APPLICATION OF GARCH MODELS TO ESTIMATE AND PREDICT FINANCIAL VOLATILITY OF DAILY STOCK RETURNS IN YAHOO FINANCE

H. D. J. S. Wijewardena[1], N. Karunathunga[2], S. S. N. Perera[2] and S. A. K. P. De Silva[2]

[1]Department of Mathematics, Faculty of Science,
University of Colombo
[2]Research & Development Centre for Mathematical Modeling,
Department of Mathematics, University of Colombo

jithma.wijewardena@gmail.com

ABSTRACT*: Investors and policymakers need to be aware of fluctuations in stock returns to manage portfolio adjustments and risk management decisions. Therefore, it is crucial to capture volatility, which is a measure of how strongly the price of a security clusters around the mean. The study used information from Yahoo Finance, a leading website of financial data and had applied the proposed methodology to one stock from each of the eleven industries in which they had separately represented the data. This project offers an approach to determine the best forecasting GARCH model among GARCH, EGARCH and GJR-GARCH that may be used to predict financial volatility of stocks. The study also used the Generalized Error Distribution, Students t Distribution, and Skewed Student t Distribution as error distributions in addition to the normal distribution. The identified models and error distributions that provided the significant parameters, were further forecasted using rolling window forecast and by relying on Root Mean Square error the best model had been selected.*

Keywords: GARCH models, error distributions, RMSE, Yahoo Finance

1. INTRODUCTION

Volatility can be defined as the dispersion around a security's mean or average return and measured by standard deviation, which reflects how strongly the price of the security clustered around the mean or moving average. Investors and policymakers need to be able to capture fluctuations in stock returns since it will help them make risk management decisions and portfolio modifications. If there is unrestrained volatility, it could have a negative impact on the real economy, limiting growth and development. As a result, finding a reliable volatility model to estimate and anticipate volatility has become extremely important.

Therefore, the objective of this project is to examine the nature of volatility/risk of selected stocks in Yahoo finance and propose a method to determine the optimal forecasting GARCH model to predict financial volatility of the stocks in Yahoo finance.

Past research illustrates, the average size of volatility does not remain constant over time but adjusts over time, which can be forecasted. Bollerslev (1986) and Taylor (1986) established the generalized auto-regressive conditional heteroscedasticity (GARCH) model, which is the oldest and most used model to capture volatility or risk and another two important models of the GARCH family which are EGARCH and GJR-GARCH.

Yahoo Finance is a website that offers financial news, data, opinion, stock quotations, financial reports, press releases and original content as well as certain online tools for managing personal finances. They've provided statistics about stocks under eleven industries. Since

Yahoo Finance is a leader among similar websites, I'll examine eleven stocks from choosing stock from each eleven industries and recommend the best volatility model from GARCH, EGARCH and GJR-GARCH for forecasting each stocks volatility. Using the methodology, I have developed a Python program which can use to find the optimal GARCH family volatility model and the error distribution which can use to forecast the volatility of any stock available on Yahoo Finance.

2. METHODOLOGY

In financial data the error terms will not be equal and error terms may be reasonably large for some points or ranges of points represent they displays heteroskedasticity. ARCH and GARCH models treat heteroskedasticity as a variance to be modeled. Therefore, I used GARCH family models to fit the Yahoo finance stock price return data. As the EGARCH and GJR-GARCH was also improved versions of GARCH model to capture the leverage effect and to resolve the issue of imposing conditions on parameters to ensure positive volatility estimate, I used EGARCH and GJR-GARCH as my other two GARCH models to predict the financial volatility.

Generalized-ARCH model (GARCH)
GARCH model was developed by Dr. Tim Bollerslev (1986), which is commonly used to predict the volatility of returns of stocks, market indices and bonds when the error term is Heteroskedastic. Which means the variance of the error term follows an autoregressive moving average pattern. GARCH model has an additional lagged conditional variance term (σ_t^2) than the ARCH model. (TEAM, 2021)

$$\sigma_{t+1}^2 = \omega + \beta\sigma_t^2 + \alpha\varepsilon_t^2 \quad (1)$$

A parameter represents the immediate impact of the stock while β represents the duration of the impact on the stock. To apply the GARCH models the data series must be stationary, ARCH effect should be available and data series should contain an autocorrelation.

Following are the requirements for a GARCH process to be covariance stationary

Condition 1 : $\omega > 0$, α , β ≥ 0 , for positive variance
Condition 2 : β = 0 if α = 0, for identification
Condition 3 : α + β < 1, for covariance stationarity

GARCH model has two basic limitations. Since the symetric GARCH model treats the positive and negative influence equally, GARCH model does not capture the leverage effect. In GARCH models it would be difficult to achieve all the parameters larger than zero. Threfore to resolve above issues GARCH models has improved to EGARCH and GJR- GARCH models.

Exponential GARCH model (EGARCH)
Exponential GARCH model is a model which uses dependent variables natural logarithm value, which delivers a positive value. As EGARCH equation is on log variance , parameter restrictions does not require and due to the log likelihood estimation with no restrictions the optimization will also be more fast and reliable (Haglund, 2014)

$$\log\sigma_{t+1}^2 = \omega + \beta\log\sigma_t^2 + \alpha\left|\frac{\varepsilon_t}{\sigma_t}\right| + \gamma\frac{\varepsilon_t}{\sigma_t} \quad (2)$$

α parameter represents the model's symmetric effect, β measures conditional variance while γ represents the leverage effect or the asymmetric performance of the model.

Glosten, Jagannathan and Runkle-GARCH model (GJR-GARCH)

Glosten, Jagannathan and Runkle-GARCH model measures the asymmetry by the sign of the indicator term to represent different impact between good news and bad news.

$$\sigma_{t+1}^2 = \omega + \beta\sigma_t^2 + \alpha\varepsilon_t^2 + \delta\varepsilon_t^2 \, I\{\varepsilon_t < 0\} \qquad (3)$$

I is a indicator variable, become one when residual is smaller than zero and become zero when the residual is not smaller than zero. $1, \ \text{if } \varepsilon_t < 0$

$$I_t = \begin{Bmatrix} 1, & \text{if } \varepsilon_t < 0 \\ 0, & \text{otherwise} \end{Bmatrix}$$

By applying indicator function to financial return data, the function will create a value of one for profit and value of zero for loss. (Jiang, 2012)

Distributions of the error term

Skewness is a statistical method to capture the asymmetrical behavior of a distribution. When skewness equals to zero, the data set is normally distributed, when skewness is greater than zero the data set is more weight in the left tail of the distribution while skewness is less than zero there is more tail in the right tail of the distribution.

Kurtosis represents whether a distribution is heavy tailed in respect of the normal distribution. Kurtosis of a normal distribution is three, the data series having a kurtosis less than three is called a playkurtic and data series having a kurtosis greater than three is called a leptokurtic.

When I compared their skewness and kurtosis of the daily stock returns, I consider in my project I discovered that they are not normally distributed, I therefore considered using various error distributions in addition to the normal distribution.

Normal distribution also known as Gaussian distribution is symmetric about the mean. Skewness is zero and kurtosis equal to three.

Probability density function is given by

$$F(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}(\frac{x-\mu}{\sigma})^2} \qquad (4)$$

Generalized error distribution is used when the errors around the mean or the tails are of special interest.

Probability density function is given by

$$F(x) = \frac{\beta}{2\alpha\Gamma(1/\beta)} e^{-(\frac{[x-\mu]}{\alpha})^\beta} \qquad (5)$$

Students t distribution is identical to the normal distribution only a little bit shorter and fatter. T distribution is commonly used when have a small sample because when there is a large sample the t distribution become almost similar to normal distribution.

