

# PREDICTIVE ANALYTICS ON INDIAN PHARMACEUTICAL SECTOR THROUGH THE APPLICATION OF ARIMA AND GARCH

Vishweswarsastry V. N.\*, Santosh B. R.\*\*, Guruprasad Desai\*\*\*

**Abstract** A company acquiring an ownership through transfer of resources and technical know-how is essential for a sustainable growth and to face competition in the existing industry. The aim is to study the effect of CAGR on Foreign Direct Investment (FDI) inflows into Indian Pharmaceutical sector; secondly to regress the stock prices of top listed Indian Pharmaceutical sector and finally to analyse the Generalised Auto Regressive Conditional Heteroskedasticity (GARCH) effect on the Stock prices of selected Pharmaceutical sector. The research methodology applied is descriptive, analytical and univariate analysis. Time series tool of Auto Regressive Integrated Moving Averages (ARIMA) and GARCH is applied for generating the output and the major findings from the study is Apollo Hospitals Enterprise Limited, Cipla Ltd and Dr. Reddy's Laboratories Limited Lab are stationary and optimum model as per information criteria is at ARIMA, (1, 1, 0) for Apollo Hospitals Enterprise Limited and ARIMA (0, 1, 1) for Cipla Limited and Dr. Reddy's Laboratories Limited Lab.

**Keywords:** ARIMA, Foreign Direct Investment, GARCH, Predictive Analytics

**JEL Code:** E47, O16, O47

## INTRODUCTION

Foreign Direct Investment (FDI) is a vital factor in the economic growth of a country. FDI brings investment and in addition also brings in non-debt financial resources for India's economic development. India is able to attract FDI because of its distinct investment benefits, such as tax rebates and relatively lower wages. Technical know-how, jobs and other benefits are among the ways in which India benefits from foreign investment. Due to the government's supportive policy environment and prosperous economic environment, India has continued to attract foreign investment.

FDI limits have recently been increased in a number of industries, including stock exchanges, PSU oil refineries, telecom and defence. This study used time series forecasting and analysis like Generalised Auto Regressive Conditional Heteroskedasticity (GARCH) and Auto Regressive

Integrated Moving Averages (ARIMA) model to anticipate future values. Instead of using the actual value, the model analyses variations in values within a series to forecast changes in the financial market. The model forecasts change in the financial market by observing fluctuations in values within a series rather than the actual values. Additionally, GARCH was used to predict market volatility, financial instrument prices and rates.

## LITERATURE REVIEW

A comprehensive literature review based on the objective of the study was carried out. In a study done by Betzenis (2006) found out the significant reason that has led to the concentration of Greek investors in the Balkans, particularly in Bulgaria, are examined, with a focus on the challenges faced when launching international firms in a Balkan nation like Bulgaria. The study comes to the conclusion that a

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company's strategy for entering a Balkan country depends on the origin of the organisation, the size of the firm and the industry to which each company belongs. In a study done by S Pal and S Pal (2009) describing the SENSEX behaviour in the coming months with the seasonal ARIMA Model which generated a good forecast of the March-April, 2009 scenario till the phase of revival of the financial and stock markets through some unpredictable events not directly linked to financial market. The data set consisting of the daily Sensex closing values are taken from 3<sup>rd</sup> March 2008 to 19<sup>th</sup> June 2009 are used to understand variation in the market. By employing ARIMA model the authors predicted that the market will remain stable during the next few months with little chance of the market to go below 14000. Nevertheless, unless unforeseen events exist, the market will not go beyond 16000 within the next two months. To conclude, the ARIMA seasonal models give effective and very-near-to-precise forecasts on the future state of the market conditions in the short-run.

In their study, Singh et al. (2022) found that the pre- and post-pandemic period saw new patterns and trends in FDI inflows and outflows from India. Evidence suggests that FDI inflow and outflow are typically rising at a far faster rate during the post-pandemic period than they were during the pre-pandemic period. During this period, India's share of global FDI is also increasing. Lokesha and Leelavathy (2012) explored the factors that influence both internal and outward FDI from India. The study finds that the policy environment, market size, economic variables, political factors, economic stability and economic factors all play a role in determining FDI inflows into India. The analysis also suggests that there are both similarities and differences in the determinants of FDI inflows into India and other developing nations.

Chattopadhyay (2014) studied the factors responsible for such differential levels of FDI inflows across the states of India. In the study the year-wise rankings of different states/regions are first made on the basis of their observed per-capita FDI inflows. The study found that this ranking is (highly) positively correlated with the states'/regions' ranking computed on the basis of their composite FDI attractiveness scores. Finally, the study concludes that the some direct and indirect policy measures for attracting FDI inflows into the laggard states are witnessed. By examining trends and patterns, Rani and Kumar (2015) determine the contribution of foreign investments in their study. Additionally, the data set spans the years 2000–2014. The study finds that FDI has a strong link with CNX Nifty and BSE Sensex using Karl Pearson's Coefficient of link and the multiple regression method.

Olugbenga and Grace (2015) evaluated the effect of FDI on the growth of the Nigerian capital market in their study. The study used the Johansen co-integration test and the ADF unit root test to analyse the secondary data from 1970 to 2010. The study's findings show that foreign direct investment has a favourable and substantial impact on market capitalisation. Additionally, the author recommends that the monetary authority and the government work to promote foreign direct investment in Nigeria.

In their paper, Vadra (2017) discusses the FDI oligopolistic rivalry between China and India in Africa and makes an effort to determine the contribution of the two Asian Economic Giants to the continent's development. India and China are not competitors in Africa, the author believes. They each have different strengths, are engaged in various areas and work well together. In addition, the three most recent participants in the race for influence in Africa are Brazil, Russia and Turkey. Further, Mehendale and HR (2018) provided evidence that the variables affecting the actual market demand and the magnitude of those influences are largely unpredictable and ill-defined. In order to discover and forecast complex sales trends, the study used artificial intelligence approaches. The outcomes were compared to those obtained using conventional forecasting models. When large-scale data is used for the study, the author concludes that neural networks can be a better alternative to conventional forecasting. In a study done by Demir and IM (2019), they examined "Do cultural affinity and language familiarity affect bilateral economic exchanges?" was examined and the results revealed that cultural institutions generally have a positive impact on bilateral trade and investment flows that is statistically and economically significant.

## Statement of Problem

FDI inflows affect the Indian Stocks and the effect of FDI inflows on the stock prices of Pharma companies are to be studied; the problem identified is to predict the prices of selected Pharma stocks listed in National Stock Exchange in the current volatile market condition along with its variation through ARIMA and GARCH. The FDI inflows and prediction of stock prices using time series is considered for the study which aids an investor in his Investment options into the stock market.

## Research Gap

Since time series prediction is related to Time and updated ARIMA (p,d,q) criteria is essential for the investors to

analyse the stocks for their investment decision. An empirical evidence is depicted through time series prediction which was majority a constraint on the earlier studies reviewed.

## OBJECTIVES OF THE STUDY

- To analyse the year on year growth and CAGR on FDI inflows into Indian Pharmaceutical Industry.
- To stationarise and predict the stock prices of Apollo Hospitals Enterprise Limited, Cipla Ltd and Dr. Reddy’s Laboratories Limited through ARIMA.
- To analyse the existence of ARCH effect through the application of GARCH model.

## Scope of the Study

The study is limited to the period of 2010–2012 for analysing FDI and 2012–2022 for predicting the stock prices. The source is limited to National Stock Exchange prices and the companies selected for the study is limited to Apollo Hospitals Enterprise Limited, Cipla Ltd and Dr. Reddy’s Laboratories Limited.

