Stat 349 Spring 2020 Final Take-home Exam

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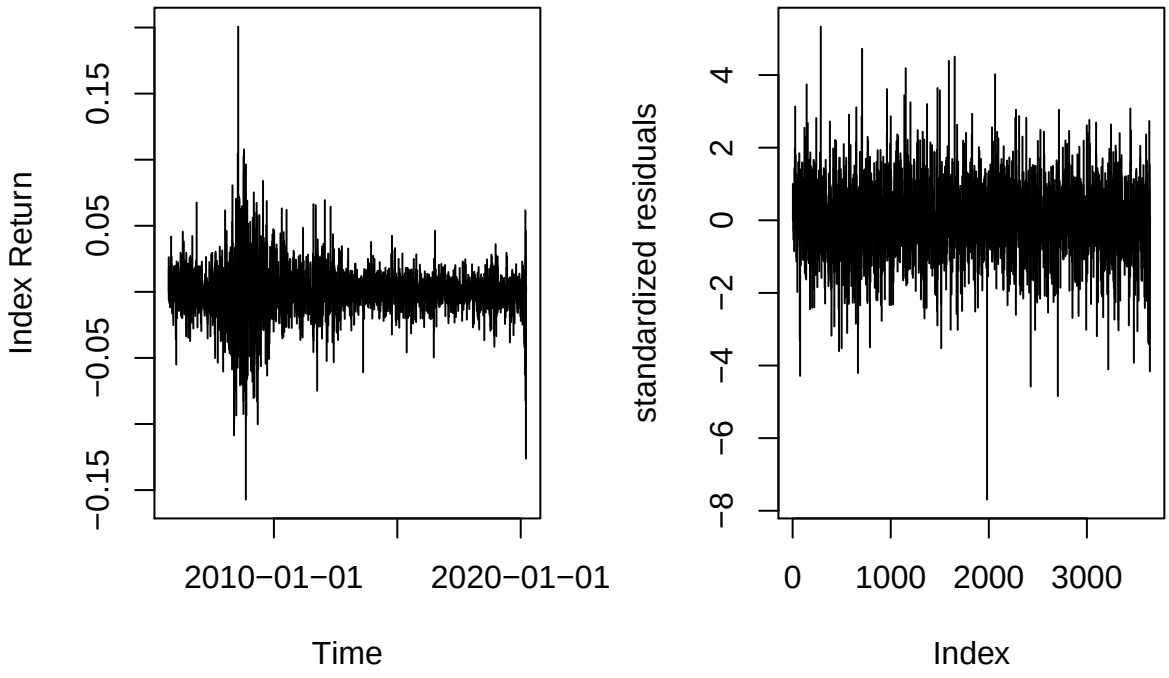
2020/4/29

Steps 1-3

AAL

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(1,2) with the following estimated parameter values and standard errors.

```
##        Estimate   Std. Error      t value     Pr(>|t|)
## a0 1.278873e-06 1.942083e-07 6.585058e+00 4.547074e-11
## a1 4.561271e-02 1.223586e-02 3.727788e+00 1.931678e-04
## a2 1.513205e-08 1.256933e-02 1.203887e-06 9.999990e-01
## b1 9.500596e-01 3.836887e-03 2.476121e+02 0.000000e+00
```