Probability density function is given by

$$F(x) = \frac{\Gamma\left[\frac{1}{2}(r+1)\right]}{\sqrt{r\pi}\,\Gamma(\frac{1}{2}r)(1+\frac{t^2}{r})^{(r+1)/2}} \qquad (6)$$

Skewed student t distribution is useful in robust statistical modeling and applicable with more complicated modeling situations.

$$F(x) = C_{a,b}^{-1}\{1 + \frac{t}{(a+b+t^2)^{\frac{1}{2}}}\}^{a+1/2}\{1 - \frac{t}{(a+b+t^2)^{1/2}}\}^{b+1/2} \quad (7)$$

2.1. Quantitative approach

Requirements to apply GARCH models : *Existence of the autocorrelation, ARCH effect and Stationarity*

a. Existence of the autocorrelation (Ljung-Box test) : The test determines if autocorrelation is existing in a time series.

H_0: The residuals are independently distributed.
H_A: The residuals are not independently distributed; they exhibit serial correlation.

b. *Existent of the ARCH effect (Arch Lagrange multiplier test)* *:* Test used to test for ARCH effects by regressing the squared errors on its lags

H_0: lagged regression coefficients are zero there are no ARCH effects.
H_A: there is ARCH effect

c. *Stationarity (Augmented Dickey-Fuller Test) :* Test for stationarity

H_0: Time series is not stationary.
H_A: Time series is stationary.

The stocks which satisfy above tests requirements, estimated the parameters for each GARCH model with four error distributions mentioned above.

d. Maximum likelihood maximizes the probability of getting the data observed under the assumed model. Prefer the models with larger likelihood values.

Then for the models which gives significant parameters under 5% significant level , forecast the test data (20% of the downloaded data) using rolling window forecast

e. *Rolling window forecast* repeatedly perform model fitting and forecast as time rolls forward. When compared to the other forecasting methods available rolling window forecast avoid lookback bias, less subject to overfitting and adopt forecast to new observations. I choose rolling window forecast as my forecasting approach because of the aforementioned benefits.

f. *Root Mean Square Error* is the standard deviation of the residuals. It indicates the absolute fit of the model to the data, provides in units of variable interest the model prediction error. As RMSE is negatively oriented scores, lower value are the better. Back testing is an approach to eval0uate model forecasting capability. It compares model predictions with actual historical value. Therefore the forecasted out of sample testing data was back tested using the RMSE. The model and the respective error distribution which delivers the least RMSE was selected as the best model to predict the financial volatility of the respective stock.

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\hat{y_i} - y_i)^2} \quad (8)$$

3. DISCUSSION AND RESULTS

Data

Yahoo Finance is a website that offers financial news, data, opinion, stock quotations, financial reports, press releases and original content as well as certain online tools for managing personal finances. They've provided statistics about stocks under eleven industries. Since Yahoo Finance is a leader among similar websites and most of the investors use it to get more information about the stocks they invest, I developed a method to obtain the best model to predict the financial volatility of the separate stocks in Yahoo finance. They have categorized their stocks under eleven industries. I have used my methodology for one stock from each category.

The stocks that I use in my analysis is Mastercard Incorporated (MA) of Financial Services, Apple Inc. (AAPL) of Technology , International Flavors & Fragrances Inc. (IFF) of Basic Materials, AstraZeneca PLC (AZN) of Healthcare, Freport-McMoRan Inc. (FCX) of Basic Materials , BCE Inc. (BCE) of Communication Services , AutoZone, Inc. (AZO) of Consumer Cyclical, Colgate-Palmolive Company (CL) of Consumer Defensive, Marathon Petroleum Corporation (MPC) of Energy, Deere & Company (DE) of Industrials, Prologis, Inc. (PLD) of Real Estate, National Grid plc (NGG) of Utilities

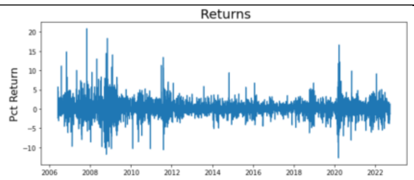
Table 2. Table of tests results before applying GARCH models

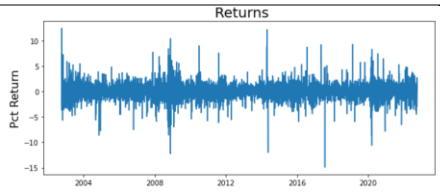
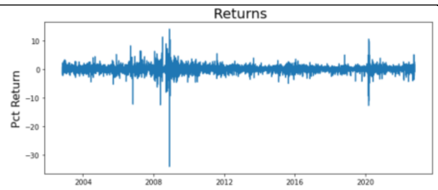
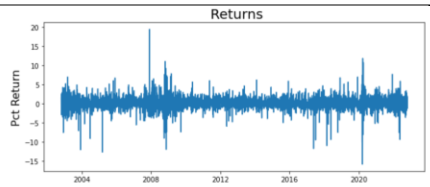
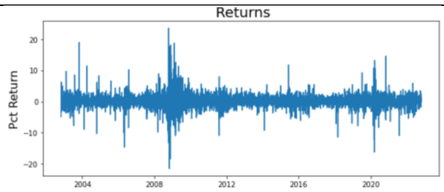
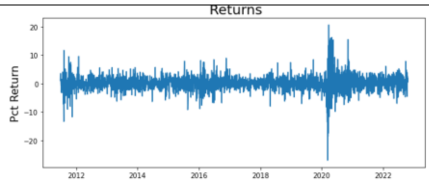
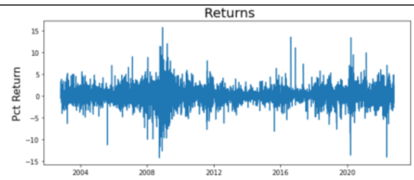
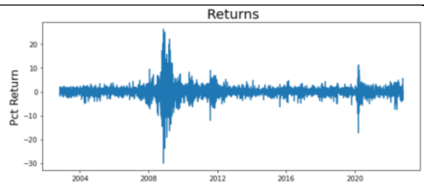
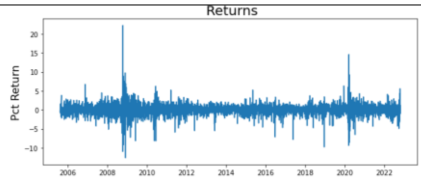
Sector	Stock	Existence of the autocorrelation Ljung-Box test	Existence of the ARCH effect Arch_Lagrange multiplier test	Stationarity Augmented Dickey-Fuller Test
Financial Services	MA	P value: 0.0001626< 0.05 Contain an autocorrelation	P value: 1.2263e-80 < 0.05 There is ARCH effect	Test statistic: -15.775<-2.86224 Series is stationary
Technology	AAPL	P value: 0.010<0.05 contain an autocorrelation	P value: 5.04-20<0.05 There is ARCH effect	Test statistic: -16.842<-2.8621 Series is stationary
Basic Materials	IFF	P value: 1.05e-09<0.05 contain an autocorrelation	P value: 5.188113e-40<0.05 There is ARCH effect-	Test statistic: 17.965<-2.8621 Series is stationary
Healthcare	AZN	P value: 0.012<0.05 contain an autocorrelation	P value: 2.41e-20<0.05 there is ARCH effect	Test statistic: -37.164<-2.8621 Series is stationary
Communication Services	BCE	P value: 6.18e-05<0.05 contain an autocorrelation	P value: 0.000537<0.05 there is ARCH effect	Test statistic: -14.55<-2.862 Series is stationary
Consumer Cyclical	AZO	P value: 1.74e-05<0.05 contain an autocorrelation	P value: 8.78294e-61<0.05 there is ARCH effect	Test statistic: - -1 -18.95<-2.862 Series is stationary