## Operational Definition

- *ARIMA*: Auto Regressive Integrated Moving Averages is an Econometric Model used for Prediction of Time

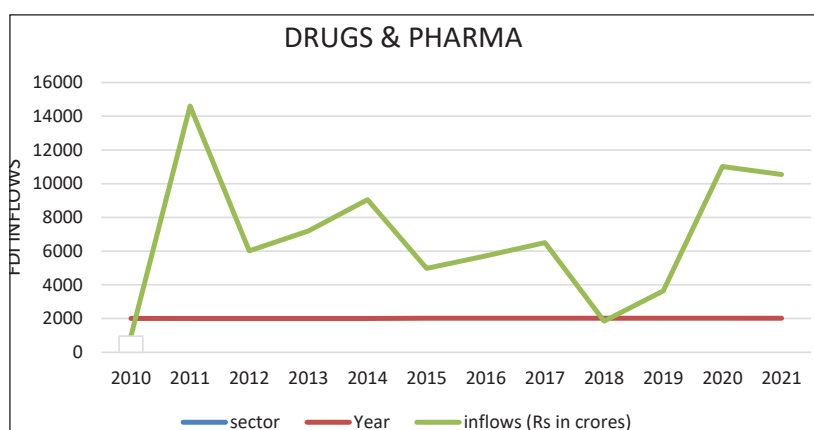
series data like Gross Domestic Product, interest rates, currency, stock prices, etc.

- *GARCH*: Generalised Auto Regressive Conditional Heteroskedasticity which is an Econometric model used to analyse the variation existence in the process of predicting the prices of Time series data.

## DATA ANALYSIS AND INTERPRETATION

**Table 1: Represents the Inflows of FDI into Indian Pharma Industry**

Year	Inflows Rs in Crores)	YOY (%)
2010	961	
2011	14605	1420
2012	6011	-59
2013	7191	20
2014	9052	26
2015	4975	-45
2016	5723	15
2017	6502	14
2018	1842	-72
2019	3650	98
2020	11015	202
2021	10552	-4

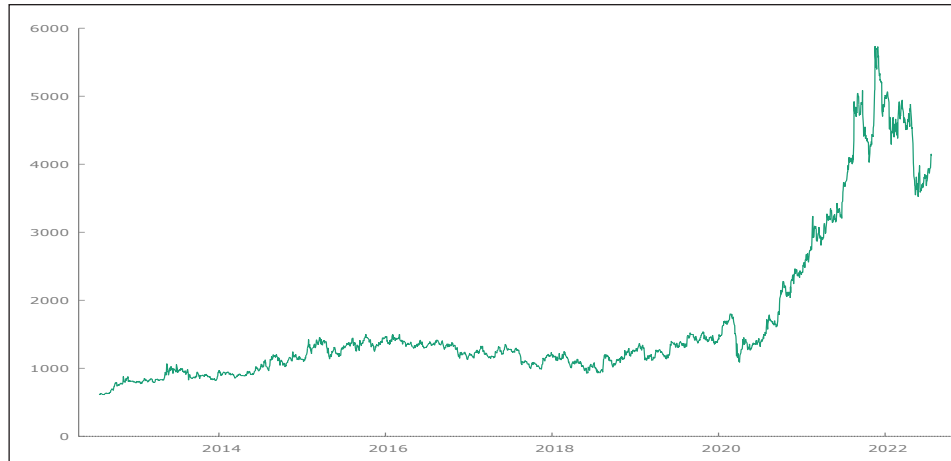


Sector	Year	inflows (Rs in Crores)	CAGR
Drugs & Pharma	2010	961	24.34%
	2011	14605	
	2012	6011	
	2013	7191	
	2014	9052	
	2015	4975	
	2016	5723	
	2017	6502	
	2018	1842	
	2019	3650	
	2020	11015	
	2021	10552	

**Graph 1: Represents the FDI Inflows into Indian Pharmaceutical Industry**

*Interpretation:* Table 1 indicates the flow of FDI inflows into Indian Drugs & Pharma Industry which is considered as one of the prominent sectors of economy which attracts consistent FDI inflows. The study period consists of 12 years, that is, from the year 2010–2021. As it is evident that

the drugs and pharma sector is a key manufacturing sector it attracts highest FDI inflows for the year 2011 and lowest for the year 2010. Graph 1 visualises the flow of FDI into Indian Pharmaceutical Industry for 12 years for the period 2010–2021.

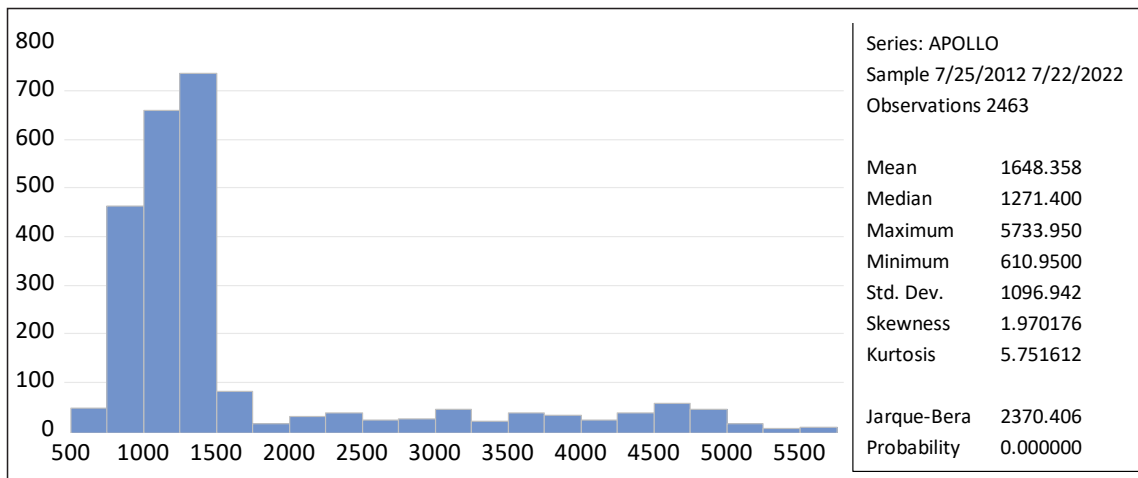


**Graph 2: Time Series Plot on the Prices of Apollo Hospitals Enterprise Limited for the Period 2012-2022**

### Normality Test

H0: Data is normally distributed.

HA: Data is non-normally distributed.



**Graph 3: Represents Normality Plot of Apollo Hospitals Enterprise Limited for the Period 2012-2022**

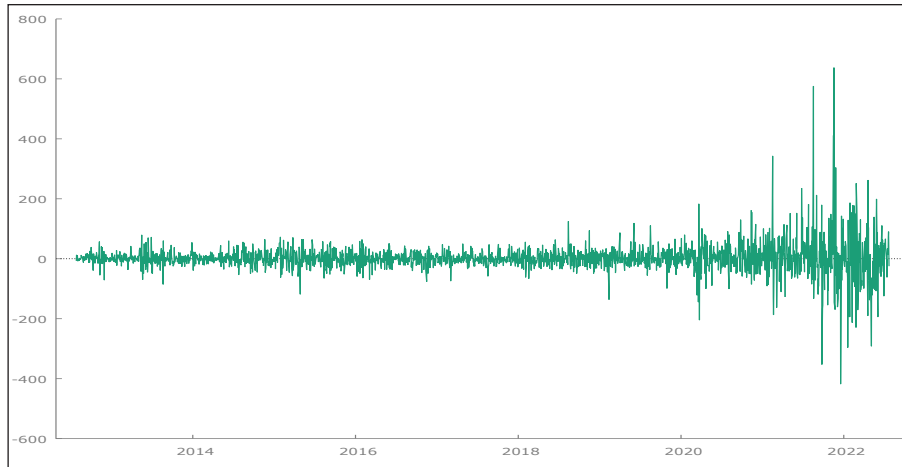
*Interpretation:* Graph 2 shows the flow of Prices for the period 2012–2022 where it is evident that the prices have trend and seasonality at different intervals. Graph 3 shows the normality plot along with summary statistics with its

mean and SD at 1648.358 and 1096.942 respectively. The normality being a diagnostic type of research shows and Jargue-Bera test results indicate P-value <0.05 significance level the data points selected are normally distributed.

