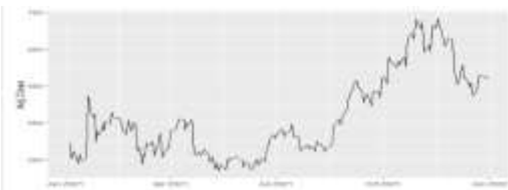
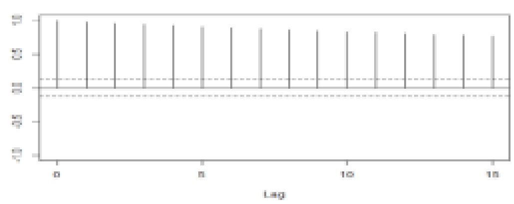
Goal: we are looking at Netflix stock data, it has daily stock values for year 2021 with 251 observations. We want to fit the best ARIMA and GARCH model for the Netflix data, in order to predict the stock closing price.

Method: we are going to fit a good Arima model we fit a Garch model.

We first need to transform the data into a time series object. With this we can create a time series model, Autocorrelation Function, and Partial Autocorrelation Function to determine the autoregressive value (p), difference, and moving average. We will first look at the time series model and see if it is stationary or not, if it is stationary, we do not need to use a difference function. With this information we can create a few different test models and calculate their Akaike Information Criterion correlated (AICc), and those with the lowest AICc will fit the data the best. We will also use the Auto ARIMA function and to see how its AICc compares to the ones we tested. Finally, we will use the Ljung- Box-lack of fit test to calculate the p-value for the model, if it is greater than 0.05 then we can conclude it fits the data well.

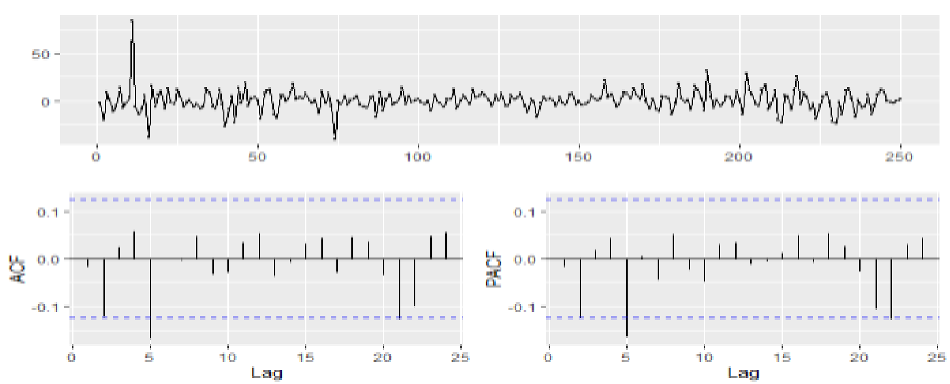
First, we select the adjusted close price variable, and we change it to a time series object using the ts function. Then we plot the time series TS plus ACF and the PACF plots.





It is clear from the graph and the ACF that the time series is not stationary, therefore we need to make differencing of order 1 (d=1) , in order to make stationary.

After doing the differencing we see that the variance is constant, hence no need to do box cox transformation.



Our aim now is to find an appropriate ARIMA(p,q) model based on the ACF and PACF in the first 3 lags we can see some significant spike in the ACF in lag 2 suggesting a MA(1). From the PACF we can see a significant spike at lag 2 as well, suggesting an autoregressive AR (1).

```
Series: netflix_1$Adj.Close
ARIMA(1,1,1)

Coefficients:
         ar1      ma1
      0.7541  -0.8123
s.e.  0.2429   0.2149

sigma^2 = 121.7:  log likelihood = -953.93
AIC=1913.86   AICc=1913.95   BIC=1924.42
```

Consequently, we begin with an ARIMA (1,1,1) model.

The model is significant no 0 is included in the 2 Standard error intervals for both coefficient of AR and MA. Also, the model has a small AICc, and BIC

2s.e. interval for AR = 0.2683, 1.2399.

2s.e. interval for MA= -1.2421, -0.3825.

We want to test other ARIMA models with different p and q such as: ARIMA (0,1,0), ARIMA (0,1,1), ARIMA (1,1,0), ARIMA (1,1,2), ARIMA (2,1,1).

