Programming Assignment in R

TIME SERIES ANALYSIS (MAL7430)

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Dataset

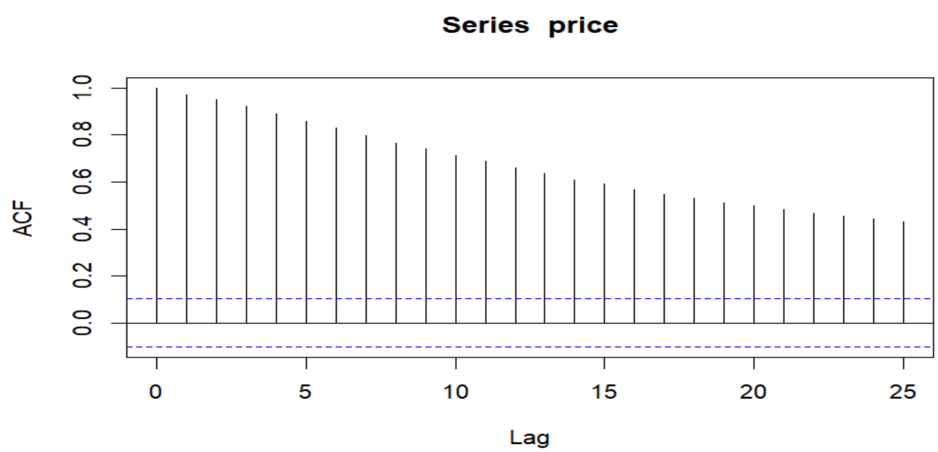
Firstly, Download the dataset from Investing.com and import in the dataset.We have shown the portion of our dataset which is “DOGECOIN in US Dollars”. We have taken daily prices of length of one year(From 2022-03-25 to 2023-03-24). From which we have done model fitting on the closing price column, which is named as “Price” in the data below.

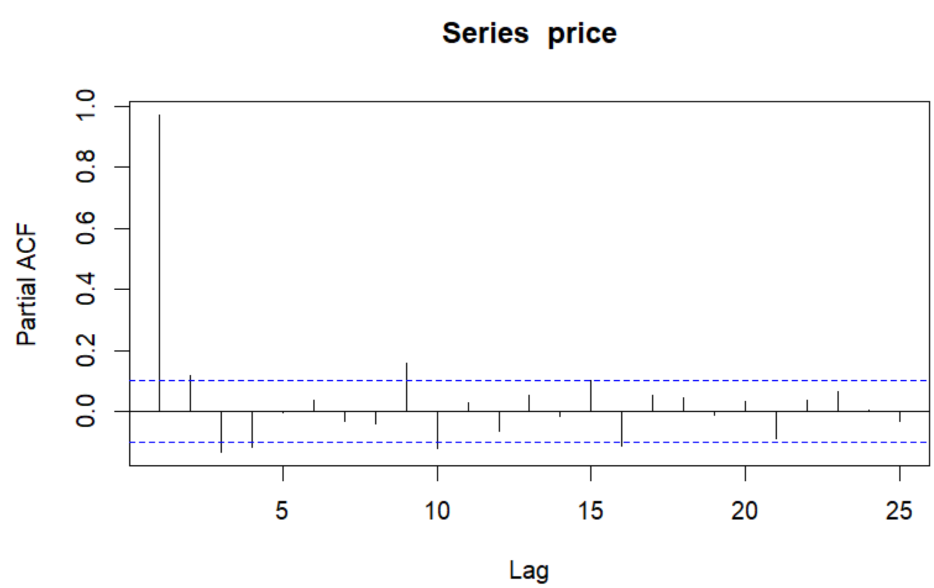
> View(dataset)

	ï..Date	Price	Open	High	Low	Vol.	Change..
1	Mar 24, 2023	0.074573	0.077387	0.077498	0.073103	1.15B	-3.64%
2	Mar 23, 2023	0.077387	0.073843	0.078919	0.072986	2.18B	4.79%
3	Mar 22, 2023	0.073851	0.076685	0.077821	0.071648	2.53B	-3.70%
4	Mar 21, 2023	0.076685	0.071342	0.077779	0.070404	1.97B	7.49%
5	Mar 20, 2023	0.071345	0.074541	0.075558	0.070528	1.37B	-4.19%
6	Mar 19, 2023	0.074462	0.072959	0.076498	0.072959	1.04B	2.06%
7	Mar 18, 2023	0.072959	0.076443	0.078775	0.072531	1.91B	-4.53%
8	Mar 17, 2023	0.076421	0.072588	0.077228	0.071528	1.66B	5.31%
9	Mar 16, 2023	0.072567	0.069681	0.074004	0.068919	1.25B	4.14%
10	Mar 15, 2023	0.069682	0.074640	0.075918	0.067488	1.91B	-6.67%

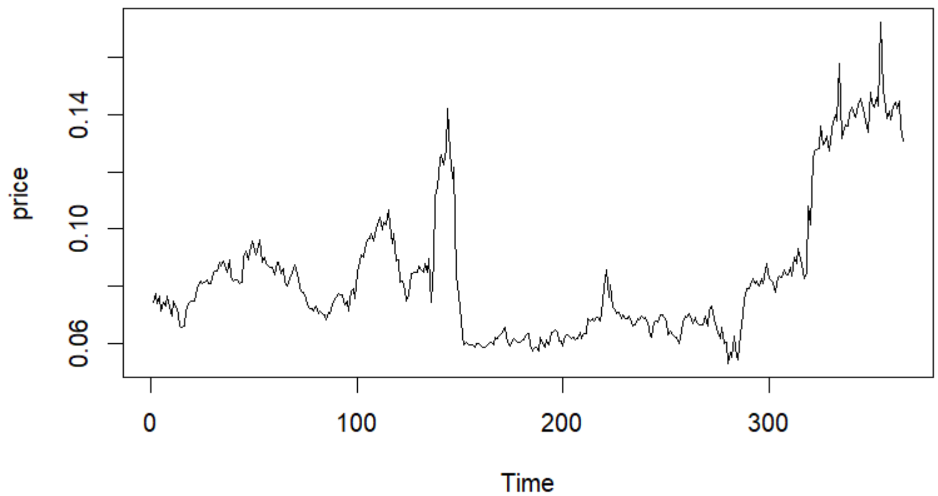
ARIMA and its variations

1) Firstly, We have plotted acf and pacf of Price





2) Then to check stationarity, we have plotted price vs time. Clearly, the plotted graph shows that the price is not stationary.



3) Done acf , pp test to check stationarity.

```
> adf.test(price)

        Augmented Dickey-Fuller Test

data:  price
Dickey-Fuller = -2.2189, Lag order = 7, p-value = 0.4845
alternative hypothesis: stationary
```

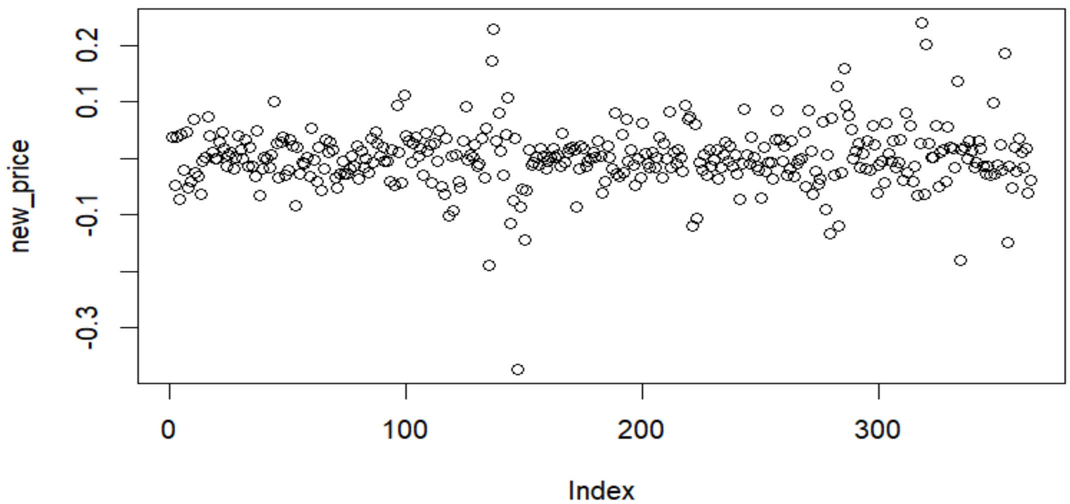
Since the value of p is more than 5%, then the price is not stationary.