### Stationarity Test

H0: Data has unit root.

HA: Data doesn't have unit root.



**Graph 4: Time Series Plot at First Difference of Apollo Hospitals Enterprise Limited for the Period 2012–2022**

**Table 2: Showing the ADF Test for Apollo Hospitals Enterprise Limited for the Period 2012–2022**

Null Hypothesis: D(APOLLO) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=26)				
			t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>				
Test critical values:			1% level	-3.432813
			5% level	-2.862514
			10% level	-2.567334
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(APOLLO,2)				
Method: Least Squares				
Date: 07/29/22 Time: 20:47				
Sample (adjusted): 7/27/2012 7/22/2022				
Included observations: 2461 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(APOLLO(-1))	-0.968859	0.020157	-48.06469	0.0000
C	1.383051	0.945522	1.462737	0.1437
R-squared	0.484401	Mean dependent var	-0.007111	
Adjusted R-squared	0.484192	S.D. dependent var	65.28001	
S.E. of regression	46.88397	Akaike info criterion	10.53404	
Sum squared resid	5405144.	Schwarz criterion	10.53876	
Log likelihood	-12960.14	Hannan-Quinn criter.	10.53576	
F-statistic	2310.215	Durbin-Watson stat	2.000625	
Prob(F-statistic)	0.000000			

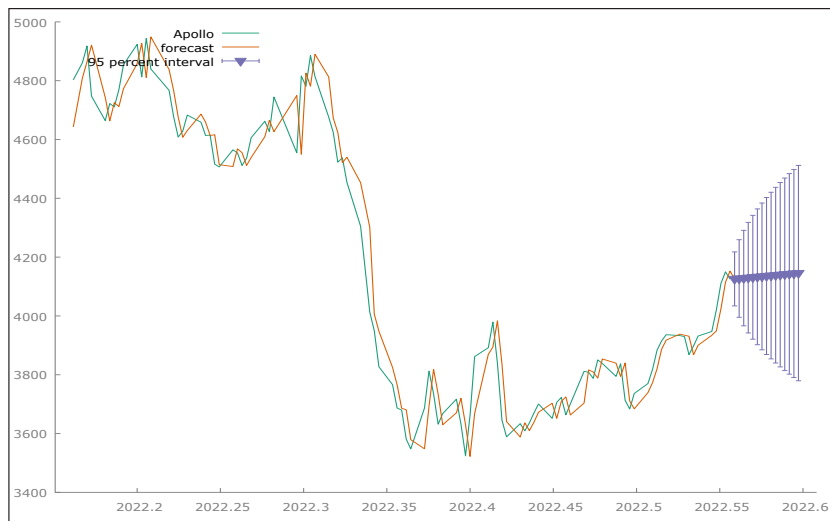
**Table 3: Showing the Model for Predictive Analytics on Apollo Hospitals Enterprise Limited for the Period 2012–2022**

Function evaluations: 19				
Evaluations of gradient: 4				
Model 1: ARIMA, using observations 2012-07-26:2022-07-22 (T = 2462)				
Estimated using AS 197 (exact ML)				
Dependent variable: (1-L) Apollo				
Standard errors based on Hessian				
	coefficient	std. error	z	p-value
const	1.42373	0.974645	1.461	0.1441
phi_1	0.0311285	0.0201413	1.546	0.1222
Mean dependent var 1.424208 S.D. dependent var 46.88798				
Mean of innovations 0.000135 S.D. of innovations 46.85572				
R-squared 0.998175 Adjusted R-squared 0.998175				
Log-likelihood -12964.92 Akaike criterion 25935.84				
Schwarz criterion 25953.27 Hannan-Quinn 25942.17				
	Real	Imaginary	Modulus	Frequency
AR				
Root 1	32.1249	0.0000	32.1249	0.0000

**Table 4: Represents the Predicted Prices of Apollo Hospitals Enterprise Limited for the Period 2012–2022**

Date	Predicted Prices	Standard Error	Range
2022-07-23	4125.91	46.8557	4034.07 - 4217.74
2022-07-24	4127.31	67.3032	3995.40 - 4259.22
2022-07-25	4128.73	82.8757	3966.30 - 4291.16
2022-07-26	4130.15	95.9540	3942.09 - 4318.22
2022-07-27	4131.58	107.452	3920.98 - 4342.18
2022-07-28	4133.00	117.834	3902.05 - 4363.95
2022-07-29	4134.42	127.372	3884.78 - 4384.07
2022-07-30	4135.85	136.244	3868.82 - 4402.88
2022-07-31	4137.27	144.572	3853.92 - 4420.63
2022-08-01	4138.70	152.447	3839.91 - 4437.49
2022-08-02	4140.12	159.934	3826.66 - 4453.58
2022-08-03	4141.54	167.086	3814.06 - 4469.03
2022-08-04	4142.97	173.944	3802.04 - 4483.89
2022-08-05	4144.39	180.541	3790.54 - 4498.25
2022-08-06	4145.81	186.906	3779.49 - 4512.14

*Interpretation:* Graph 4 shows the mean reversions and homoscedastic and Table 2 shows the stationarity test for Apollo Hospitals Enterprise Limited where the P value indicates 0.0001 which is <0.05 cut off rate and hence HO is rejected and said that the data is stationary and suitable for predicting the future. The stock prices of Apollo Hospitals Enterprise Limited is stationary at first order difference and the DW statistics value of 2.000625 which is < 5% confirms the stock prices are stationary.



**Graph 5: Represents the Predicted Prices of Apollo Hospitals Enterprise Limited for 15 Days Based on 100 Previous Observations for the Period 2022**

*Interpretation:* Based on stationarity test a prediction of Apollo Hospitals Enterprise Limited is conducted and based on information criteria the model suitable for prediction is ARIMA (1, 1, 0) which is evident in Table 3 and the predicted stock prices are shown in the Table 4 for a period of 15 days based on 100 previous observation which was included from 2012 to 2022 closing stock prices. Graph 5 creates a wonderful shaded tail for those 15 days. The predicted line and actual line are very close at ARIMA (0,

1, 1) which is considered as best fit for the above mentioned period in Table 4.

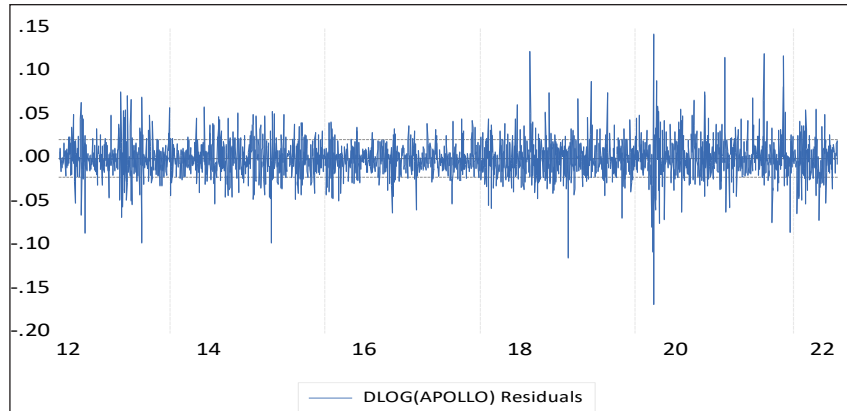
### GARCH Model

H0: There is no ARCH & GARCH effect on the stock of prices of Apollo.