For ARIMA (0,1,0): there is no coefficient estimate for AR, but the AICc (1911.83) and the BIC (1915.34) are both small.   Also, using auto. Arima function gives a similar model Arima (0,1,0)

For ARIMA (0,1,1), ARIMA (1,1,0), ARIMA (1,1,2), ARIMA (2,1,1) the coefficient estimate is not significant in all these models since 0 is included in the 2 standard error intervals.

Form this we can conclude that a good model to fit is ARIMA (1,1,1).

Now we will fit a GARCH model:

First, we start by fitting a GARCH (1,1) model to our Arima (1,1,1) defining the distribution to be normal. We can see that this model is not a good a fit since the Adjusted Pearson Goodness-of-Fit Test p-values are not all bigger than 0.05. from this we can that there is heavy tailed in the qq plot. Meaning that the data might follow a t-distribution.

Then, we try to fit a GARCH (1,1) model to Arima (1,1,1), with a t-distribution.

```
Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     16.56       0.6196
2    30     26.00       0.6255
3    40     31.92       0.7821
4    50     40.80       0.7914
```

first, All the Adjusted Pearson Goodness-of-Fit Test p-values are bigger than 0.05.

however in this alpha (0.2)is not significant because of its big p-value > 0.05 . therefore we will take out from our model.

hence, we will a fit the following model ARIMA (1,1,1) GARCH (0,1) with a student's t-distribution.

We get the following result.

```
Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     12.72       0.8526
2    30     20.96       0.8606
3    40     25.52       0.9527
4    50     31.60       0.9746
```

All the Adjusted Pearson Goodness-of-Fit Test p-values are bigger than 0.05.

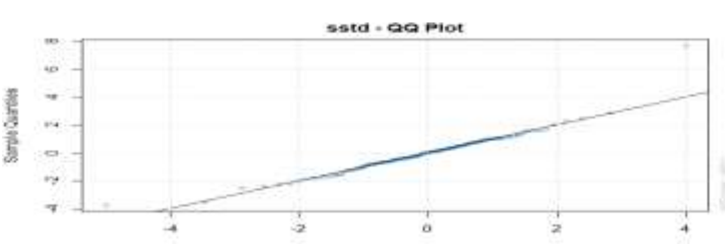
```
Optimal Parameters
------------------------------------
        Estimate  Std. Error    t value Pr(>|t|)
mu       0.19664    0.509406    0.38601 0.699489
ar1      0.59623    0.174749    3.41189 0.000645
ma1     -0.68295    0.158770   -4.30151 0.000017
omega    0.32495    0.327777    0.99137 0.321506
beta1    0.99728    0.002899  344.02210 0.000000
skew     0.89532    0.076923   11.63913 0.000000
shape    3.28940    0.483807    6.79901 0.000000
```

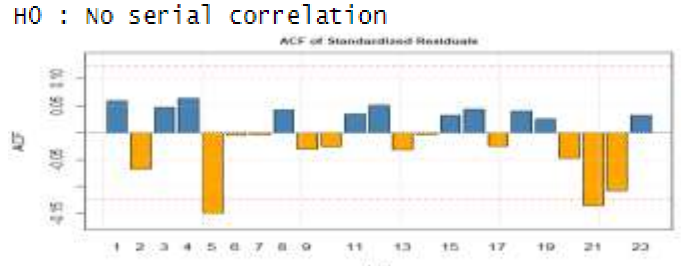
All the coefficients' parameters are significant with a p-value less than 0.05

The Ljung-Box test also shows that the residuals have no remaining autocorrelations.

```
Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.8814  0.3478
Lag[2*(p+q)+(p+q)-1][5]    3.6878  0.1394
Lag[4*(p+q)+(p+q)-1][9]    6.3498  0.2038
d.o.f=2
H0 : No serial correlation
```

Also this model the lowest AICc = 7.3801 and the biggest loglikelihood = -915.5159. The following are the ACF of Standardized Residuals and QQ-Plot of Standardized Residuals .





Final ARIMA-GARCH Model: ARIMA (1,1,1)-GARCH (0,1):

$Y_t = 0.19664 + 0.59623Y_{t-1} + \varepsilon_t - 0.68295\ \varepsilon_{t-1}$

$\varepsilon_t = \sigma_t z_t$

$\sigma_t^2 = 0.32495 + 0.99728\ \sigma_t^2$

Forecasting: Thus, we fit the final ARIMA (1,1,1) GARCH (0,1) in order to predict the next closing stock price, the next 20 days. Using ugarchforecast function.