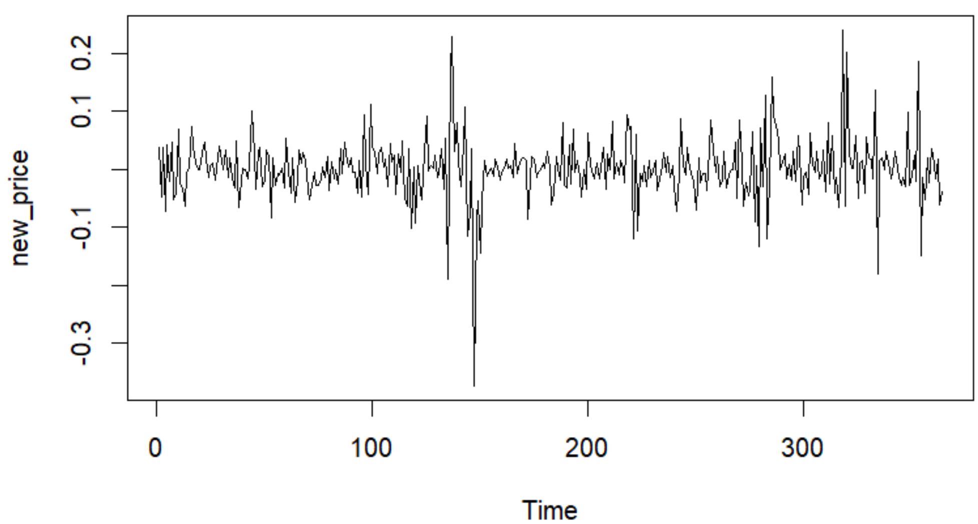
```
> PP.test(price)

        Phillips-Perron Unit Root Test

data:  price
Dickey-Fuller = -1.9941, Truncation lag parameter = 5, p-value = 0.5794
```

Since the value of p is more than 5%, then the price is not stationary.

4) To make price stationary, we have changed it into

```
new_price=diff(log(price))
```



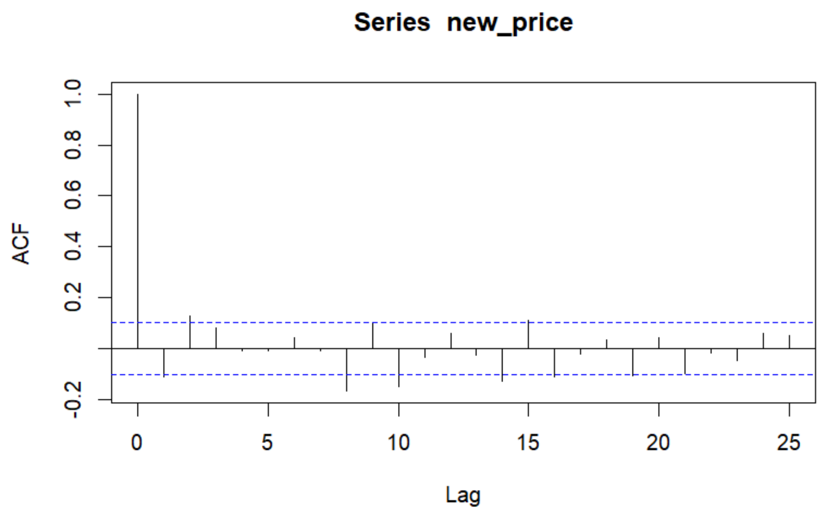


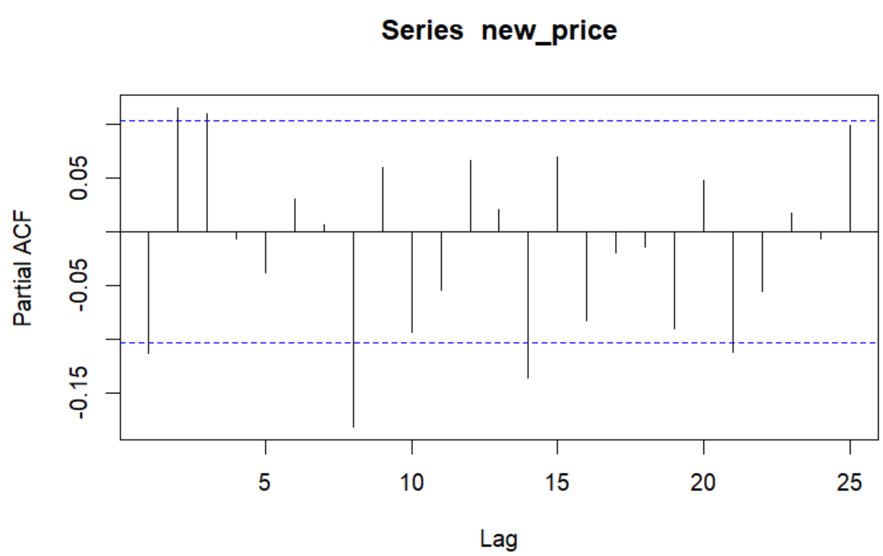
Clearly the above graph has constant mean along the horizontal line, so the price has become stationary.

```
> adf.test(new_price)

        Augmented Dickey-Fuller Test

data:  new_price
Dickey-Fuller = -7.4326, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary
```

```
> PP.test(new_price)

	Phillips-Perron Unit Root Test

data:  new_price
Dickey-Fuller = -21.149, Truncation lag parameter = 5, p-value = 0.01
```

Since, the value of p is less than 5% in both tests, so the new_price has become stationary. And we will use this price to fit the ARIMA model.





Also from the graphs of acf and pacf, the new_price is stationary.

5) Using auto.arima, I get the best model of ARIMA. According to this the best model is with order = c(1,0,3).

```
> auto.arima(new_price)
Series: new_price
ARIMA(1,0,3) with zero mean

Coefficients:
         ar1     ma1     ma2     ma3
     -0.8911  0.7868  0.0408  0.1887
s.e.  0.0615  0.0776  0.0649  0.0538

sigma^2 = 0.002913:  log likelihood = 548.02
AIC=-1086.03   AICc=-1085.87   BIC=-1066.55
```

6) This is the model fitted.

```
> model1

Call:
arima(x = new_price, order = c(1, 0, 3))

Coefficients:
         ar1     ma1    ma2     ma3  intercept
     -0.8911  0.7864  0.040  0.1882     0.0015
s.e.  0.0615  0.0776  0.065  0.0539     0.0030

sigma^2 estimated as 0.002879:  log likelihood = 548.14,  aic = -1084.28
```

7) Used some tests to check the model fitted.

```
> print(box_pierce_test)

        Box-Pierce test

data:  res1
X-squared = 15.254, df = 10, p-value = 0.1231

> print(ljung_box_test)

        Box-Ljung test

data:  res1
X-squared = 15.686, df = 10, p-value = 0.109
```

Using these tests, we see as the p value is more than 5%, our model is fitted very accurately.