Consumer Defensive	CI	P value: 9.61<0.05 Does not contain an autocorrelation	P value: 3.60e-231<0.05 there is ARCH effect	Test statistic: -16.99< -2.862 Series is stationary
Energy	MPC	P value: 0.02<0.05 contain an autocorrelation	P value: 1.4e-101<0.05 there is ARCH effect	Test statistic: -10.54< -2.862 Series is stationary
Industrials	DE	P value: 0.041<0.05 contain an autocorrelation	P value: 1.44e-149<0.05 there is ARCH effect	Test statistic: -15.84 < -2.862 Series is stationary
Real Estate	PLD	P value: 2.8e-26<0.05 contain an autocorrelation	P value: 0.0<0.05 there is ARCH effect	Test statistic: -12.48< -2.862 Series is stationary
Utilities	NGG	P value: 1.09e-08<0.05 contain an autocorrelation	P value: 1.11e-134<0.05 there is ARCH effect	Test statistic: -12.48<-2.862 Series is stationary
Basic Materials	FCX	P value: 0.75221456>0.05 does not contain an autocorrelation	P value: 1.419572495<0.05 There is ARCH effect	Test statistic: -70.802<-2.862 Series is stationary

As CI and FCX stocks does not satisfy all the requirements to apply GARCH models, I had to stop it from further analyzing with GARCH models.

Table 3. Table of summary and identify the characteristics of each of the stock

Stock	Return series	Summary	Remarks
MA		Sample size: 4115 Std dev: 2.1540867 Mean: 0.1025750021 Minimum: -13.611137 maximum: 18.9349403 Skewness: 0.3312552 Kurtosis: 8.4279754	Skewness >0 ,data set is more weight in the left tail of the distribution. Kurtosis >3, stock is called a leptokurtic
AAPL		Sample size: 5031 Std dev: 2.12069252 Mean: 0.13022741965 Minimum: -19.7469677 maximum: 13.01942373 Skewness: -0.1213620 Kurtosis: 5.32769335	Skewness <0 is more tail in the right tail of the distribution Kurtosis >3, stock is called a leptokurtic
IFF		Sample size: 5032 Std dev: 1.62192985 Mean: 0.02815133872 Minimum: -17.3720838 maximum: 14.94218063 Skewness: -0.3774962 Kurtosis: 12.3414823	Skewness <0 is more tail in the right tail of the distribution Kurtosis >3, stock is called a leptokurtic

AZN		Sample size: 5032 Std dev: 1.6188790691 Mean: 0.0400042344061 Minimum: -16.144492721 maximum: 11.7270683779 Skewness: -0.257091614 Kurtosis: 8.4805078271	Skewness <0 is more tail in the right tail of the distribution. Kurtosis >3, stock is called a leptokurtic
BCE		Sample size: 5032 Std dev: 1.452378108 Mean: 0.036579467069 Minimum: -41.62325556 maximum: 13.125591525 Skewness: -5.10034476 Kurtosis: 146.2249511	Skewness <0 is more tail in the right tail of the distribution. Kurtosis >3, stock is called a leptokurtic
AZO		Sample size: 5032 Std dev: 1.6620032 Mean: 0.0659965640 Minimum: -17.360506 maximum: 17.7334013 Skewness: -0.733809 Kurtosis: 13.879115	Skewness <0 is more tail in the right tail of the distribution. Kurtosis >3, stock is called a leptokurtic
CI		Sample size: 5032 Std dev: 2.23000622 Mean: 0.06436445439 Minimum: -24.2216130 maximum: 21.13944815 Skewness: -0.3790749 Kurtosis: 14.7801536	Skewness <0 is more tail in the right tail of the distribution. Kurtosis >3, stock is called a leptokurtic
MPC		Sample size: 2852 Std dev: 2.61184073 Mean: 0.07477404460 Minimum: -31.4833037 maximum: 18.75457659 Skewness: -0.8189395 Kurtosis: 14.0439356	Skewness <0 is more tail in the right tail of the distribution. Kurtosis >3, stock is called a leptokurtic
DE		Sample size: 5032 Std dev: 2.053923 Mean: 0.063793386 Minimum: -15.32869 maximum: 14.576502 Skewness: -0.37842 Kurtosis: 6.929402	Skewness <0 is more tail in the right tail of the distribution. Kurtosis >3, stock is called a leptokurtic
PLD		Sample size: 5032 Std dev: 2.5626225 Mean: 0.0406902951 Minimum: -35.780618 maximum: 23.3803365 Skewness: -0.968881 Kurtosis: 28.588129	Skewness <0 is more tail in the right tail of the distribution. Kurtosis >3, stock is called a leptokurtic
NGG		Sample size: 4331 Std dev: 1.4916453 Mean: 0.0223441544 Minimum: -13.530802 maximum: 20.0764650 Skewness: 0.0118257 Kurtosis: 16.982694	Skewness >0 ,data set is more weight in the left tail of the distribution. Kurtosis >3, stock is called a leptokurtic

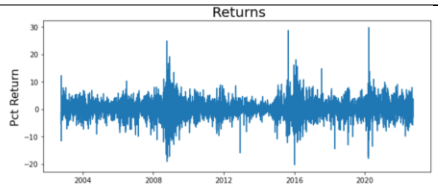
FCX		Sample size: 5031 Std dev: 3.3256103167 Mean: 0.0404018343362 Minimum: -22.731158298 maximum: 25.9935131870 Skewness: -0.221373630 Kurtosis: 5.6744845106	Skewness <0 is more tail in the right tail of the distribution. Kurtosis >3, stock is called a leptokurtic

Table 3. Summary of the stocks results with the best model to predict the financial volatility.

Stock	Models having significant parameters under 5% significant level	RMSE	Optimal model to forecast financial volatility
MA	GARCH **studentst**	3.2272116	EGARCH with generalized error distribution
	GARCH **skewstudent**	3.24771221	
	GARCH **generalized error**	3.194908120	
	EGARCH **normal**	3.213161	
	EGARCH **studentst**	3.207301574	
	EGARCH **skewstudent**	3.2269101556	
	EGARCH **generalized error**	3.176921062	
	GJR-GARCH **studentst**	3.238880	
	GJR-GARCH **skewstudent**	3.243022007	
	GJR-GARCH **generalized error**	3.23008497	
AAPL	GARCH **normal**	3.0554379105	EGARCH with Normal distribution
	GARCH **studentst**	3.0300564676	
	GARCH **generalized error**	2.994660528	
	EGARCH **normal**	2.9821861786	
	EGARCH **studentst**	3.028362615	
	EGARCH **generalized error**	3.004102875	
IFF	GARCH **normal**	2.852356678	EGARCH with generalized error distribution
	GARCH **studentst**	2.825615407	
	GARCH **skewstudent**	2.829377037	
	GARCH **generalized error**	2.809551274	
	EGARCH **studentst**	2.8126038971	
	EGARCH **skewstudent**	2.816068440	
	EGARCH **generalized error**	2.785429393	
	GJR-GARCH **generalized error**	2.83593810	
AZN	GARCH **normal**	2.372508377	EGARCH with generalized error distribution
	GARCH **generalized error**	2.35004894	
	EGARCH **normal**	2.37756455	
	EGARCH **studentst**	2.36381078	
	EGARCH **generalized error**	2.359806899	
BCE	EGARCH **normal**	1.6234388	EGARCH with generalized error distribution
	EGARCH **studentst**	1.606573	
	EGARCH **skewstudent**	1.610681	
	EGARCH **generalized error**	1.605467	
AZO	GARCH **normal**	2.31877	EGARCH with generalized error distribution
	EGARCH **normal**	2.31411	
	EGARCH **studentst**	2.32045	
	EGARCH **generalized error**	2.298631	