The sum of the squared error of the final model.

```
## [1] 3636.662
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3637.247    1    1
## [2,] 3636.662    1    2
## [3,] 3636.886    2    1
## [4,] 3637.188    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

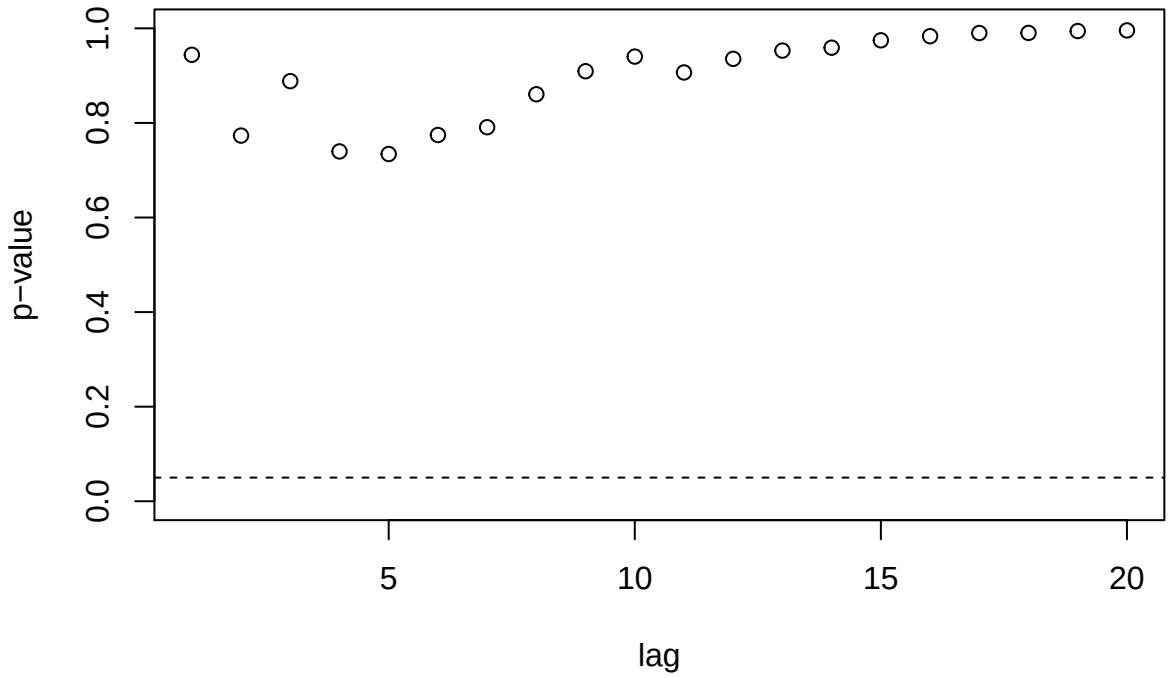
The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

```
##
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.97803, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 1103.4, df = 2, p-value < 2.2e-16
```

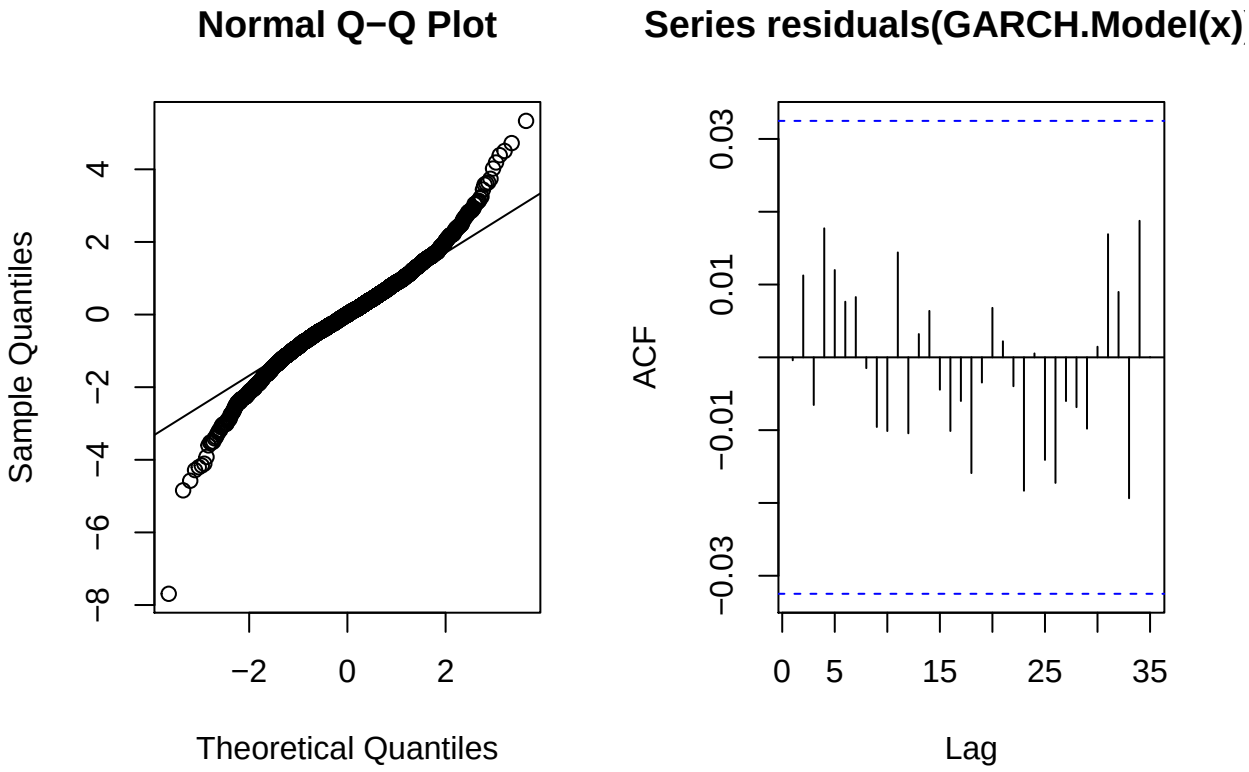
```
## [1] -0.1776689
```