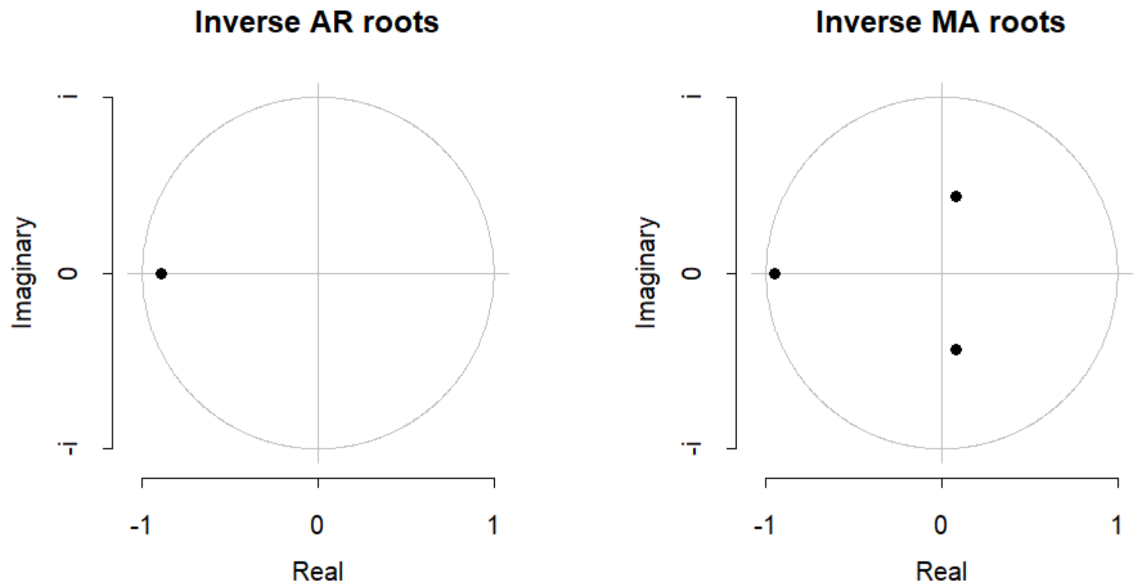
8) Summary of the model1 and its evaluation

```
> summary(model1)

Call:
arima(x = new_price, order = c(1, 0, 3))

Coefficients:
         ar1     ma1    ma2     ma3  intercept
     -0.8911  0.7864  0.040  0.1882     0.0015
s.e.  0.0615  0.0776  0.065  0.0539     0.0030

sigma^2 estimated as 0.002879:  log likelihood = 548.14,  aic = -1084.28

Training set error measures:
                   ME       RMSE        MAE      MPE     MAPE      MASE        ACF1
Training set 2.284797e-06 0.05365766 0.03591419 104.7944 190.7375 0.6309907
0.005007664
```

By looking at these MAE and MPE, we can say that our model is fitted so well.

9) Check forecasted prices

```
> forecasted_prices
    Point Forecast       Lo 80       Hi 80       Lo 95      Hi 95
365   -0.011576717 -0.08034177 0.05718834 -0.11674380 0.09359036
366    0.002002794 -0.06713849 0.07114407 -0.10373967 0.10774526
367   -0.010278794 -0.08002514 0.05946755 -0.11694662 0.09638903
368    0.011981136 -0.05792814 0.08189041 -0.09493588 0.11889815
369   -0.007854984 -0.07789338 0.06218341 -0.11496946 0.09925949
370    0.009821246 -0.06031951 0.07996200 -0.09744978 0.11709227
371   -0.005930278 -0.07615220 0.06429165 -0.11332545 0.10146489
372    0.008106115 -0.06218020 0.07839243 -0.09938753 0.11559976
373   -0.004401901 -0.07473931 0.06593551 -0.11197369 0.10316988
374    0.006744158 -0.06363380 0.07712211 -0.10088963 0.11437795
```



Variation of ARIMA with order = c(1,1,2)

1) Model fitted

```
> model2

Call:
arima(x = new_price, order = c(1, 1, 2))

Coefficients:
          ar1      ma1     ma2
      -0.4418  -0.6750  -0.325
s.e.   0.2277   0.2373   0.237

sigma^2 estimated as 0.002976:  log likelihood = 537.73,  aic = -1067.46
```

2) Evaluation with Box, L jung tests

```
> print(box_pierce_test2)

        Box-Pierce test

data:  res2
X-squared = 27.507, df = 10, p-value = 0.002164

> print(ljung_box_test2)

        Box-Ljung test
```

data: res2
X-squared = 28.205, df = 10, p-value = 0.001674

Using these tests, we see as the p value is less than 5%, our model is not fitted accurately with this variation.

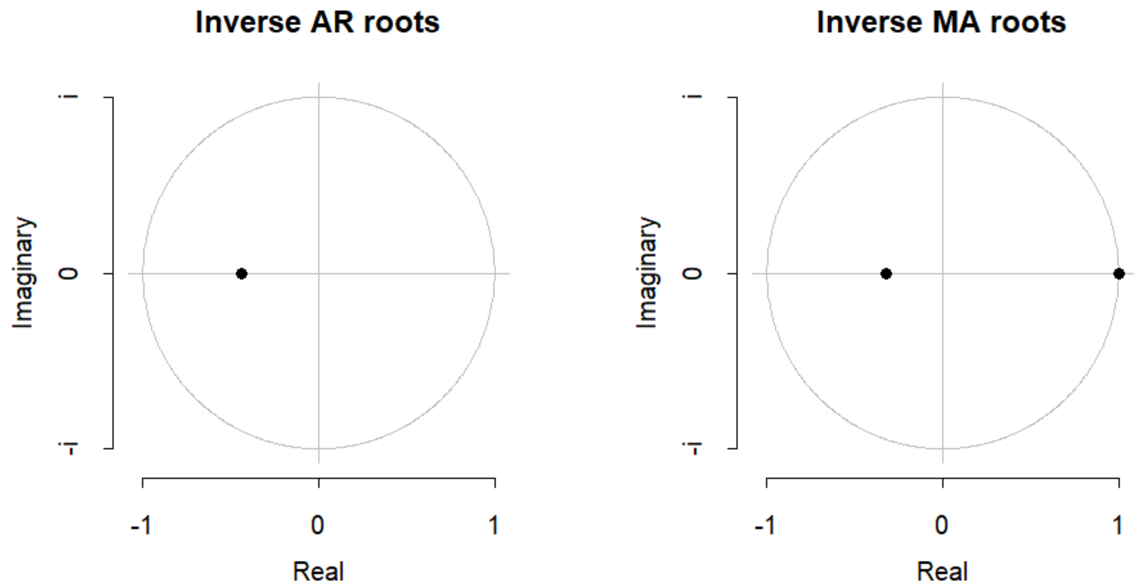
3) Summary of this model

```
> summary(model2)

Call:
arima(x = new_price, order = c(1, 1, 2))

Coefficients:
         ar1      ma1     ma2
      -0.4418  -0.6750  -0.325
s.e.   0.2277   0.2373   0.237

sigma^2 estimated as 0.002976:  log likelihood = 537.73,  aic = -1067.46

Training set error measures:
                      ME       RMSE        MAE      MPE     MAPE      MASE       ACF1
Training set 0.001012948 0.05447365 0.03602601 100.4219 141.9838 0.6329554
0.01500424
```

In this case, the MAE and MPE error is comparatively higher than model1. So, this is not a good model.

4) Forecast

```
> forecasted_prices2
    Point Forecast        Lo 80       Hi 80      Lo 95     Hi 95
365   0.0036371468 -0.06636560 0.07363989 -0.1034228 0.1106971
366   0.0006067545 -0.06984962 0.07106313 -0.1071470 0.1083605
367   0.0019456545 -0.06861195 0.07250326 -0.1059629 0.1098542
368   0.0013540964 -0.06921750 0.07192569 -0.1065758 0.1092840
369   0.0016154609 -0.06896141 0.07219233 -0.1063225 0.1095535
370   0.0014999838 -0.06907679 0.07207676 -0.1064379 0.1094378
371   0.0015510044 -0.06902625 0.07212826 -0.1063876 0.1094896
372   0.0015284623 -0.06904867 0.07210559 -0.1064099 0.1094669
373   0.0015384219 -0.06903878 0.07211562 -0.1064001 0.1094769
374   0.0015340215 -0.06904315 0.07211119 -0.1064044 0.1094725
```



Variation of ARIMA with order = c(1,1,2)

1) Model Fitted

```
> model3

Call:
arima(x = new_price, order = c(2, 0, 2))

Coefficients:
         ar1      ar2      ma1     ma2  intercept
      0.3486  -0.0472  -0.4606  0.2331     0.0015
s.e.  0.4082   0.2481   0.4021  0.2255     0.0031

sigma^2 estimated as 0.00291:  log likelihood = 546.29,  aic = -1080.58
```

2) Evaluation

```
> print(box_pierce_test3)

        Box-Pierce test

data:  res3
X-squared = 18.548, df = 10, p-value = 0.0464

> print(ljung_box_test3)
```

Box-Ljung test

data: res3
X-squared = 19.099, df = 10, p-value = 0.03902

Using these tests, we see as the p value is less than 5%, our model is fitted very accurately. But this is better than the previous variation.