MPC	GARCH **normal**	3.325727	GARCH with generalized error distribution
	GARCH **studentst**	3.3226102	
	GARCH **skewstudent**	3.33014180	
	GARCH **generalized error**	3.318444	
	EGARCH **normal**	3.3665887	
	EGARCH **studentst**	3.3619474	
	EGARCH **skewstudent**	3.37073131	
	EGARCH **generalized error**	3.357866446	
DE	EGARCH **normal**	2.974024223	EGARCH with normal distribution
	EGARCH **studentst**	3.05230617	
	EGARCH **generalized error**	3.01201386	
	GJR-GARCH **studentst**	3.05620688	
PLD	GARCH **normal**	2.7265096	GARCH with generalized error distribution
	GARCH **studentst**	2.7419020	
	GARCH **skewstudent**	2.7461191	
	GARCH **generalized error**	2.73111514	
	EGARCH **normal**	2.73135173	
	EGARCH **studentst**	2.75167933	
	EGARCH **skewstudent**	2.755684568	
	EGARCH **generalized error**	2.73777791	
NGG	GARCH **normal**	2.320685463	EGARCH with generalized error distribution
	GARCH **generalized error**	2.30827224	
	EGARCH **normal**	2.29173722	
	EGARCH **studentst**	2.30162642	
	EGARCH **skewstudent**	2.301771939	
	EGARCH **generalized error**	2.28761365	

The results in detail of the stocks I conducted in analysis for the all eleven stocks are shown in the Annexures section below the references.

4. CONCLUSION

Throughout the project I have analyzed eleven stocks from each industry in Yahoo finance and come up with the best GARCH model and the error distribution which can be used to predict the financial volatility of that respective stock. By considering different GARCH family models and different error distributions in my analysis the final method I can propose to predict the financial volatility of the stocks is, first have to convert the downloaded adjusted close price data to return data and then should test the Ljung-Box test for the existence of the autocorrelation, ARCH LM test for test the existence of the ARCH effect and ADF test for stationarity. If the respective stock satisfies all the requirements, then can use it to the analysis using GARCH models. Then do a summary statistic of sample size, Standard. deviation, mean, maximum, skewness and kurtosis to understand about the stock we are going to predict the model. Then split the data into training and testing by taking 80% of the data for in sample data and 20% data for out of sample data. Using in sample data using maximum likelihood estimation find the parameters for each GARCH, EGARCH and GJR-GARCH model under normal, students t, skewed t and generalized error distribution. Then by considering the models which gives significant parameters under 5% significant level, using rolling window forecast predict the volatility for the out of sample data. Then calculate the RMSE for each predicted result and choose the model and the error distribution which gives the least value for the RMSE as the best model. Since I have developed the python program for the above method by entering the respective symbol for the stock in Yahoo finance, the investors can easily find the best model to predict the financial volatility. I have developed this only for GARCH(1,1), EGARCH(1,1) and GJR-GARCH(1,1) models as the initial analysis. But if we want to predict the volatility with higher order models, can use the same methodology I propose, and python program can be straightforwardly improved to satisfy that requirement. Even though I have considered only the financial background of the stocks when it comes to the actual scenario the stock prices can also affect by internal factors and by external factors such as economic, political and policy changes. This can be analysed by checking the existence of the structure break. This can be taken as a further improvement step of predicting the financial volatility.

REFERENCES

[1] T. I. TEAM, "Generalized AutoRegressive Conditional Heteroskedasticity (GARCH)," *Investopedia,* 2021.

[2] O. A. &. E. Haglund, "Financial Econometrics: A Comparison of GARCH," Uppsala University, 2014.

[3] W. Jiang, "Modeling and predicting of different stock markets with GARCH model," Upsala University, 2012.

[4] H. WAGNER, "Why Volatility is Important for Investors," [Online]. Available: https://www.investopedia.com/articles/financial-theory/08/volatility.asp. [Accessed 19 05 2022].

[5] C. N. a. O. K. U. Ekong, "Application of Garch Models to Estimate and Predict Financial Volatility of Daily Stock Returns in Nigeria," 2017.

ANNEXURES

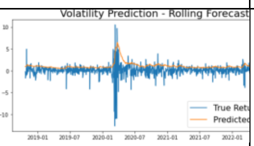
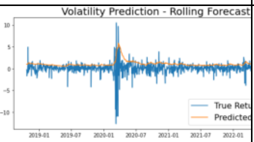
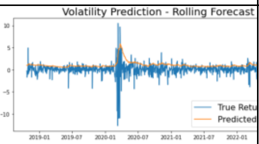
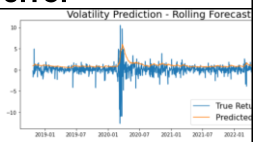
BCE Inc. (BCE) of Communication Services

Table 4. Table of BCE Inc. (BCE) of Communication Services

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	omega 0.20274 alpha[1] 0.00355 beta[1] 0.000	omega 0.001652 alpha[1] 0.000004 beta[1] 0.000000	omega 0.206019 alpha[1] 0.005291 gamma[1] 0.914683 beta[1] 0.000000
Studentst	Omega1.6348e-01 alpha[1] 6.573e-02 beta[1] 2.80e-114 nu 1.409e-30	omega 5.35145e-03 alpha[1] 5.6185e-06 beta[1] 0.0000e+00 nu 7.366108e-31	omega 1.31e-01 alpha[1]2.76e-02 gamma[1]3.27e-01 beta[1] 6.854890e-116 nu 2.841538e-30
skewstudent	omega 1.63045e-01 alpha[1] 6.4426e-02 beta[1] 5.5898e-116 eta 4.775424e-31 lambda 2.4053e-03	omega 4.42351e-03 alpha[1] 6.5908e-06 beta[1] 0.0000e+00 eta 1.818345e-31 lambda 2.2339e-03	omega 1.2376e-01 alpha[1] 2.279885e-02 gamma[1] 3.126e-01 beta[1] 3.590561e-121 eta 9.584287e-31

			lambda 2.1709e-03
generalized error	omega 1.14e-01 alpha[1] 2.1595e-02 beta[1] 1.1401e-203 nu 5.386608e-130	omega 4.7980e-03 alpha[1] 6.027e-06 beta[1] 0.000e+00 nu 1.5430e-125	omega 1.309e-01 alpha[1] 1.6441e-02 gamma[1] 4.7656e-01 beta[1] 9.453863e-175 nu 1.651255e-128

Table 5. Table of forecasted results for test data for the models and distributions having 5% significant parameters and RMSE

	normal	**studentst**	**Skewstudent**	**generalized error**
EGARCH	 RMSE : 1.6234388	 RMSE : 1.606573	 RMSE : 1.610681	 RMSE : 1.605467

The model with the least RMSE is EGARCH with generalized error distribution. Therefore, EGARCH with generalized error distribution is the best model to predict “BCE” stock.