HA: There is ARCH & GARCH effect on the stock of prices of Apollo.

**Table 5: Represents the GARCH Model on Apollo Hospitals Enterprise Limited for the Period 2012–2022**

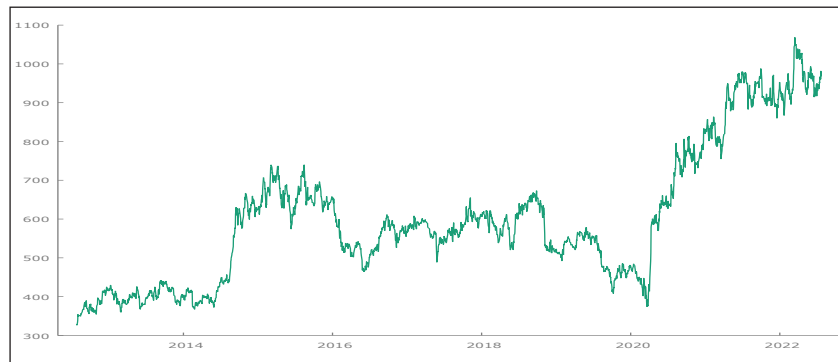
Dependent Variable: DLOG(APOLLO)				
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)				
Date: 07/30/22 Time: 00:41				
Sample (adjusted): 7/27/2012 7/22/2022				
Included observations: 2461 after adjustments				
Convergence achieved after 35 iterations				
Coefficient covariance computed using outer product of gradients				
MA Backcast: 7/26/2012				
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	0.000860	0.000377	2.280422	0.0226
AR(1)	-0.587031	0.326640	-1.797178	0.0723
MA(1)	0.617049	0.316496	1.949627	0.0512
Variance Equation				
C	0.000108	1.05E-05	10.28827	0.0000
RESID(-1)^2	0.208849	0.017895	11.67080	0.0000
GARCH(-1)	0.559823	0.034338	16.30340	0.0000
R-squared	0.000598	Mean dependent var	0.000776	
Adjusted R-squared	-0.000215	S.D. dependent var	0.021553	
S.E. of regression	0.021555	Akaike info criterion	-4.955600	
Sum squared resid	1.142027	Schwarz criterion	-4.941439	
Log likelihood	6103.866	Hannan-Quinn criter.	-4.950455	
Durbin-Watson stat	2.035013			
Inverted AR Roots	-.59			
Inverted MA Roots	-.62			



**Graph 6: Shows the Residual Plot of Apollo Hospitals Enterprise Limited for the Period 2012–2022**

*Interpretation:* Table 5 shows the impact of ARCH on the stock prices of Apollo Hospitals Enterprise Limited prices which is evident from variance equation in Table 5 with its P value at first order difference for residual square

standing at 0.0000 suggesting to reject the null and conclude that there exist ARCH effect on the stock prices of Apollo Hospitals Enterprise Limited with homoskedasticity at every cluster which is visible from Graph 6.

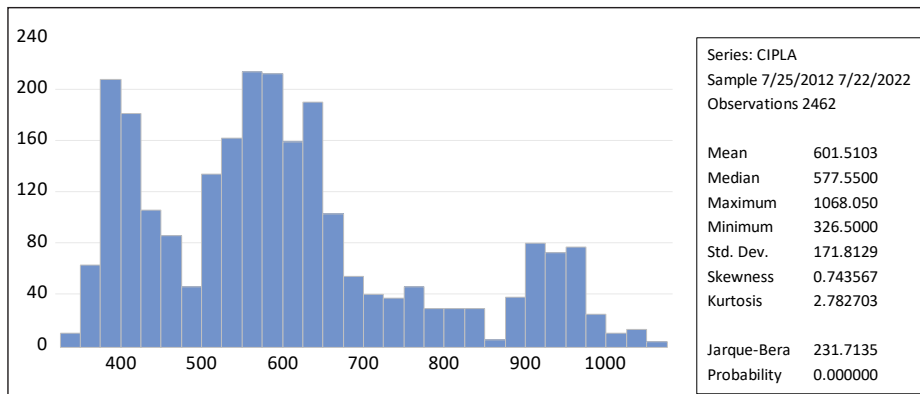


**Graph 7: Represents the Time Series Plot of CIPLA Ltd for the Period 2012–2022**

### Normality Test

H0: Data is normally distributed.

HA: Data is non-normally distributed.



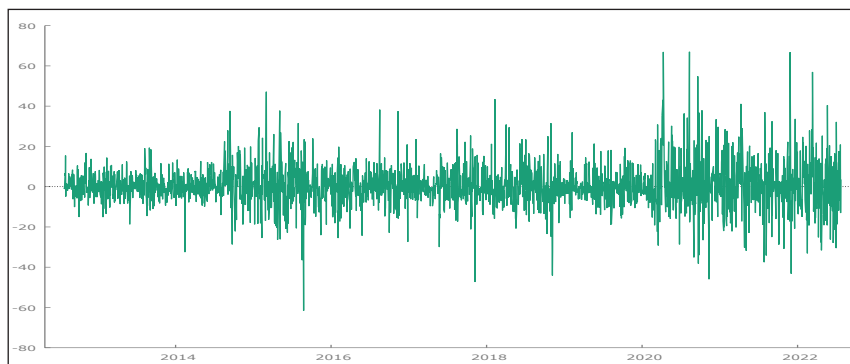
**Graph 8: Represents the Normality Test for CIPLA Ltd for the Period 2012–2022**

Interpretation: Graph 7 shows the Original Time series plot on the prices of CIPLA ltd for the period 2012–2022 where clearly suggesting that the trend existence which needs to be stationarised to know its mean, variance and autocorrelation function. Graph 8 shows the normality on the continuous data considered for the study whose test of Jarque-Bera value is < 005 suggesting the data is normal and the test provided a descriptive statistics which explain the

mean value of 601.5103 and standard deviation of 171.8129 indicating better stock on the basis on risk reward ratio.

### Stationarity Test

- H0: Data is non-stationary.
- HA: Data is Stationary.



Graph 9: Time Series Plot at First Difference of CIPLA Ltd for the Period 2012–2022

Table 6: Represents the ADF Test of Cipla Ltd for the Period 2012–2022

Null Hypothesis: D(CIPLA) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=26)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-52.21974	0.0001
Test critical values:	1% level		-3.432814	
	5% level		-2.862514	
	10% level		-2.567334	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(CIPLA,2)				
Method: Least Squares				
Date: 07/29/22 Time: 20:51				
Sample (adjusted): 7/27/2012 7/22/2022				
Included observations: 2460 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CIPLA(-1))	-1.051882	0.020143	-52.21974	0.0000
C	0.275497	0.211118	1.304945	0.1920
R-squared	0.525931	Mean dependent var		0.001687
Adjusted R-squared	0.525738	S.D. dependent var		15.20020
S.E. of regression	10.46787	Akaike info criterion		7.535310
Sum squared resid	269338.4	Schwarz criterion		7.540032
Log likelihood	-9266.432	Hannan-Quinn criter.		7.537026
F-statistic	2726.901	Durbin-Watson stat		2.001363
Prob(F-statistic)	0.000000			

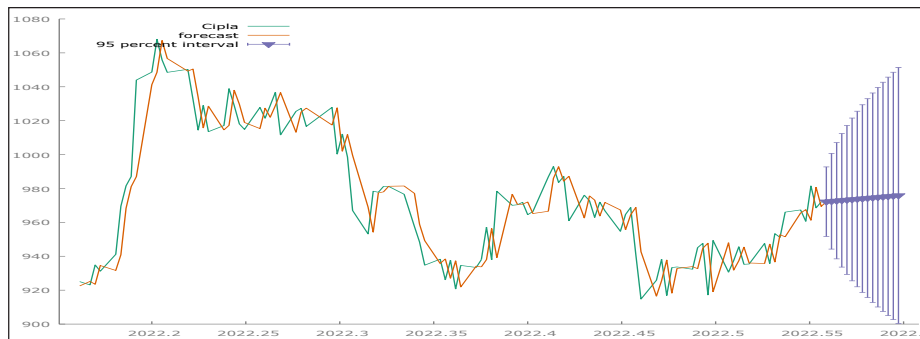
Interpretation: Graph 9 shows the mean reversions of Cipla Ltd for the year 2012–2022 and also suggests the variance is constant or homoscedastic at first order difference and Table 6 indicates the ADF test which confirms there is no autocorrelation among its previous values which helps in the reduction of white noise existence and further making the prices of Cipla suitable for prediction which helps many stakeholders for decision-making.