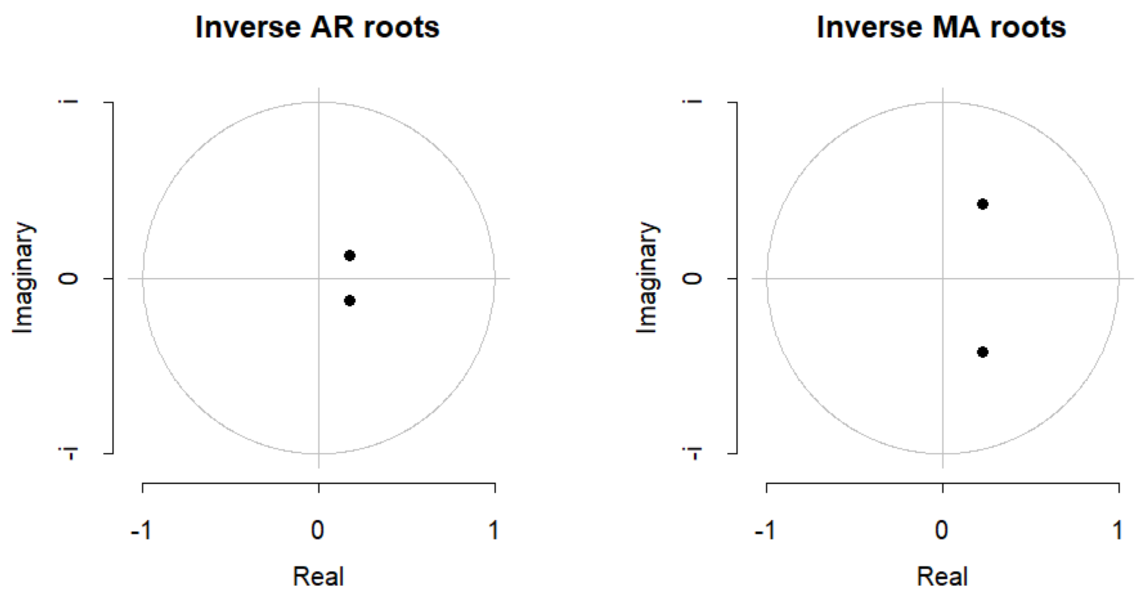
3) Summary of the model

```
> summary(model3)

Call:
arima(x = new_price, order = c(2, 0, 2))

Coefficients:
         ar1      ar2      ma1     ma2  intercept
      0.3486  -0.0472  -0.4606  0.2331     0.0015
s.e.  0.4082   0.2481   0.4021  0.2255     0.0031

sigma^2 estimated as 0.00291:  log likelihood = 546.29,  aic = -1080.58

Training set error measures:
                       ME       RMSE        MAE      MPE     MAPE      MASE
Training set 4.066745e-06 0.05394287 0.03597446 115.9026 174.8021
0.6320497
                     ACF1
Training set 0.0004684999
```

In this case the error of MAE and MPE is higher than the 1st model but lesser than the previous variation. So, this variation is better than the previous variation.

4) Forecast

```
> forecasted_prices3
    Point Forecast       Lo 80      Hi 80      Lo 95     Hi 95
365  -0.0016075758 -0.07073815 0.06752300 -0.1073337 0.1041185
366  -0.0089427256 -0.07850586 0.06062040 -0.1153304 0.0974449
367  -0.0019987530 -0.07229858 0.06830108 -0.1095131 0.1055156
368   0.0007678573 -0.06964028 0.07117600 -0.1069121 0.1084478
369   0.0014047979 -0.06900887 0.07181846 -0.1062836 0.1090932
370   0.0014963537 -0.06891742 0.07191013 -0.1061922 0.1091849
371   0.0014982300 -0.06891554 0.07191200 -0.1061903 0.1091868
372   0.0014945661 -0.06891921 0.07190834 -0.1061940 0.1091831
373   0.0014932003 -0.06892057 0.07190697 -0.1061954 0.1091818
374   0.0014928970 -0.06892088 0.07190667 -0.1061957 0.1091815
```



GARCH and its variations

1) Since the stationarity is checked for new_price, we will directly check if there is any arch effect or not.

```
> ArchTest(new_price)

	ARCH LM-test; Null hypothesis: no ARCH effects
```

data: new_price
Chi-squared = 29.955, df = 12, p-value = 0.002836

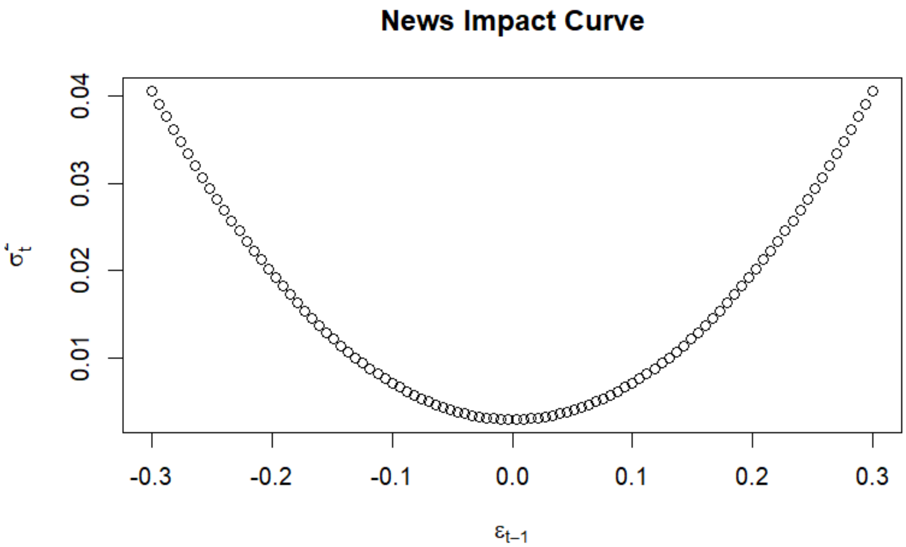
Since p value is less than 5%, we conclude that there is no arch effect present.
So, we can use garch model.

2) Model fitted with order = c(1,1)

```
*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.003626    0.001864   1.9452 0.051757
ar1    -0.516039    0.169928  -3.0368 0.002391
ma1     0.336119    0.186252   1.8047 0.071130
omega   0.000537    0.000127   4.2217 0.000024
alpha1  0.418530    0.113450   3.6891 0.000225
beta1   0.475112    0.075884   6.2610 0.000000

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.003626    0.002097   1.7289 0.083826
ar1    -0.516039    0.178154  -2.8966 0.003772
ma1     0.336119    0.176163   1.9080 0.056392
omega   0.000537    0.000191   2.8142 0.004891
alpha1  0.418530    0.146349   2.8598 0.004239
beta1   0.475112    0.096712   4.9127 0.000001

LogLikelihood : 585.2012

Information Criteria
------------------------------------

Akaike       -3.1824
Bayes        -3.1182
Shibata      -3.1830
Hannan-Quinn -3.1569

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.226  0.2682
```

```
Lag[2*(p+q)+(p+q)-1][5]     1.569  0.9966
Lag[4*(p+q)+(p+q)-1][9]     3.190  0.8597
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      0.504  0.4778
Lag[2*(p+q)+(p+q)-1][5]     1.033  0.8521
Lag[4*(p+q)+(p+q)-1][9]     1.555  0.9510
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.1585 0.500 2.000  0.6905
ARCH Lag[5]    0.3409 1.440 1.667  0.9292
ARCH Lag[7]    0.7220 2.315 1.543  0.9541

Nyblom stability test
------------------------------------
Joint Statistic:  1.4126
Individual Statistics:
mu     0.34180
ar1    0.06084
ma1    0.13426
omega  0.37240
alpha1 0.09509
beta1  0.12617

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:        1.49 1.68 2.12
Individual Statistic:            0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.5506 0.5823
Negative Sign Bias  0.7291 0.4664
Positive Sign Bias  0.6136 0.5399
Joint Effect        1.4905 0.6845


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     37.87     0.006168
2    30     51.38     0.006379
3    40     56.66     0.033492
4    50     62.37     0.095010


Elapsed time : 0.1376641
```

3) News impact curve



As it is symmetric then our model is fitted well.

