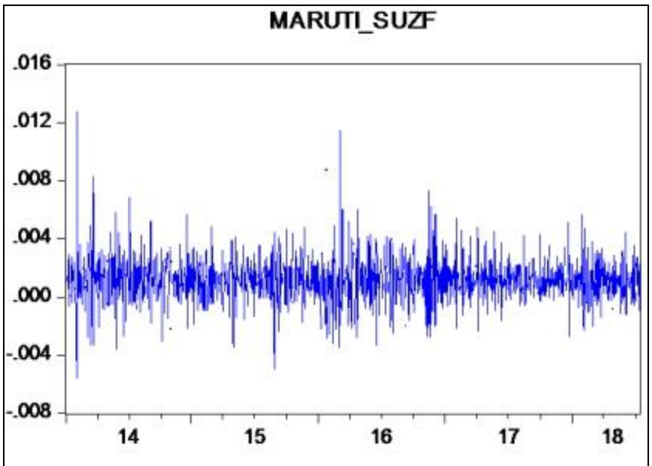
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.001159	0.000680	1.703787	0.0884
AR(1)	0.095161	0.048447	1.964228	0.0495
MA(2)	-0.062724	0.029299	-2.140859	0.0323
	Variance Equation			
C	0.000238	2.19E-05	10.89438	0.0000
RESID(-1)^2	0.262463	0.049733	5.277490	0.0000
GARCH(-1)	-0.151300	0.058567	-2.583367	0.0098
R-squared	0.013814	Mean dependent var		0.001350
Adjusted R-squared	0.010228	S.D. dependent var		0.016632
S.E. of regression	0.016547	Akaike info criterion		-5.451189
Sum squared resid	0.150588	Schwarz criterion		-5.404368
Log likelihood	1513.254	Hannan-Quinn criter.		-5.432896
Durbin-Watson stat	2.009131			
Inverted AR Roots	.10			
Inverted MA Roots	.25	-.25		

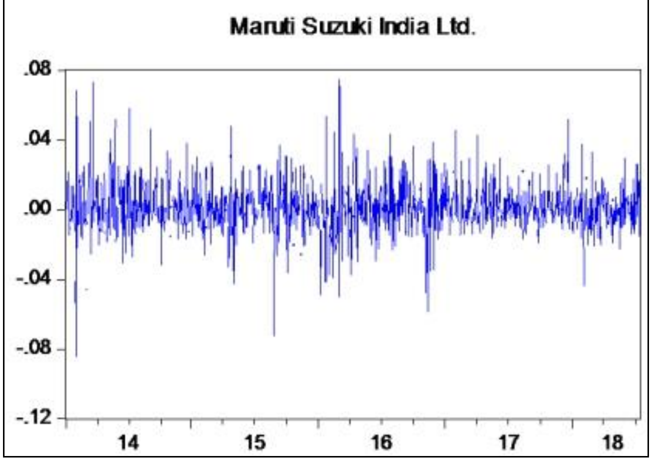
After estimating the coefficients of the mean equation and variance equation, the correlogram for residuals has been checked to know that the mean equation has been correctly specified. Correlogram for squared residuals and heteroskedasticity test (ARCH) ensured the efficiency of the coefficients. Results have been shown below:

Correlogram For Residuals Correlogram For Squared Residuals									
	AC	**PAC**	**Q-Stat**	**Prob***		**AC**	**PAC**	**Q-Stat**	**Prob***
1	0.011	0.011	0.0672	0.795	1	0.038	0.038	0.8224	
2	0.038	0.037	0.8537	0.653	2	-0.024	-0.025	1.1401	
3	-0.073	-0.074	3.8257	0.281	3	-0.044	-0.042	2.2256	0.136
4	0.007	0.008	3.8563	0.426	4	0.024	0.027	2.5573	0.278
5	0.043	0.049	4.9143	0.426	5	-0.043	-0.047	3.5931	0.309
6	0.094	0.088	9.8747	0.13	6	0.015	0.018	3.7215	0.445
7	-0.005	-0.01	9.8899	0.195	7	0.028	0.027	4.1727	0.525
8	0.025	0.025	10.245	0.248	8	-0.053	-0.059	5.7284	0.454
9	-0.032	-0.019	10.806	0.289	9	0.015	0.026	5.861	0.556
10	0.045	0.04	11.935	0.289	10	0.007	0.003	5.8915	0.659
11	0.095	0.093	17.018	0.107	11	0.004	-0.001	5.8985	0.75
12	0.052	0.037	18.557	0.1	12	0.071	0.08	8.7734	0.554
13	-0.008	-0.011	18.594	0.136	13	-0.001	-0.015	8.7743	0.643
14	-0.047	-0.042	19.877	0.134	14	0.004	0.011	8.7846	0.721
15	0.019	0.028	20.075	0.169	15	-0.077	-0.068	12.142	0.516
16	0.025	0.011	20.425	0.202	16	-0.004	-0.008	12.152	0.594
17	-0.006	-0.033	20.447	0.252					
18	-0.004	-0.011	20.455	0.308					
19	-0.041	-0.035	21.41	0.315					
Heteroskedasticity Test: ARCH									
Fstatistic	0.06657	Prob. F(1,550)		0.7965					
Obs*Rsquared	0.06681	Prob. Chi-Square(1)		0.796					

Forecasted Returns

The comparative graphs for actual maruti suzuki returns and forecasted Maruti Suzuki Returns are stated below:





Limitations of the study

The study tried to forecast the risk and returns of an individual stock market company but for investment strategies diversification of investments must be there so as to by diversifying, the risk can be minimised for the portfolio.

Study used the last 5 years data ranging from 2013 to 2018 only. 10 year or 15 year data analysis can also give a good sight for future returns. However the limitations of the study can overcome by further research and can become scope for further studies.

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