Table 7: Showing the Model for Predictive Analytics on Cipla Ltd for the Period 2012–2022

Function evaluations: 34				
Evaluations of gradient: 10				
Model 1: ARIMA, using observations 2012-07-26:2022-07-22 (T = 2461)				
Estimated using AS 197 (exact ML)				
Dependent variable: (1-L) Cipla				
Standard errors based on Hessian				
	coefficient	std. error	z	p-value
const	0.261620	0.199719	1.310	0.1902
theta_1	-0.0529249	0.0202616	-2.612	0.0090 ***
Mean dependent var	0.261662	S.D. dependent var	10.47773	
Mean of innovations	-0.000016	S.D. of innovations	10.46119	
R-squared	0.996291	Adjusted R-squared	0.996291	
Log-likelihood	-9269.630	Akaike criterion	18545.26	
Schwarz criterion	18562.69	Hannan-Quinn	18551.59	
	Real	Imaginary	Modulus	Frequency
MA				
Root 1	18.8947	0.0000	18.8947	0.0000

Table 8: Represents the Predicted Prices of Apollo Hospitals Enterprise Limited for the Period 2012–2022

Date	Predicted Prices	Standard Error	Range
2022-07-23	972.219	10.4612	951.716 - 992.723
2022-07-24	972.481	14.4082	944.241 - 1000.72
2022-07-25	972.742	17.4858	938.471 - 1007.01
2022-07-26	973.004	20.0976	933.613 - 1012.39
2022-07-27	973.266	22.4070	929.349 - 1017.18
2022-07-28	973.527	24.4996	925.509 - 1021.55
2022-07-29	973.789	26.4271	921.993 - 1025.58
2022-07-30	974.050	28.2232	918.734 - 1029.37
2022-07-31	974.312	29.9117	915.686 - 1032.94
2022-08-01	974.574	31.5098	912.816 - 1036.33
2022-08-02	974.835	33.0307	910.096 - 1039.57
2022-08-03	975.097	34.4846	907.508 - 1042.69
2022-08-04	975.359	35.8796	905.036 - 1045.68
2022-08-05	975.620	37.2224	902.666 - 1048.57
2022-08-06	975.882	38.5184	900.387 - 1051.38



Graph 10: Represents the Predicted Prices of Cipla Ltd for 15 Days Based on 100 Previous Observations for the Period 2022

Interpretation: Table 7 shows the Model selection based on information criteria and the model suitable for prediction as per AIC and BIC is ARIMA (0, 1, 1) which is considered and forecasted the prices for 15 days which is observed in Table 8 along with its range without maximum volatility in the actual and predicted values which can be visualized through Graph 10. The shaded portion in Graph 10 shows the predicted values for 15 days based on 100 previous observations.

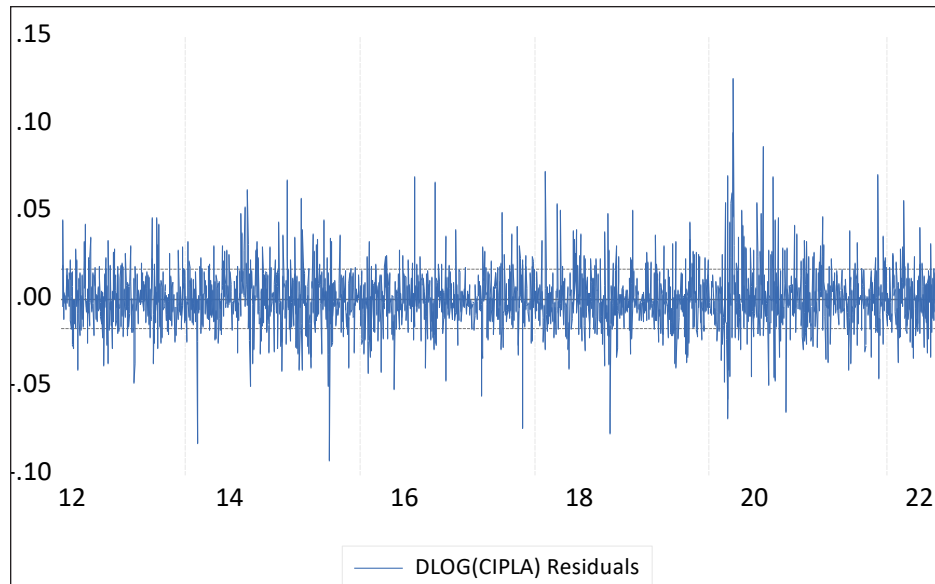
### GARCH Model

H0: There is no ARCH & GARCH effect on the stock of prices of Cipla Ltd.

HA: There is ARCH & GARCH effect on the stock of prices of Cipla Ltd.

Table 9: Represents the GARCH Model on Cipla Ltd for the Period 2012–2022

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000492	0.000286	1.720282	0.0854
AR(1)	0.231430	0.317692	0.728475	0.4663
MA(1)	-0.291827	0.311549	-0.936697	0.3489
Variance Equation				
C	6.92E-05	7.92E-06	8.729339	0.0000
RESID(-1)^2	0.149884	0.018428	8.133684	0.0000
GARCH(-1)	0.599884	0.037118	16.16166	0.0000
R-squared	-0.000619	Mean dependent var		0.000442
Adjusted R-squared	-0.001433	S.D. dependent var		0.016866
S.E. of regression	0.016878	Akaike info criterion		-5.394808
Sum squared resid	0.699944	Schwarz criterion		-5.380642
Log likelihood	6641.613	Hannan-Quinn criter.		-5.389661
Durbin-Watson stat	1.937136			
Inverted AR Roots	.23			
Inverted MA Roots	.29			



**Graph 11: Shows the Residual Plot of Cipla Ltd for the Period 2012–2022**

*Interpretation:* Table 9 indicates the GARCH results on Cipla and the variance equation suggests that there is ARCH effect since its P-value is  $<0.05$  and at the same time Graph 11 suggest there is a conditional heteroscedasticity with

constant variance at each cluster. This has resulted at first order difference which was used for prediction of prices of Cipla Ltd.