4) Evaluated our model

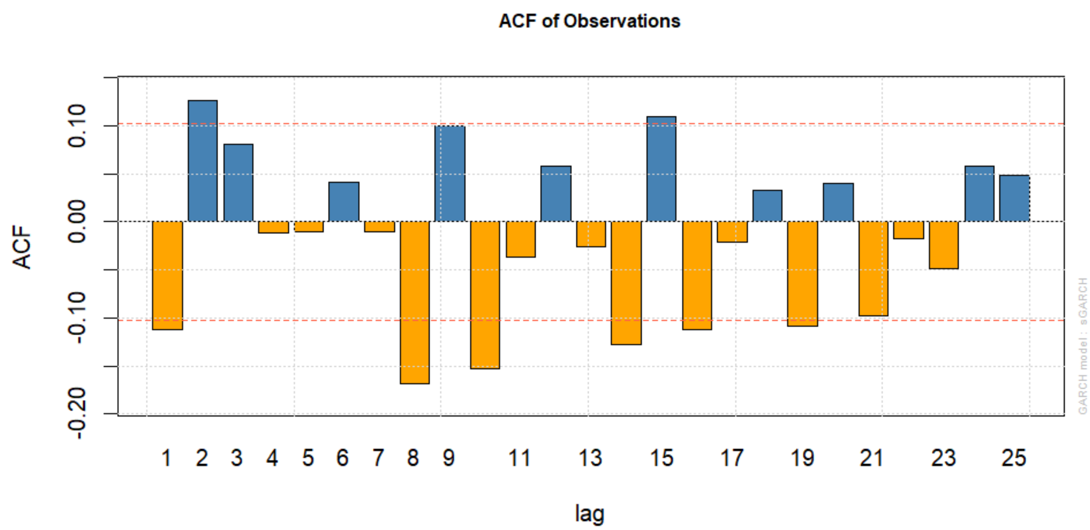
```
> print(box_pierce_test4)

        Box-Pierce test

data:  res4
X-squared = 29.2, df = 10, p-value = 0.001156

> print(ljung_box_test4)

        Box-Ljung test

data:  res4
X-squared = 29.898, df = 10, p-value = 0.0008902
```

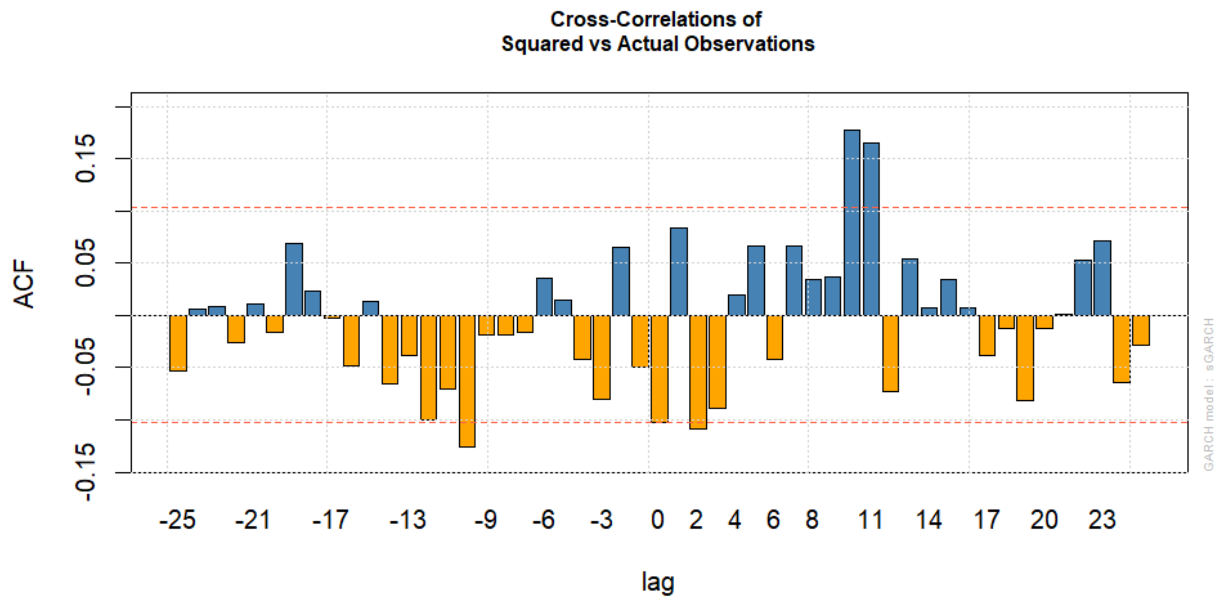
From the p value, it shows that the model is fitted well.

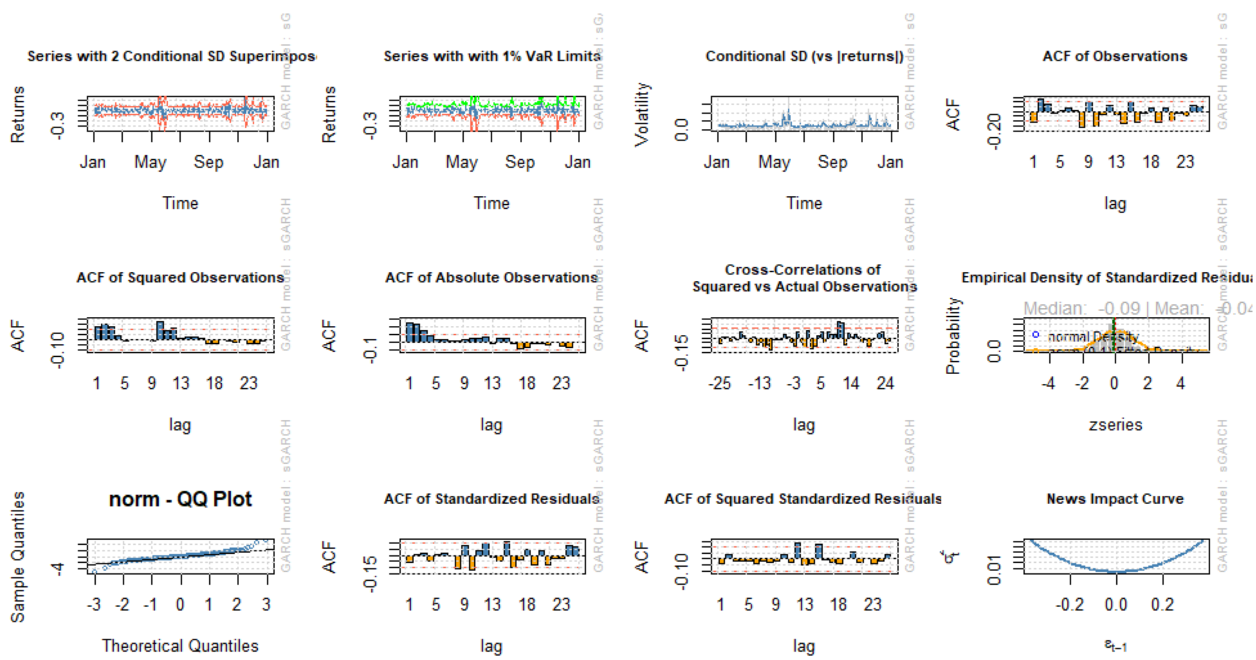
5) Forecast

```
*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: sGARCH
Horizon: 10
```

```
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=1970-12-31 05:30:00]:
       Series   Sigma
T+1  0.006987 0.05631
T+2  0.001891 0.05806
T+3  0.004521 0.05957
T+4  0.003164 0.06090
T+5  0.003864 0.06206
T+6  0.003503 0.06307
T+7  0.003689 0.06397
T+8  0.003593 0.06476
T+9  0.003643 0.06546
T+10 0.003617 0.06608
```







eGARCH

1) Model fitted with order = c(1,1)

----
*   GARCH Model Fit   *

```
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001377    0.001867  0.73755 0.460787
ar1    -0.579751    0.101139 -5.73220 0.000000
ma1     0.405483    0.115593  3.50786 0.000452
omega  -1.288585    0.273829 -4.70580 0.000003
alpha1 -0.167905    0.078153 -2.14841 0.031681
beta1   0.778874    0.045280 17.20136 0.000000
gamma1  0.630077    0.101068  6.23421 0.000000

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001377    0.001842  0.74751 0.454756
ar1    -0.579751    0.078248 -7.40910 0.000000
ma1     0.405483    0.075311  5.38408 0.000000
omega  -1.288585    0.415396 -3.10206 0.001922
alpha1 -0.167905    0.086287 -1.94589 0.051668
beta1   0.778874    0.063647 12.23733 0.000000
gamma1  0.630077    0.103738  6.07373 0.000000

LogLikelihood : 590.3509

Information Criteria
------------------------------------

Akaike       -3.2052
Bayes        -3.1303
Shibata      -3.2059
Hannan-Quinn -3.1754

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.513  0.2187
Lag[2*(p+q)+(p+q)-1][5]     2.006  0.9569
Lag[4*(p+q)+(p+q)-1][9]     3.853  0.7251
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.2579  0.6116
Lag[2*(p+q)+(p+q)-1][5]    0.8514  0.8923
Lag[4*(p+q)+(p+q)-1][9]    1.3338  0.9680
```

```
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.06924 0.500 2.000  0.7924
ARCH Lag[5]   0.26213 1.440 1.667  0.9502
ARCH Lag[7]   0.61665 2.315 1.543  0.9666

Nyblom stability test
------------------------------------
Joint Statistic:  1.2476
Individual Statistics:
mu     0.27537
ar1    0.02897
ma1    0.05199
omega  0.18004
alpha1 0.05097
beta1  0.20826
gamma1 0.05328

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:        1.69 1.9 2.35
Individual Statistic:             0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.5705 0.5687
Negative Sign Bias  0.9071 0.3650
Positive Sign Bias  0.1151 0.9084
Joint Effect        2.3624 0.5007


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     25.23       0.1531
2    30     38.53       0.1110
3    40     48.53       0.1410
4    50     56.33       0.2198


Elapsed time : 0.1413
```