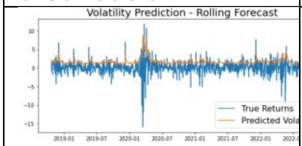
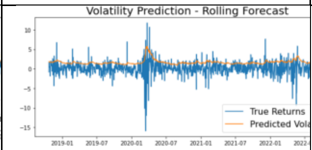
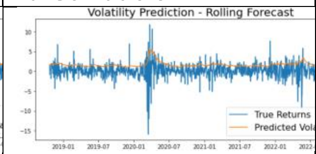
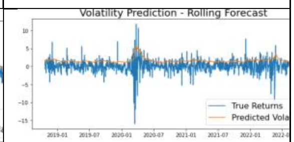
AutoZone, Inc. (AZO) of Consumer Cyclical

Table 6. Table of estimated parameters for AZO stock

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	omega 1.2e-02 alpha[1] 6.8e-03 beta[1] 2.2e-29	omega 0.003 alpha[1] 0.00002 beta[1] 0.00	omega 5.6e-03 alpha[1] 1.3e-01 gamma[1] 2.2e-03 beta[1] 1.3e-42
Studentst	omega 8.490e-02 alpha[1] 1.869e-02 beta[1] 1.148e-122 nu 8.03898e-58	omega 1.088e-04 alpha[1] 1.269e-11 beta[1] 0.000e+00 nu 2.59633e-56	omega 1.15918e-01 alpha[1] 6.5830e-02 gamma[1] 5.693e-02 beta[1] 5.38522e-51 nu 6.057138e-54
Skewstudent	omega 9.060e-02 alpha[1] 2.0588e-02 beta[1] 2.306e-116	omega 1.1516e-04 alpha[1] 1.571e-11 beta[1] 0.000e+00	omega 1.1531e-01 alpha[1] 6.6697e-02 gamma[1] 5.400e-02

	eta 1.15865e-57 lambda 7.264e-02	eta 4.50269e-56 lambda 8.096e-02	beta[1] 1.71785e-51 eta 6.331076e-54 lambda 5.6740e-02
generalized error	omega 1.928e-01 alpha[1] 9.1246e-02 beta[1] 3.2795e-26 nu 5.9141e-186	omega 2.475e-04 alpha[1] 1.7919e-10 beta[1] 0.000e+00 nu 2.873900e-183	omega 4.253e-02 alpha[1] 5.7845e-02 gamma[1] 1.11e-02 beta[1] 1.0588e-40 nu 8.61354e-190

Table 7. The table of forecast results for test data for the models and distributions having 5% significant parameters and calculated RMSE

GARCH normal distribution	**EGARCH normal distribution**	**EGARCH studentst distribution**	**generalized error**
			
RMSE : 2.31877	RMSE : 2.31411	RMSE : 2.32045	RMSE : 2.298631

The model with the least RMSE is EGARCH with generalized error distribution. Therefore, EGARCH with generalized error distribution is the best model to predict “AZO” stock

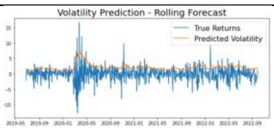
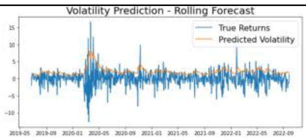
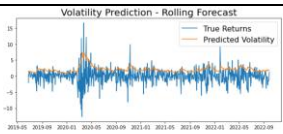
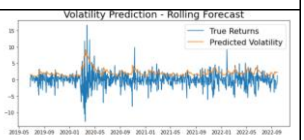
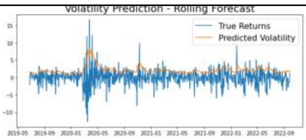
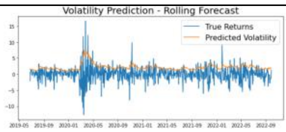
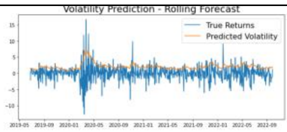
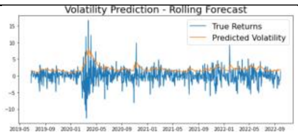
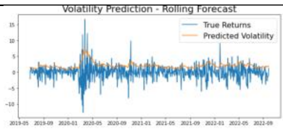
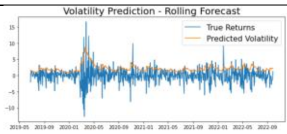
Mastercard Incorporated (MA) of Financial Services

Table 8. Table of estimated parameters of mastercard Incorporated (MA) of Financial Services

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	omega 1.395159e-01 alpha[1] 9.846718e-03 beta[1] 7.273999e-155	omega 2.507145e-03 alpha[1] 2.049520e-07 beta[1] 0.000000e+00	omega 1.212589e-01 alpha[1] 1.391068e-03 gamma[1] 5.985390e-02 beta[1] 1.552e-147
studentst	omega 2.9367e-03 alpha[1] 2.14630e-06 beta[1] 5.369e-268 Nu 6.1133e-43	omega 3.1177e-05 alpha[1] 1.20407e-15 beta[1] 0.0000e+00 nu 1.078697e-43	omega 1.251423e-04 alpha[1] 1.101004e-05 gamma[1] 4.4217e-07 beta[1] 0.000000e+00 nu 2.343961e-41
skewstudent	omega 3.6771e-03 alpha[1] 3.954e-06 beta[1] 6.90e-263 eta	omega 3.514164e-05 alpha[1] 6.845e-15 beta[1] 0.00000e+00 eta 2.324170e-43	omega 2.038805e-04 alpha[1] 1.273822e-05 gamma[1] 3.3417e-07 beta[1]

	1.39e-42 lambda 3.174e-03	lambda 5.96768e-03	0.000000e+00 eta 1.386766e-42 lambda 1.578003e-03
generalized error	omega 1.145525e-02 alpha[1] 6.618942e-05 beta[1] 6.42910e-223 nu 4.519689e-154	omega 8.347588e-05 alpha[1] 2.9101e-13 beta[1] 0.0000e+00 nu 4.771790e-160	omega 4.660530e-04 alpha[1] 2.660325e-05 gamma[1] 2.0067e-05 beta[1] 0.000000e+00 nu 3.379772e-139

Table 9. Table of forecasted results for test data for the models and distributions having 5% significant parameters and calculate RMSE

Error Distribution	GARCH	EGARCH	GJR-GARCH
Normal	Parameters not significant	 RMSE : 3.213161	Parameters not significant
studentst	 RMSE : 3.2272116	 RMSE : 3.207301574	 RMSE : 3.238880
skewstudent	 RMSE : 3.24771221	 RMSE : 3.2269101556	 RMSE : 3.243022007
generalized erro r	 RMSE : 3.194908120	 RMSE : 3.176921062	 RMSE : 3.23008497

The model with the least RMSE is EGARCH with normal distribution. Therefore, EGARCH with generalized error distribution is the best model to predict “MA” stock

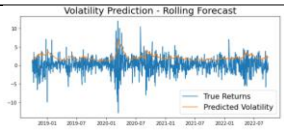
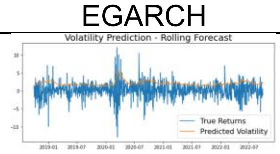
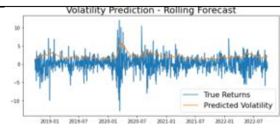
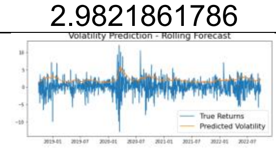
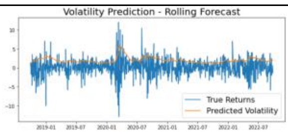
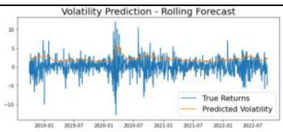
Apple Inc. (AAPL) of Technology