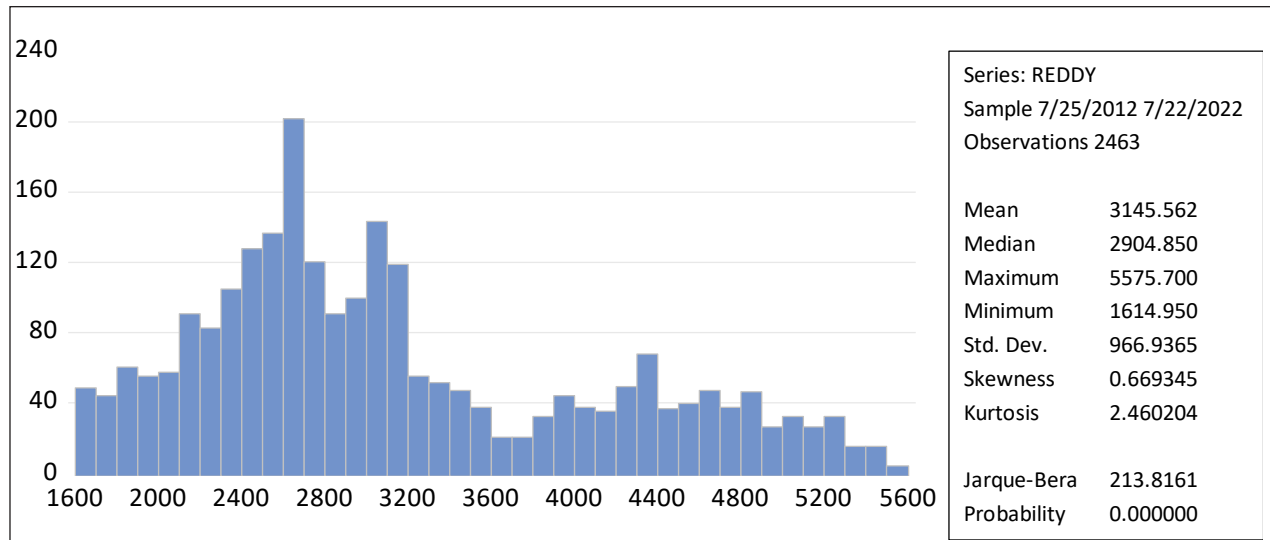


**Graph 12: Represents the Tome Series Plot of Dr. Reddy’s Laboratories Limited Lab for the Period 2012–2022**

### Normality Test

H0: Data is normally distributed.

HA: Data is non-normally distributed.



**Graph 13: Represents the Normality Test for Dr. Reddy’s Laboratories Limited Lab for the Period 2012–2022**

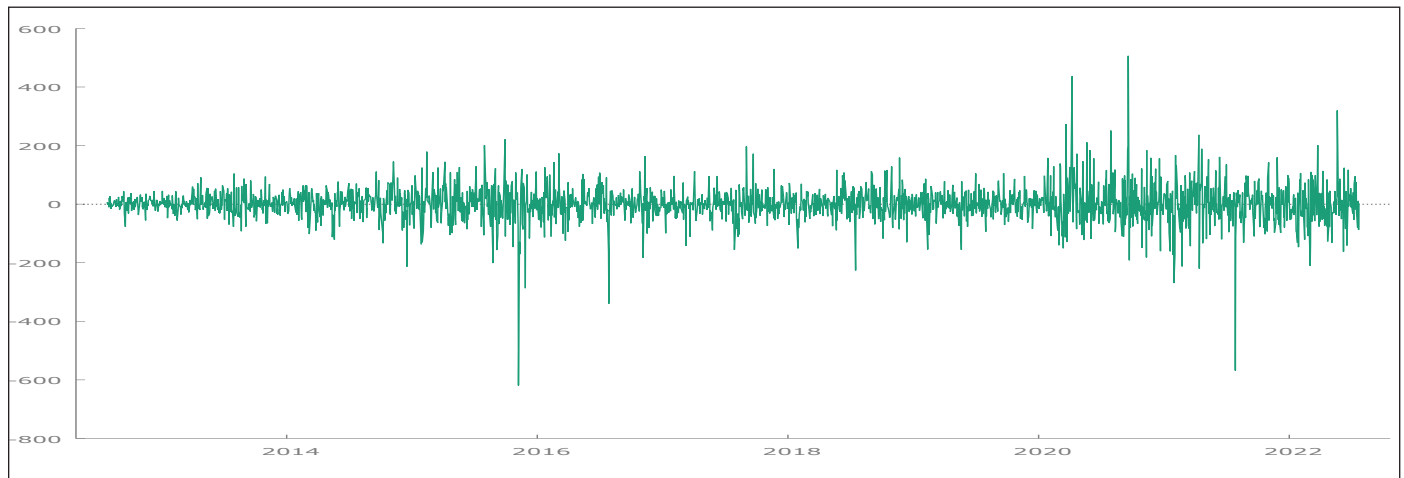
*Interpretation:* Graph 12 suggests the original values plotted which has trend and cyclical component. The prices need to be addressed which is suitable for prediction of its prices, whereas the normality results particularly Jarque-Bera test suggests P-value <0.05 significant level proving data is normally distributed. Graph 13 adds descriptive statistics which helps an investor analyse the characteristics of Dr.

Reddy’s Laboratories Limited Lab where its mean and SD standing at 3145.562 and 966.9365, respectively.

### Stationarity Test

Ho: Data is non-stationary.

HA: Data is stationary.



**Graph 14: Time Series Plot at First Difference of CIPLA Ltd for the Period 2012–2022**

**Table 10: Represents the ADF Test of Dr. Reddy’s Laboratories Limited Lab for the Period 2012–2022**

Null Hypothesis: D(REDDY) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=26)				
			t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>				
Test critical values:			-46.30211	0.0001
	1% level		-3.432813	
	5% level		-2.862514	
	10% level		-2.567334	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(REDDY,2)				
Method: Least Squares				
Date: 07/29/22 Time: 20:55				
Sample (adjusted): 7/27/2012 7/22/2022				
Included observations: 2461 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(REDDY(-1))	-0.931537	0.020119	-46.30211	0.0000
C	1.040983	1.162638	0.895362	0.3707
R-squared	0.465770	Mean dependent var		-0.001991
Adjusted R-squared	0.465553	S.D. dependent var		78.87992
S.E. of regression	57.66588	Akaike info criterion		10.94802
Sum squared resid	8177046.	Schwarz criterion		10.95274
Log likelihood	-13469.54	Hannan-Quinn criter.		10.94974
F-statistic	2143.885	Durbin-Watson stat		2.000580
Prob(F-statistic)	0.000000			

*Interpretation:* Graph 14 and Table 10 suggests the stationarity process of Dr. Reddy’s Laboratories Limited Lab where Graph 14 indicates the mean zero and variance constant at one and Table 10 suggests that there is no autocorrelation among the prices of Dr Reddy’s Lab for the

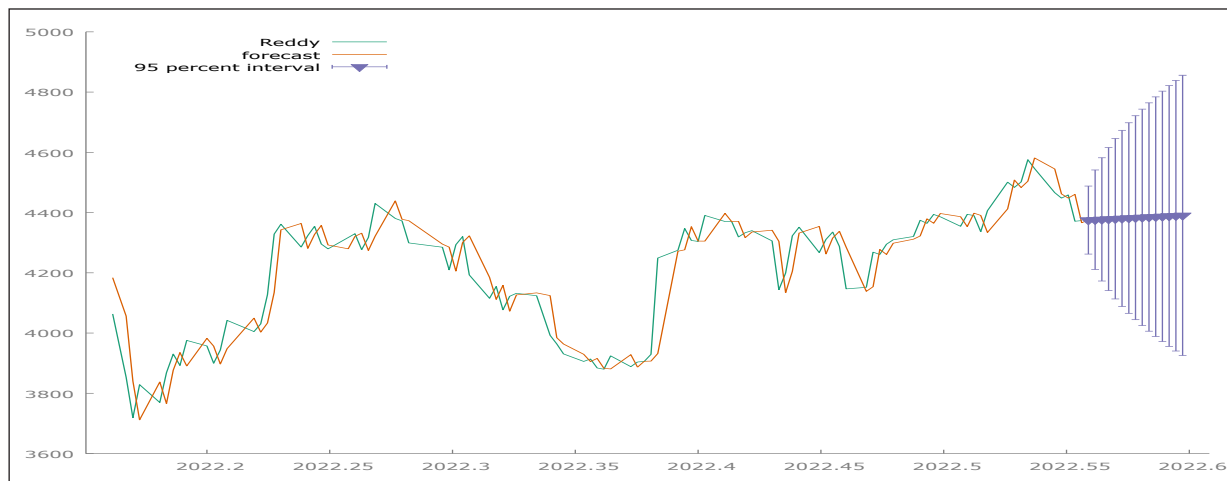
considered period 2012–2022 at first order difference whose inference is taken at probability value of 5%. Table 10 also shows the t-Statistic value of -46.30211 which is beyond cutoff limit of -2.862514, hence the null is not accepted and concludes that the data at first order is stationary.