2) Evaluating model

```
> print(box_pierce_test5)

        Box-Pierce test

data:  res5
```

X-squared = 29.2, df = 10, p-value = 0.001156

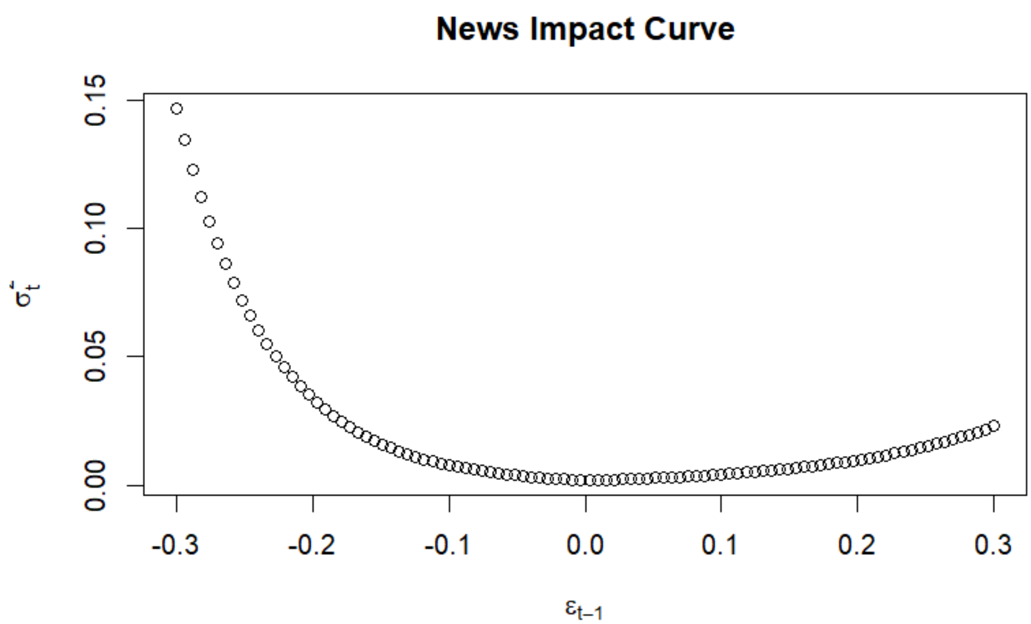
> print(ljung_box_test5)

Box-Ljung test

data: res5
X-squared = 29.898, df = 10, p-value = 0.0008902

From looking at the p value, it is clear that this model is not fitted well.

3) News Impact Curve

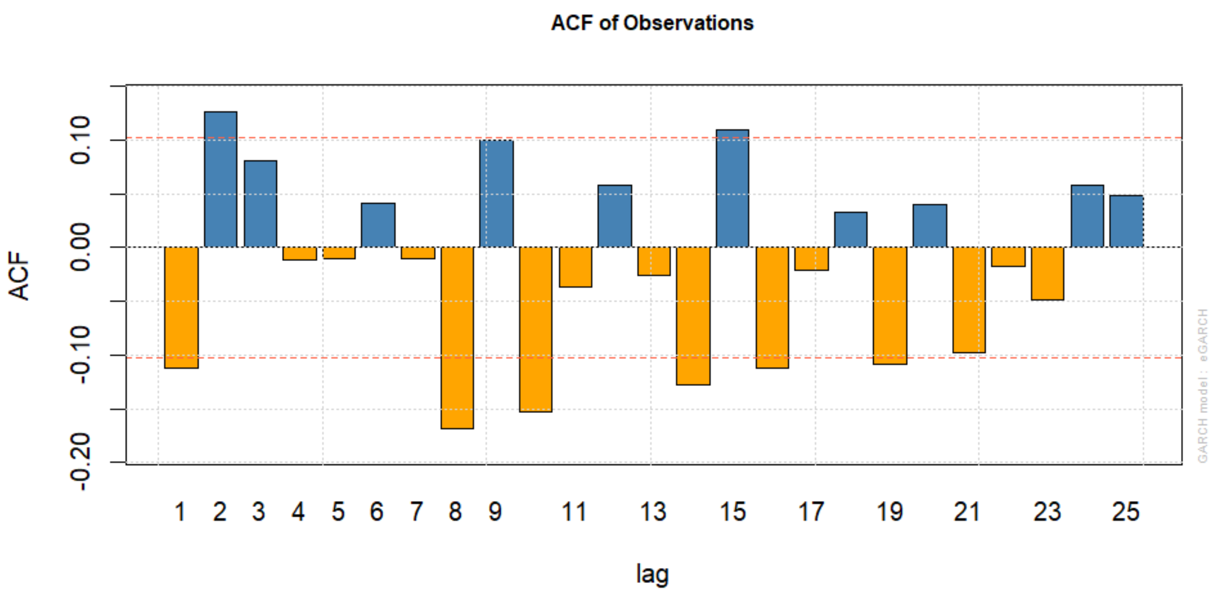


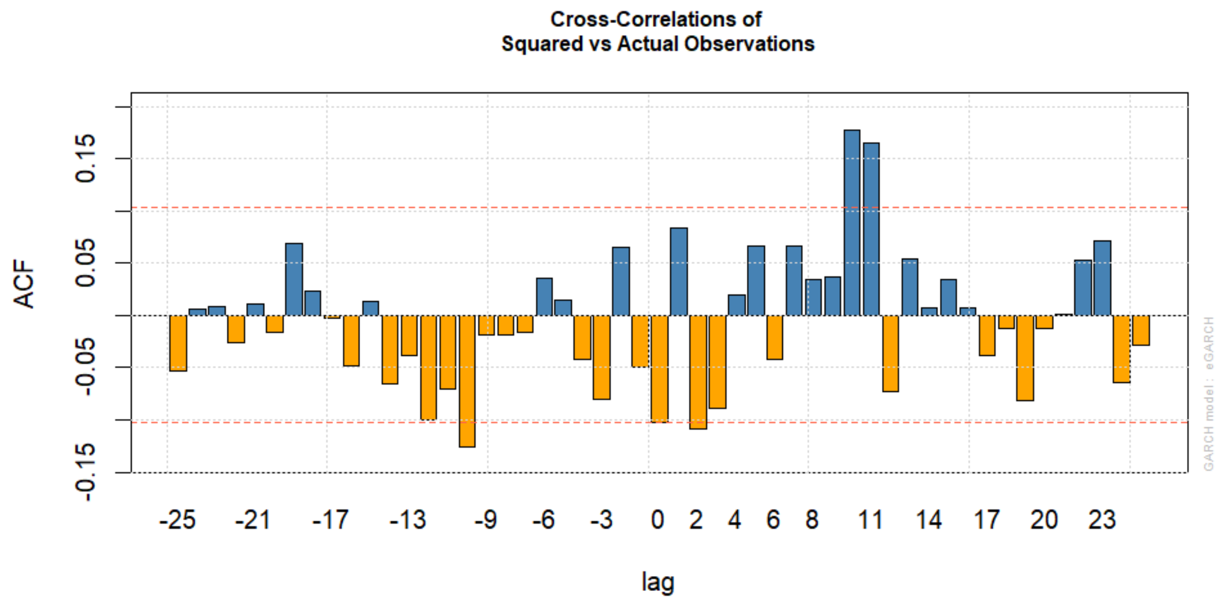
Since it is not symmetric, the model is not very good.