Table 10. Table of estimated parameters of Apple Inc. (AAPL) of Technology

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	omega 0.037843 alpha[1] 0.000351 beta[1] 0.000000	omega 2.850778e-03 alpha[1] 9.985665e-07 beta[1] 0.000000e+00	omega 2.509852e-01 alpha[1] 2.457445e-02 gamma[1] 1.441020e-01 beta[1] 3.968133e-160

studentst	omega 3.944014e-02 alpha[1] 1.912305e-05 beta[1] 0.000000e+00 nu 2.795838e-47	omega 1.923935e-04 alpha[1] 4.137247e-12 beta[1] 0.000000e+00 nu 1.267238e-45	omega 2.270800e-01 alpha[1] 6.053170e-03 gamma[1] 5.603665e-02 beta[1] 7.163142e-288 nu 9.819923e-40
skewstudent	omega 4.267351e-02 alpha[1] 2.738194e-05 beta[1] 0.000000e+00 eta 1.375982e-47 lambda 8.589604e-02	omega 2.028276e-04 alpha[1] 8.448563e-12 beta[1] 0.000000e+00 eta 7.823888e-46 lambda 1.397937e-01	omega 2.376720e-01 alpha[1] 6.977834e-03 gamma[1] 6.121363e-02 beta[1] 1.207167e-270 eta 5.387684e-40 lambda 1.040708e-01
generalized error	omega 2.385144e-02 alpha[1] 1.911001e-05 beta[1] 0.000000e+00 nu 1.060695e-244	omega 2.928753e-04 alpha[1] 1.002191e-10 beta[1] 0.000000e+00 nu 7.649530e-234	omega 1.875967e-01 alpha[1] 9.093174e-03 gamma[1] 6.077708e-02 beta[1] 2.636472e-262 nu 3.006824e-199

Table 11. Table of forecasted results for test data for the models and distributions having 5% significant parameters and calculate RMSE

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	 RMSE : 3.0554379105	 RMSE : 2.9821861786	Parameters not significant
studentst	 RMSE : 3.0300564676	 RMSE : 3.028362615	Parameters not significant
skewstudent	Parameters not significant	Parameters not significant	Parameters not significant
generalized error	 RMSE : 2.994660528	 RMSE : 3.004102875	Parameters not significant

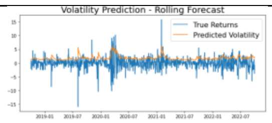
The model with the least RMSE is EGARCH with normal distribution. Therefore, EGARCH with normal distribution is the best model to predict “AAPL” stock.

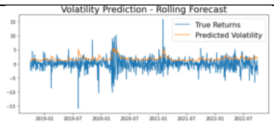
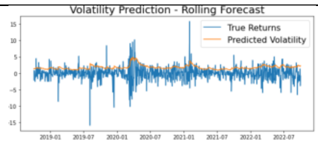
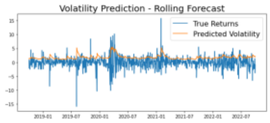
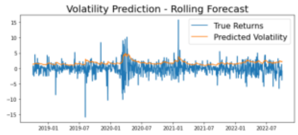
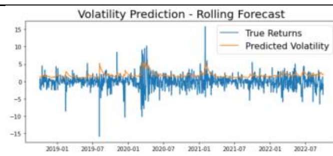
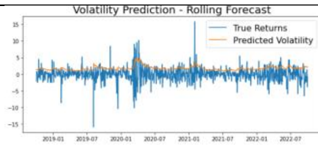
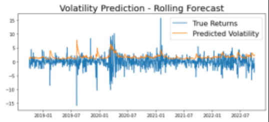
International Flavors & Fragrances Inc. (IFF) of Basic Materials

Table 12. Table of estimated parameters of International Flavors & Fragrances Inc. (IFF) of Basic Materials

Error Distribution	GARCH	EGARCH	GJR-GARCH
Normal	omega 6.435068e-03 alpha[1] 5.804559e-04 beta[1] 8.022218e-53	omega 1.304190e-01 alpha[1] 1.885852e-02 beta[1] 1.776633e-191	omega 8.331163e-04 alpha[1] 6.203176e-02 gamma[1] 1.015458e-02 beta[1] 2.585830e-48
studentst	omega 2.461307e-02 alpha[1] 5.370186e-03 beta[1] 9.919301e-69 nu 1.320771e-50	omega 2.274073e-04 alpha[1] 3.473125e-10 beta[1] 0.000000e+00 nu 1.700102e-51	omega 1.762790e-02 alpha[1] 5.789287e-02 gamma[1] 3.569875e-03 beta[1] 4.667061e-67 nu 1.137332e-47
skewstudent	omega 2.630941e-02 alpha[1] 5.923447e-03 beta[1] 5.809718e-68 eta 1.015892e-50 lambda 3.547610e-02	omega 2.369150e-04 alpha[1] 4.8442e-10 beta[1] 0.000e+00 eta 1.171653e-51 lambda 4.5572e-02	omega 1.646483e-02 alpha[1] 6.105073e-02 gamma[1] 3.0873e-03 beta[1] 6.3352e-70 eta 9.600412e-48 lambda 1.450618e-02
generalized error	omega 1.230317e-02 alpha[1] 2.086738e-03 beta[1] 1.209606e-59 nu 6.096261e-161	omega 5.302777e-03 alpha[1] 3.76308e-06 beta[1] 0.0000e+00 nu 1.223717e-168	omega 5.986145e-03 alpha[1] 4.741850e-02 gamma[1] 1.7045e-03 beta[1] 8.595720e-56 nu 2.111401e-163

Table 13. Table of forecasted results for test data for the models and distributions having 5% significant parameters and calculate RMSE

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	 RMSE : 2.8523566788	Parameters not significant	Parameters not significant

studentst	 RMSE : 2.8256154071	 RMSE : 2.8126038971	Parameters not significant
skewstudent	 2.8293770370	 2.816068440	Parameters not significant
generalized err or	 RMSE : 2.8095512738	 RMSE : 2.785429393	 RMSE : 2.83593810

The model with the least RMSE is EGARCH with normal distribution. Therefore, EGARCH with generalized error distribution is the best model to predict “IFF” stock

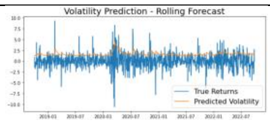
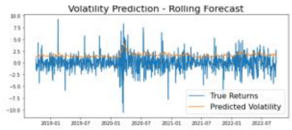
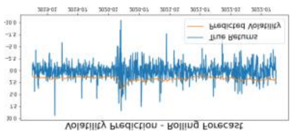
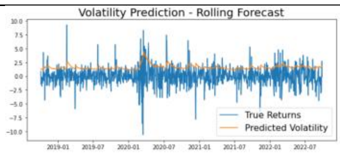
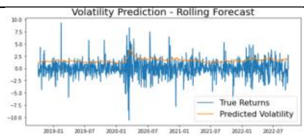
AstraZeneca PLC (AZN) of healthcare

Table 14. Table of estimated parameters of AstraZeneca PLC (AZN) of Healthcare

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	omega 9.879839e-03 alpha[1] 5.124522e-05 beta[1] 2.116535e-289	omega 7.553385e-04 alpha[1] 2.308085e-08 beta[1] 0.000000e+00	omega 1.762892e-02 alpha[1] 1.994691e-02 gamma[1] 9.226650e-01 beta[1] 1.336653e-229
studentst	omega 2.458140e-01 alpha[1] 7.077735e-02 beta[1] 1.043878e-95 nu 7.521483e-54	omega 7.127241e-03 alpha[1] 8.369935e-06 beta[1] 0.000000e+00 nu 5.966435e-53	omega 1.534753e-01 alpha[1] 8.318352e-02 gamma[1] 6.956408e-02 beta[1] 6.726963e-174 nu 1.344450e-52
skewstudent	ga 2.361924e-01 alpha[1] 6.545881e-02 beta[1] 4.948810e-98 eta 7.752958e-54 lambda 1.746932e-01	ome omega 6.612512e-03 alpha[1] 6.897188e-06 beta[1] 0.000000e+00 eta 7.251396e-53 lambda 1.993293e-01	omega 1.451257e-01 alpha[1] 8.099594e-02 gamma[1] 6.157479e-02 beta[1] 2.131588e-180 eta 1.562024e-52 lambda 1.486805e-01

generalized error	omega 4.793543e-02 alpha[1] 2.295494e-03 beta[1] 1.007289e-183 nu 1.203022e-192	omega 5.302777e-03 omega 1.828630e-03 alpha[1] 1.456297e-07 beta[1] 0.000000e+00 nu 1.069654e-180	omega 4.162509e-02 alpha[1] 2.423167e-02 gamma[1] 3.065052e-01 beta[1] 1.471623e-220 nu 4.525370e-190