**Table 11: Showing the Model for Predictive Analytics on Dr. Reddy’s Laboratories Limited Lab for the Period 2012–2022**

Function evaluations: 29				
Evaluations of gradient: 7				
Model 1: ARIMA, using observations 2012-07-26:2022-07-22 (T = 2462)				
Estimated using AS 197 (exact ML)				
Dependent variable: (1-L) Reddy				
Standard errors based on Hessian				
	coefficient	std. error	z	p-value
-----				
const	1.12046	1.24011	0.9035	0.3663
theta_1	0.0676938	0.0199720	3.389	0.0007 ***
Mean dependent var	1.120146	S.D. dependent var	57.77815	
Mean of innovations	-0.000110	S.D. of innovations	57.63245	
R-squared	0.996448	Adjusted R-squared	0.996448	
Log-likelihood	-13474.59	Akaike criterion	26955.18	
Schwarz criterion	26972.60	Hannan-Quinn	26961.51	
	Real	Imaginary	Modulus	Frequency
-----				
MA				
Root 1	-14.7724	0.0000	14.7724	0.5000
-----				

**Table 12: Represents the Predicted Prices of Dr. Reddy’s Laboratories Limited Lab for the Period 2012–2022**

Date	Predicted Prices	Standard Error	Range
2022-07-23	4375.12	57.6325	4262.16 - 4488.07
2022-07-24	4376.24	84.3084	4211.00 - 4541.48
2022-07-25	4377.36	104.376	4172.79 - 4581.93
2022-07-26	4378.48	121.164	4141.00 - 4615.96
2022-07-27	4379.60	135.894	4113.25 - 4645.95
2022-07-28	4380.72	149.176	4088.34 - 4673.10
2022-07-29	4381.84	161.369	4065.56 - 4698.12
2022-07-30	4382.96	172.703	4044.47 - 4721.45
2022-07-31	4384.08	183.338	4024.75 - 4743.42
2022-08-01	4385.20	193.389	4006.17 - 4764.24
2022-08-02	4386.32	202.942	3988.56 - 4784.08
2022-08-03	4387.44	212.066	3971.80 - 4803.08
2022-08-04	4388.56	220.813	3955.78 - 4821.35
2022-08-05	4389.68	229.227	3940.41 - 4838.96
2022-08-06	4390.80	237.342	3925.62 - 4855.99



**Graph 15: Represents the Predicted Prices of Dr. Reddy’s Laboratories Limited Lab for 15 Days Based on 100 Previous Observations for the Period 2022**

*Interpretation:* The above Table 11 shows the model selection as per information criteria and the best model identified for prediction of Dr. Reddy’s Laboratories Limited lab is ARIMA (0, 1, 1) where its AIC and BIC is least standing at 26955.18 and 26972.60 whereas Table 12 suggests that predictive prices of Dr. Reddy’s Laboratories Limited lab for 15 days by consideration of 100 observation from the consideration period of 2012–2022.

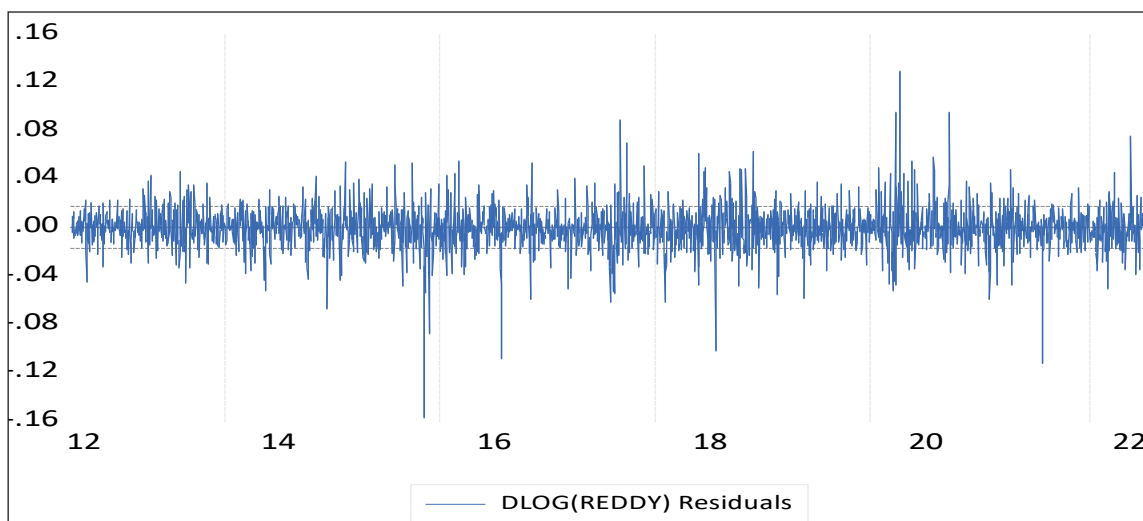
### GARCH Model

H0: There is no ARCH & GARCH effect on the stock of prices of Dr. Reddy Laboratories Ltd.

HA: There is ARCH & GARCH effect on the stock of prices of Dr. Reddy Laboratories Ltd.

**Table 13: Represents the GARCH Model on Dr. Reddy’s Laboratories Limited Lab for the Period 2012–2022**

Dependent Variable: DLOG(REDDY) Method: ML ARCH - Normal distribution (BFGS / Marquardt steps) Date: 07/30/22 Time: 00:54 Sample (adjusted): 7/27/2012 7/22/2022 Included observations: 2461 after adjustments Convergence achieved after 50 iterations Coefficient covariance computed using outer product of gradients MA Backcast: 7/26/2012 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	0.000693	0.000350	1.981360	0.0476
AR(1)	-0.875011	0.055650	-15.72343	0.0000
MA(1)	0.911783	0.045076	20.22756	0.0000
Variance Equation				
C	2.53E-05	2.73E-06	9.233975	0.0000
RESID(-1)^2	0.074270	0.007550	9.837641	0.0000
GARCH(-1)	0.844545	0.014170	59.60139	0.0000
R-squared	0.004450	Mean dependent var	0.000403	
Adjusted R-squared	0.003640	S.D. dependent var	0.017365	
S.E. of regression	0.017333	Akaike info criterion	-5.323143	
Sum squared resid	0.738488	Schwarz criterion	-5.308982	
Log likelihood	6556.128	Hannan-Quinn criter.	-5.317998	
Durbin-Watson stat	1.932840			
Inverted AR Roots	-.88			
Inverted MA Roots	-.91			



**Graph 16: Shows the Residual Plot of Dr. Reddy’s Laboratories Limited Ltd for the Period 2012–2022**

*Interpretation:* Table 13 indicates the GARCH results on Dr. Reddy’s Laboratories Limited lab and the variance equation in Table 13 suggests that there is ARCH effect since its P-value is <0.05 and at the same time Graph 16 suggest there is a conditional heteroscedasticity with constant variance at each cluster. This has resulted in the first order difference which was used for prediction of Dr. Reddy’s Laboratories Limited lab prices.

### OUTCOME OF THE STUDY

- Summary statistics are found in Graphs 3, 8 and 13 with a mean of 1648.358, 601.5103, 3145.562 and standard deviation of 1096.942, 171.8129 and 966.9365 for

Apollo Hospitals Enterprise Limited, Cipla and Dr. Reddy’s Laboratories Limited lab respectively.