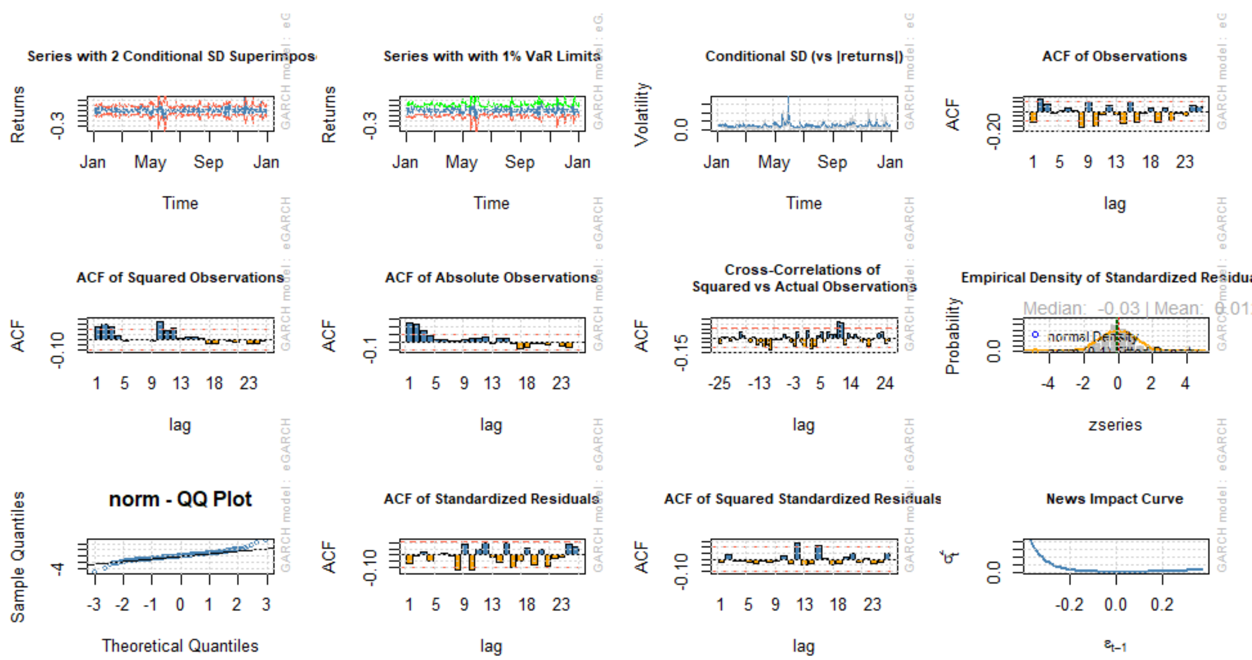
4) Forecast

```
*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=1970-12-31 05:30:00]:
      Series   Sigma
```

T+1 0.0033754 0.06491
T+2 0.0002185 0.06239
T+3 0.0020487 0.06050
T+4 0.0009876 0.05906
T+5 0.0016028 0.05797
T+6 0.0012462 0.05713
T+7 0.0014529 0.05649
T+8 0.0013331 0.05599
T+9 0.0014026 0.05561
T+10 0.0013623 0.05531







gjrGARCH

1) Model fitted with order = c(1,1)

```
*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*
```

```
Conditional Variance Dynamics
-----------------------------------
GARCH Model     : gjrGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.002316    0.001761   1.3149 0.188545
ar1    -0.550397    0.167346  -3.2890 0.001006
ma1     0.344477    0.191305   1.8007 0.071755
omega   0.000547    0.000113   4.8403 0.000001
alpha1  0.219058    0.076159   2.8763 0.004023
beta1   0.402340    0.066271   6.0712 0.000000
gamma1  0.711742    0.280479   2.5376 0.011162

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.002316    0.001806   1.2826 0.199615
ar1    -0.550397    0.202311  -2.7205 0.006517
ma1     0.344477    0.227254   1.5158 0.129564
omega   0.000547    0.000154   3.5575 0.000374
alpha1  0.219058    0.074346   2.9465 0.003214
beta1   0.402340    0.064403   6.2472 0.000000
gamma1  0.711742    0.390089   1.8246 0.068067

LogLikelihood : 590.6057

Information Criteria
------------------------------------

Akaike       -3.2066
Bayes        -3.1317
Shibata      -3.2073
Hannan-Quinn -3.1768

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.320  0.2507
Lag[2*(p+q)+(p+q)-1][5]     1.871  0.9775
Lag[4*(p+q)+(p+q)-1][9]     3.906  0.7129
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.1607  0.6885
Lag[2*(p+q)+(p+q)-1][5]    0.9800  0.8642
Lag[4*(p+q)+(p+q)-1][9]    1.4253  0.9615
d.o.f=2
```

```
Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.3362 0.500 2.000  0.5621
ARCH Lag[5]    0.4672 1.440 1.667  0.8933
ARCH Lag[7]    0.8056 2.315 1.543  0.9430

Nyblom stability test
------------------------------------
Joint Statistic:  1.3964
Individual Statistics:
mu     0.3617
ar1    0.1349
ma1    0.2017
omega  0.2650
alpha1 0.1757
beta1  0.1471
gamma1 0.1677

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:       1.69 1.9 2.35
Individual Statistic:            0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias          0.7246 0.4692
Negative Sign Bias  1.0578 0.2909
Positive Sign Bias  0.1665 0.8678
Joint Effect       3.4138 0.3321


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     26.22       0.1242
2    30     35.73       0.1817
3    40     44.35       0.2562
4    50     50.84       0.4012


Elapsed time : 0.3211601
```

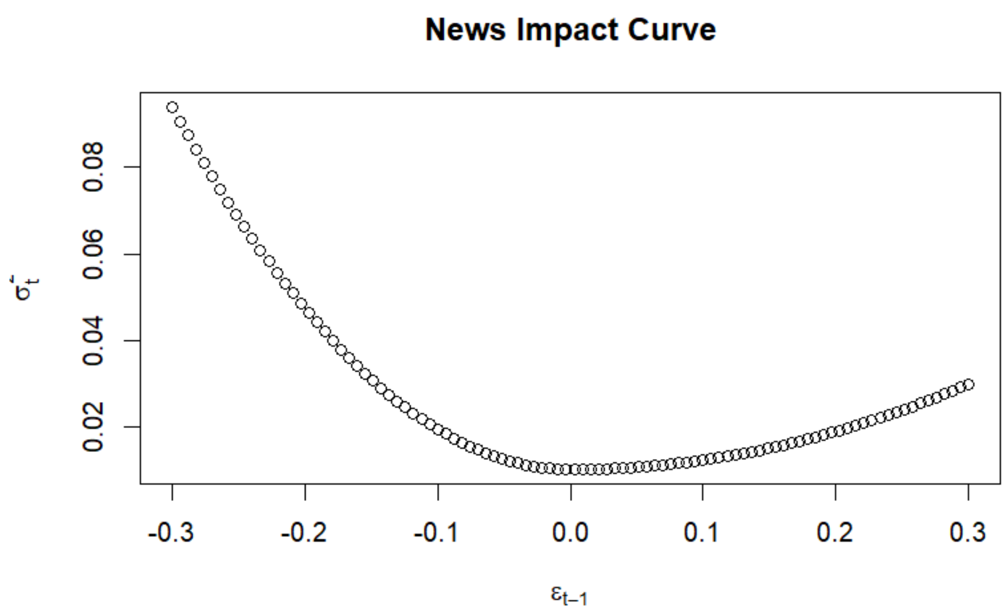
2) Evaluating model

```
> print(box_pierce_test6)

        Box-Pierce test
```

```
data:  res6
X-squared = 30.745, df = 10, p-value = 0.0006465

> print(ljung_box_test6)

        Box-Ljung test

data:  res6
X-squared = 31.449, df = 10, p-value = 0.0004944
```

From looking at the p value, it is clear that this model is not fitted well.