Table 15. Table of forecasted results for test data for the models and distributions having 5% significant parameters and calculate RMSE

Error Distribution	GARCH	EGARCH	GJR-GARCH
Normal	 RMSE : 2.372508377	 RMSE: 2.37756455	Parameters not significant
Studentst	Parameters not significant	 RMSE : 2.36381078	Parameters not significant
skewstudent	Parameters not significant	Parameters not significant	Parameters not significant
generalized error	 RMSE : 2.35004894	 RMSE : 2.359806899	Parameters not significant

The model with the least RMSE is EGARCH with normal distribution. Therefore, GARCH with generalized error distribution is the best model to predict “AZN” stock

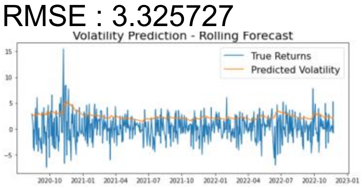
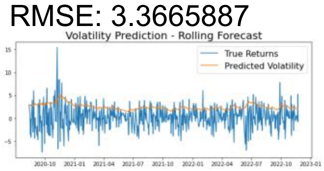
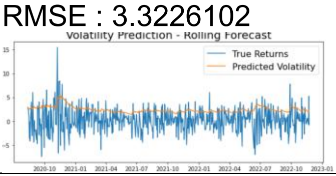
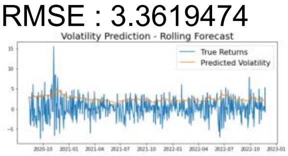
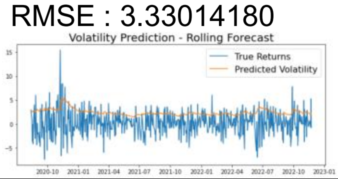
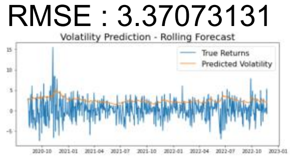
Marathon Petroleum Corporation (MPC) of Energy

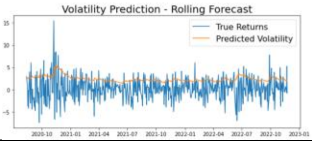
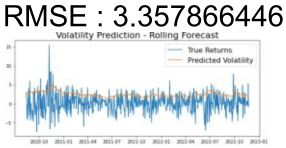
Table 16. Table of estimated parameters of Marathon Petroleum Corporation (MPC) of Energy

Error Distribution	GARCH	EGARCH	GJR-GARCH
Normal	omega 1.632695e-02 alpha[1] 6.948400e-05 beta[1] 8.591417e-308	omega 2.738128e-03 alpha[1] 1.0779e-07 beta[1] 0.0000e+00	omega 0.002056 alpha[1] 0.428250 gamma[1] 0.000038 beta[1] 0.000000
Studentst	omega 7.009651e-03 alpha[1] 9.094778e-06	omega 1.39558e-03 alpha[1] 2.3083e-09	omega 1.12808e-03 alpha[1] 2.93755e-01

	beta[1] 0.00000e+00 nu 1.894619e-17	beta[1] 0.0000e+00 nu 7.67493e-17	gamma[1] 1.7456e-06 beta[1] 0.00000e+00 nu 4.131360e-16
skewstudent	omega 5.349792e-03 alpha[1] 2.8729e-06 beta[1] 0.0000e+00 eta 2.436526e-17 lambda 6.1049e-05	omega 1.18901e-03 alpha[1] 5.0923e-10 beta[1] 0.0000e+00 eta 8.22951e-17 lambda 4.0087e-0	omega 5.910208e-04 alpha[1] 2.87364e-01 gamma[1] 7.8388e-07 beta[1] 0.00000e+00 eta 5.734457e-16 lambda 1.191685e-04
generalized error	omega 8.231085e-03 alpha[1] 1.162689e-05 beta[1] 0.0000e+00 nu 2.605761e-117	omega 1.611409e-03 alpha[1] 5.4364e-09 beta[1] 0.000e+00 nu 3.2821e-112	omega 1.341109e-03 alpha[1] 3.1780e-01 gamma[1] 5.4354e-06 beta[1] 0.0000e+00 nu 5.741533e-114

Table 17. Table of forecasted results for test data for the models and distributions having 5% significant parameters and calculate RMSE

Error Distribution	GARCH	EGARCH	GJR-GARCH
Normal	RMSE : 3.325727 	RMSE: 3.3665887 	Parameters not significant
Studentst	RMSE : 3.3226102 	RMSE : 3.3619474 	Parameters not significant
skewstudent	RMSE : 3.33014180 	RMSE : 3.37073131 	Parameters not significant

generalized error	RMSE : 3.318444 	RMSE : 3.357866446 	Parameters not significant

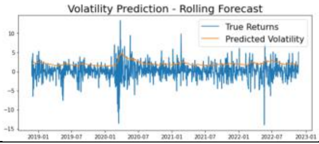
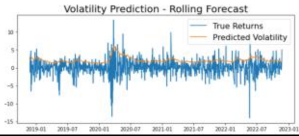
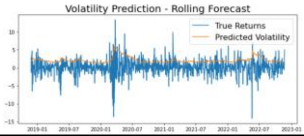
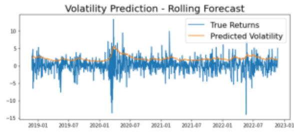
The model with the least RMSE is EGARCH with normal distribution. Therefore, GARCH with generalized error distribution is the best model to predict “**MPC**” stock

Deere & Company (DE) of Industrials, Prologis

Table 18. Table of estimated parameters of Marathon Petroleum Corporation (DE) of Energy

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	omega 0.069782 alpha[1] 0.000160 beta[1] 0.000000	omega 0.000378 alpha[1] 0.000451 beta[1] 0.000000	omega 0.034354 alpha[1] 0.589924 gamma[1] 0.011536 beta[1] 0.000000
studentst	omega 1.170195e-01 alpha[1] 1.679300e-06 beta[1] 0.00000e+00 nu 4.201452e-33	omega 3.384018e-04 alpha[1] 1.344933e-17 beta[1] 0.000000e+00 nu 4.230364e-30	omega 2.969886e-02 alpha[1] 3.895633e-02 gamma[1] 2.596847e-06 beta[1] 0.000000e+00 nu 3.419114e-31
skewstudent	omega 1.222654e-01 alpha[1] 1.780340e-06 beta[1] 0.000000e+00 eta 5.933093e-33 lambda 1.854345e-01	omega 3.060351e-04 alpha[1] 1.545094e-17 beta[1] 0.000000e+00 eta 5.979936e-30 lambda 2.153720e-01	omega 3.145138e-02 alpha[1] 3.868710e-02 gamma[1] 3.084367e-06 beta[1] 0.000000e+00 eta 3.721964e-31 lambda 2.016274e-01
generalized error	omega 6.752008e-02 alpha[1] 6.294386e-06 beta[1] 0.000000e+00 nu 4.757543e-126	omega 6.983625e-05 alpha[1] 5.492423e-10 beta[1] 0.000000e+00 nu 5.594225e-110	omega 2.011220e-02 alpha[1] 1.202777e-01 gamma[1] 8.779806e-05 beta[1] 0.000000e+00 nu 7.276945e-118