- It is found from Graphs 3, 8 and 13 a normality results and being a type of diagnostic research the prices are normally distributed for Apollo, Cipla and Dr. Reddy’s Laboratories Limited Lab at first order difference.
- FDI inflows are seen from Table 1 for the period 2010–2021 which suggests the huge inflows into the sector in the year 2011, 2019 and 2020 to an extent of 1420, 98, 202 crores which acted as a fuel for Indian Pharma Sector stocks which contributed in increasing its average and minimizing the risk resulting in best risk reward ratio for investors. Table 1 also explains CAGR of 24.34% FDI inflows for the period 2010–2021.

- It is observed in Table 2 and Graph 5 that the prices of Apollo Hospitals Enterprise Limited are stationary at first order difference, DW statistics of Apollo Hospitals Enterprise Limited is 2.000625 which is less than cut off limit of 4 proving the prices are suitable for predictive analysis on Apollo Hospitals Enterprise Limited.
- From Graph 9 and Table 6 Author's found that the DW statistics is within 4 at first order differencing eliminating trend component. The DW stood at 2.001363 which suggests for further predictive analytics on Cipla Ltd
- It is observed from Graph 14 and Table 10 that the data is stationary with its DW statistics being 2.000580 which is within cutoff limit of 4 providing a path for predicting the prices of Dr. Reddy's Laboratories Limited Lab.
- The author's found the best predictive model for Apollo Hospitals Enterprise Limited, Cipla Ltd and Dr. Reddy's Laboratories Limited Lab with Lowest Akaike information and Schwarz Information at ARIMA (1,1,0), ARIMA (0,1,1) and ARIMA (0,1,1) which is observed from Tables 3, 7 and 11.
- Tables 5, 9 and 13 along with Graph 6, 11 and 16 showed ARCH effect existence with its variance equation P value being below 0.05 for Apollo Hospitals Enterprise Limited, Cipla Ltd and Dr. Reddy's Laboratories Limited Lab at first order difference.
- It is found from Tables 4, 8 and 12 and Graphs 4, 10 and 15 the predicted prices of Apollo Hospitals Enterprise Limited, Cipla Ltd and Dr. Reddy's Laboratories Limited Lab for the period of 15 days from 23<sup>rd</sup> August 2022 to 06<sup>th</sup> September 2022 through the best fit model of ARIMA specified in point number 7.
- Predicted prices of selected companies have lower standard error suggesting investors and stakeholders an insight on selecting the defensive stocks into their portfolio.

## REFERENCES

- Bitzenis, A. (2006). Determinants of Greek FDI outflows in the Balkan region: The case of Greek entrepreneurs in Bulgaria. *Eastern European Economics*, 44(3), 79-96.
- Chattopadhyay, S. (2014). Distributional heterogeneity in FDI inflows into India. A state-level analysis. *ICRA Bulletin: Money and Finance*, 15(4), 67-102.
- Comolli, P. (2018). Migration, FDI, and welfare. *Atlantic Economic Journal*, 46(2), 179-188.
- Demir, F., & Im, H. (2020). Effects of cultural institutes on bilateral trade and FDI flows: Cultural diplomacy or economic altruism? *The World Economy*, 43(9), 2463-2489.
- Goud, M. M. (2022). A study on the saving and investment behaviour of individual investors. *Journal of Commerce and Accounting Research*, 11(1), 23-30.
- Jones, J. D. (1989). A comparison of lag-length selection techniques in tests of Granger causality between money growth and inflation: Evidence for the US, 1959-86. *Applied Economics*, 21(6), 809-822.
- Joseph, T. J. (2007). Spillovers from FDI and absorptive capacity of firms: Evidence from Indian manufacturing industry after liberalisation. *IIMB Management Review*, 19(2), 119-130.
- Kathuria, V., & Das, S. (2005). Impact of FDI on R&D strategies of firms in the post-1991 era. *IIMB Management Review*, 17(2), 17-28.
- Kundu, A., & Goyal, A. K. (2020). ARCH-Based ARIMA forecasting of money plus Quasi money in the economy of India. *IUP Journal of Applied Finance*, 26(2), 59-70.
- Loksha, B. K., & Leelavathy, D. S. (2012). Determinants of foreign direct investment: A macro perspective. *Indian Journal of Industrial Relations*, 459-469.
- Mehendale, A., & HR, N. S. (2018). Application of artificial intelligence (AI) for effective and adaptive sales forecasting. *Journal of Contemporary Management Research*, 12(2).
- Bitzenis, A. (2006). Determinants of Greek FDI outflows in the Balkan region: The case of Greek entrepreneurs in Bulgaria. *Eastern European Economics*, 44(3), 79-96.
- Olugbenga, A. A., & Grace, O. O. (2015). Impact of foreign direct investment on Nigerian capital market development. *International Journal of Academic Research in Accounting, Finance and Management Sciences*, 5(1), 103-108.
- Pal, S., & Pal, S. (2009). Predicting SENSEX variation pattern in changing national and global economic scenario. *Globsyn Management Journal*, 3(1).
- Pandey, A. (2022). Empirical evidence of calendar anomalies for the Egyptian stock market. *Journal of Commerce and Accounting Research*, 11(4), 15-26.
- Raghuvanshi, R. (2015). Has FDI played a role in Indian industrial growth? *Journal of Marketing & Communication*, 11(1).
- Rani, K., & Kumar, S. (2015). Analysis of dynamic interaction between foreign investments and Indian stock market. *Journal of International Economics* (0976-0792), 6(2).
- Samadder, S., & Bhunia, A. (2018). Integration between Indian stock market and developed stock markets. *Journal of Commerce and Accounting Research*, 7(1), 13-23.

- Sharma, D. P. C. (2022). Mutual fund flow scale: A multi-item scale for measuring perception of mutual fund investors. *Journal of Commerce and Accounting Research*, 11(2), 82-93.
- Singh, J., Jha, S. R., & Singh, Y. (2011). Impact of liberalization on foreign direct investment: An empirical analysis of Indian economy in post-reform period. *IUP Journal of Public Finance*, 9(3).
- Svetunkov, I., & Boylan, J. E. (2020). State-space ARIMA for supply-chain forecasting. *International Journal of Production Research*, 58(3), 818-827.
- Tamizharasan, M. (2019). Impact of FDI on hotel and tourism sector in the Indian Economy. *Editorial Board*, 10(2), 71-78.
- Tripathi, V., & Kumar, A. (2015). Do macroeconomic variables affect stock returns in BRICS markets? An ARDL approach. *Journal of Commerce and Accounting Research*, 4(2), 1-15.
- Vadra, R. (2017). FDI in Africa by India and China: Partners or rivals? *Journal of International Economics* (0976-0792), 8(2).
- Vishweswarsastry, V. N., & Mathew, B. (2021). Impact of dual class and single class on the selected top market capitalized companies. *PalArch's Journal of Archaeology of Egypt/Egyptology*, 18(09), 187-198.
- Vishweswarsastry, V. N., Mathew, B., & Banu, A. (2017). Efficient model selection for nifty index and impact of money supply, gold and exchange rate on S&P nifty 50. *Social Sciences*, 7(2).
- Vishweswarsastry V. N., & Vittala, P. (2022). Impact of data localisation on the GDP of selected economies. *Journal of Commerce and Accounting Research*, 11(4), 27-41.
- Wang, C. C., Hsu, Y. S., & Liou, C. H. (2011). A comparison of ARIMA forecasting and heuristic modelling. *Applied Financial Economics*, 21(15), 1095-1102.
- Wang, S. J., Huang, C. T., Wang, W. L., & Chen, Y. H. (2010). Incorporating ARIMA forecasting and service-level based replenishment in RFID-enabled supply chain. *International Journal of Production Research*, 48(9), 2655-2677.