3) News Impact Curve

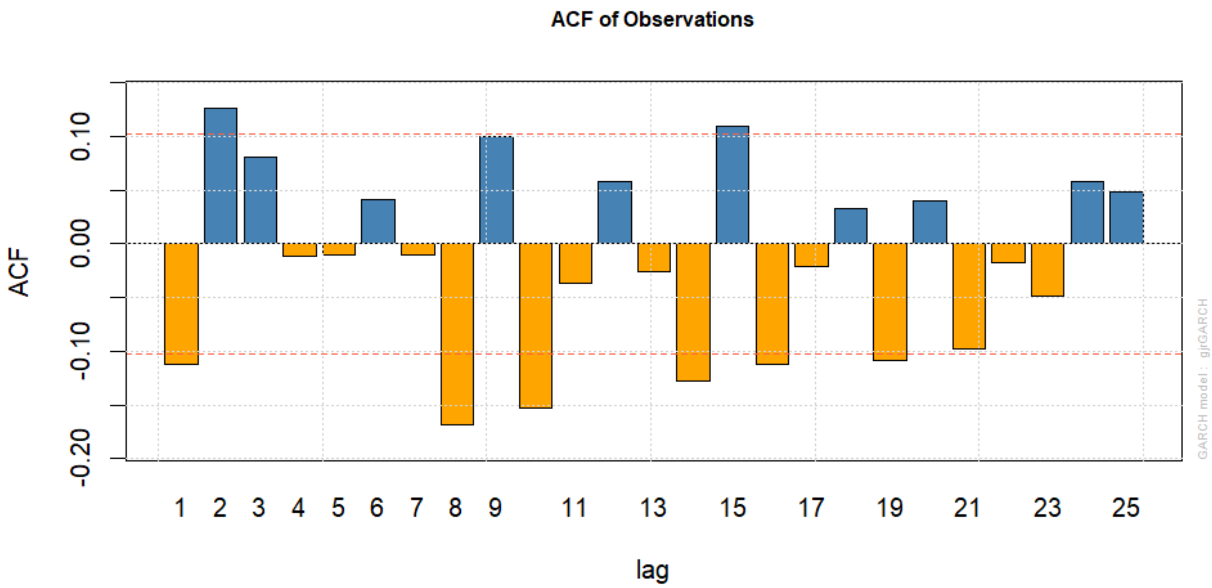


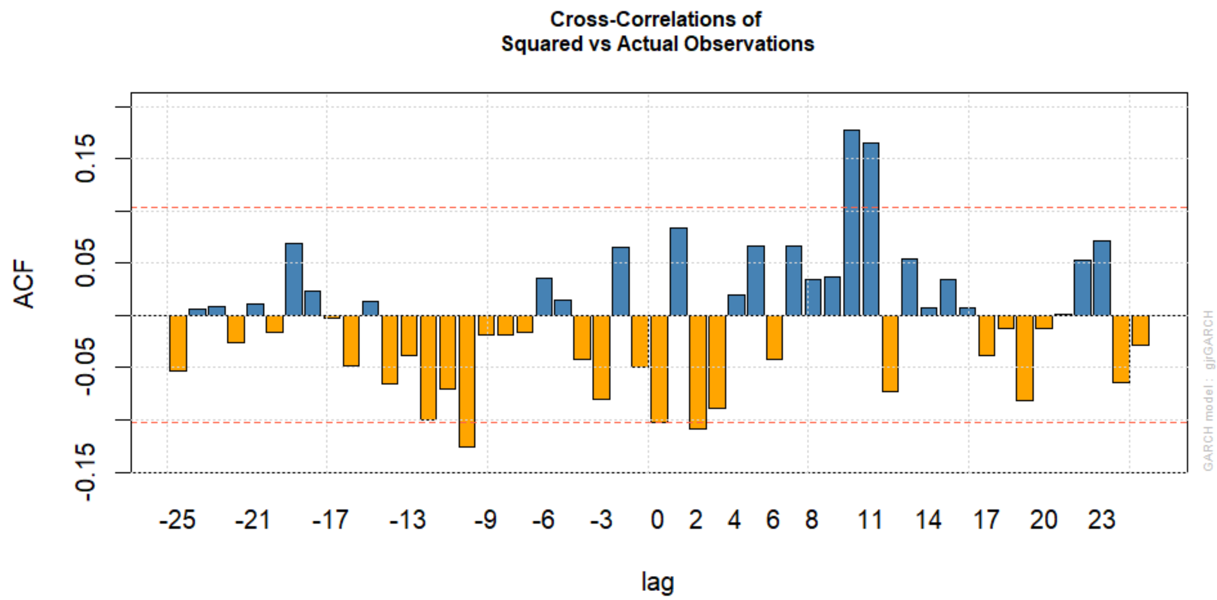
Again, it is not symmetric. So, the model is not good.

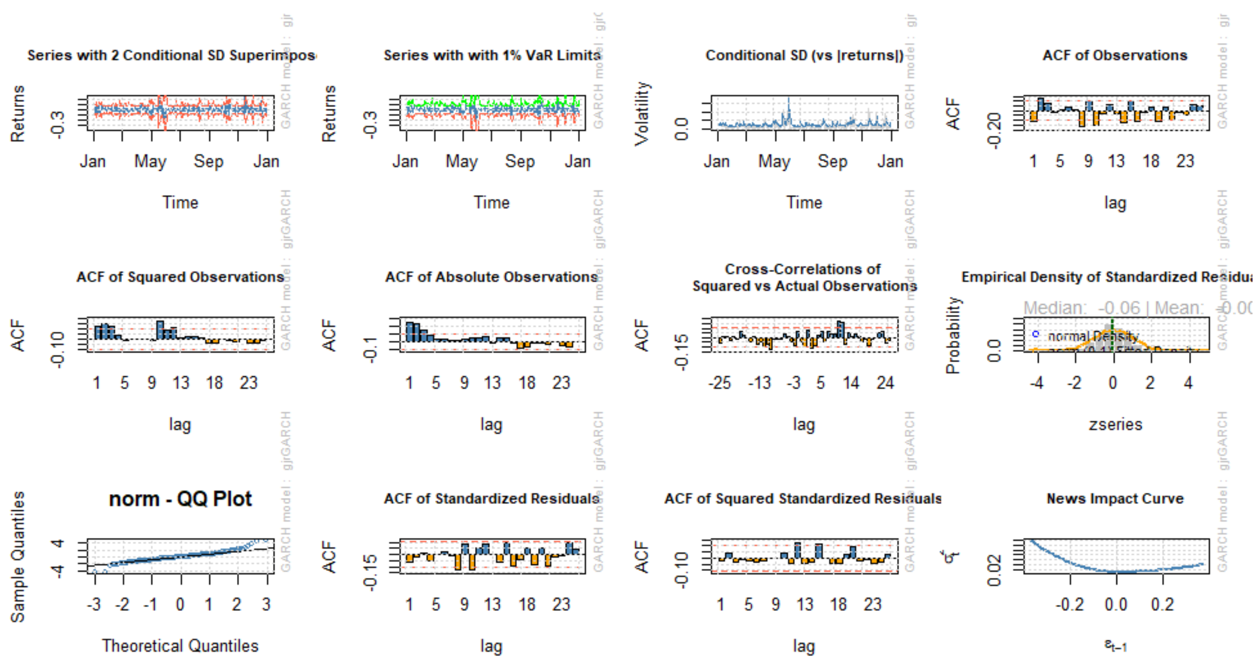
4) Forecast

```
*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: gjrGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=1970-12-31 05:30:00]:
       Series   Sigma
T+1  0.0058244 0.07274
```

```
T+2  0.0003848 0.07561
T+3  0.0033787 0.07832
T+4  0.0017309 0.08088
T+5  0.0026379 0.08330
T+6  0.0021387 0.08560
T+7  0.0024134 0.08779
T+8  0.0022622 0.08988
T+9  0.0023454 0.09188
T+10 0.0022996 0.09379
```




Cross-Correlations of
Squared vs Actual Observations
ACF
0.15
0.05
-0.05
-0.15
-25
-21
-17
-13
-9
-6
-3
0
2
4
6
8
11
14
17
20
23
lag
GARCH model : gjrGARCH


Series with 2 Conditional SD Superimpos
Series with with 1% VaR Limits
Conditional SD (vs |returns|)
ACF of Observations
Returns
Volatility
Time
Jan
May
Sep
Jan
ACF of Squared Observations
ACF of Absolute Observations
Cross-Correlations of
Squared vs Actual Observations
Empirical Density of Standardized Residu
Median: -0.06 | Mean:
normal Density
Probability
zseries
lag
norm - QQ Plot
Sample Quantiles
Theoretical Quantiles
ACF of Standardized Residuals
ACF of Squared Standardized Residuals
News Impact Curve
GARCH model : gjrGARCH