Table 19. Table of forecasted results for test data for the models and distributions having 5% significant parameters and calculate RMSE

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	Parameters not significant	RMSE: 2.974024223 	Parameters not significant
studentst	Parameters not significant	RMSE : 3.05230617 	RMSE : 3.05620688 
skewstudent	Parameters not significant	Parameters not significant	Parameters not significant
generalized error	Parameters not significant	RMSE : 3.01201386 	Parameters not significant

The model with the least RMSE is EGARCH with normal distribution. Therefore, EGARCH with normal distribution is the best model to predict "DE" stock

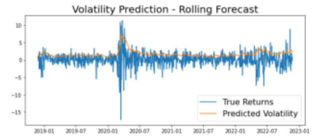
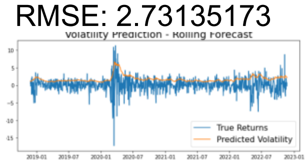
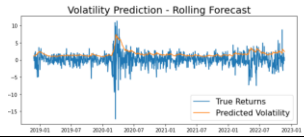
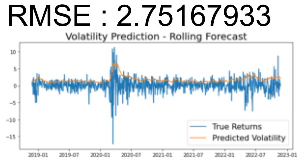
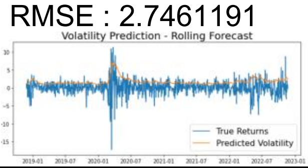
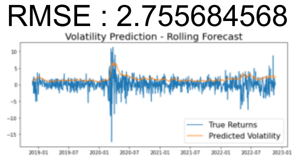
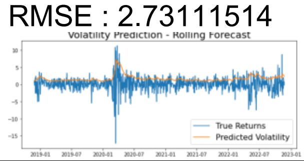
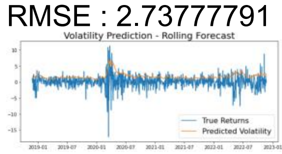
Prologis, Inc. (PLD) of Real Estate

Table 20. Table of estimated parameters of Marathon Petroleum Corporation (PLD) of Energy

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	omega 6.185582e-04 alpha[1] 9.434617e-11 beta[1] 0.000000e+00	omega 2.099536e-04 alpha[1] 2.207788e-15 beta[1] 0.000000e+00	omega 0.000079 alpha[1] 0.057960 gamma[1] 0.000002 beta[1] 0.000000
studentst	omega 6.326705e-04 alpha[1] 2.264311e-13 beta[1] 0.000000e+00 nu 3.679051e-18	omega 1.301269e-04 alpha[1] 3.250385e-19 beta[1] 0.000000e+00 nu 1.422615e-18	omega 2.373790e-05 alpha[1] 5.949486e-02 gamma[1] 1.204788e-07 beta[1] 0.000000e+00 nu 6.942600e-18
skewstudent	omega 4.300233e-04 alpha[1] 6.117431e-14 beta[1] 0.000000e+00	omega 3.852412e-05 alpha[1] 1.460392e-19 beta[1] 0.000000e+00	omega 7.286773e-06 alpha[1] 1.396549e-01 gamma[1] 9.911944e-09

	eta 2.319993e-18 lambda 5.212712e-08	eta 5.858088e-19 lambda 6.219713e-08	beta[1] 0.000000e+00 eta 6.252703e-18 lambda 3.743984e-09
generalized error	omega 4.363963e-04 alpha[1] 2.415514e-12 beta[1] 0.000000e+00 nu 3.012412e-196	omega 1.349878e-04 alpha[1] 7.614329e-18 beta[1] 0.000000e+00 nu 5.938588e-186	omega 2.675232e-05 alpha[1] 6.129856e-02 gamma[1] 2.823658e-07 beta[1] 0.000000e+00 nu 4.128049e-200

Table 21. Table of forecasted results for test data for the models and distributions having 5% significant parameters and calculate RMSE

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	RMSE : 2.7265096 	RMSE: 2.73135173 	Parameters not significant
studentst	RMSE : 2.7419020 	RMSE : 2.75167933 	Parameters not significant
skewstudent	RMSE : 2.7461191 	RMSE : 2.755684568 	Parameters not significant
generalized error	RMSE : 2.73111514 	RMSE : 2.73777791 	Parameters not significant

The model with the least RMSE is EGARCH with normal distribution. Therefore, GARCH with normal distribution is the best model to predict "PLD" stock

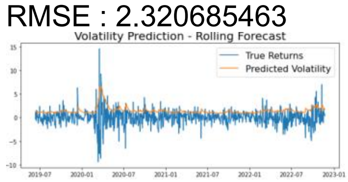
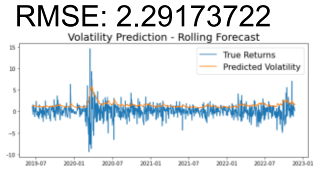
National Grid plc (NGG) of Utilities

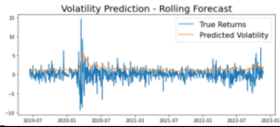
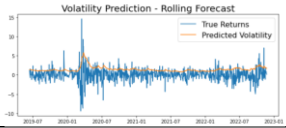
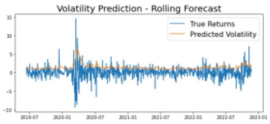
Table 22. Table of estimated parameters of Marathon Petroleum Corporation (NGG) of Energy

Error Distribution	GARCH	EGARCH	GJR-GARCH
normal	omega 1.023630e-02	omega 0.013407	omega 8.275453e-03

	alpha[1] 5.236296e-04 beta[1] 3.558621e-103	alpha[1] 0.000012 beta[1] 0.000000	alpha[1] 2.062482e-02 gamma[1] 9.496625e-02 beta[1] 5.168364e-108
studentst	omega 6.876216e-02 alpha[1] 8.791721e-03 beta[1] 7.908193e-167 nu 1.423666e-23	omega 1.417682e-02 alpha[1] 3.968682e-05 beta[1] 0.000000e+00 nu 2.019823e-23	omega 5.243262e-02 alpha[1] 7.773132e-03 gamma[1] 1.196085e-01 beta[1] 9.475872e-162 nu 5.124489e-23
skewstudent	omega 5.660211e-02 alpha[1] 6.042511e-03 beta[1] 2.423186e-183 eta 7.816257e-23 lambda 2.416157e-05	omega 9.882932e-03 alpha[1] 1.557527e-05 beta[1] 0.000000e+00 eta 1.742434e-22 lambda 1.958503e-05	omega 4.522831e-02 alpha[1] 5.881127e-03 gamma[1] 1.094188e-01 beta[1] 3.344913e-171 eta 2.904843e-22 lambda 1.922544e-05
generalized error	omega 2.177694e-02 alpha[1] 1.520056e-03 beta[1] 4.496996e-143 nu 2.379015e-124	omega 1.205204e-02 alpha[1] 1.443601e-05 beta[1] 0.000000e+00 nu 4.130999e-124	omega 1.385409e-02 alpha[1] 6.489144e-03 gamma[1] 6.309754e-02 beta[1] 2.479233e-156 nu 4.945182e-119

Table 23. Table of forecasted results for test data for the models and distributions having 5% significant parameters and calculate RMSE

Error Distribution	GARCH	EGARCH	GJR-GARCH
Normal	RMSE : 2.320685463 	RMSE: 2.29173722 	Parameters not significant

studentst	Parameters not significant	RMSE : 2.30162642 	Parameters not significant
skewstudent	Parameters not significant	RMSE : 2.301771939 	Parameters not significant
generalized error	RMSE : 2.30827224 	RMSE : 2.28761365 	Parameters not significant

The model with the least RMSE is EGARCH with normal distribution. Therefore, EGARCH with generalized error distribution is the best model to predict “NGG” stock