```
## [1] 2.673021
```



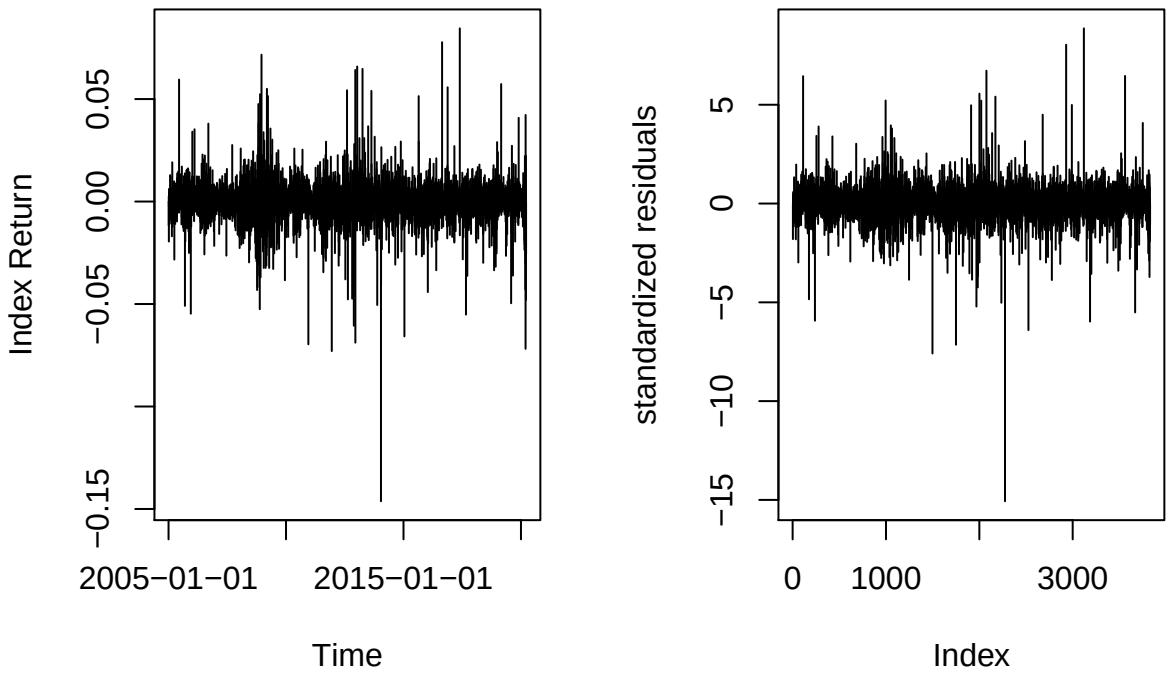

```
## [1] 0.9956664
```

QQ plot and ACF



BBY

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(2,2) with the following estimated parameter values and standard errors.

```
##        Estimate  Std. Error  t value Pr(>|t|)
## a0 3.333303e-05          NA       NA       NA
## a1 1.006025e-01          NA       NA       NA
## a2 8.716197e-02          NA       NA       NA
## b1 1.352446e-08          NA       NA       NA
## b2 5.541311e-01          NA       NA       NA
```

The sum of the squared error of the final model.

```
## [1] 3805.511
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3827.059    1    1
## [2,] 3832.356    1    2
## [3,] 3813.128    2    1
## [4,] 3805.511    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

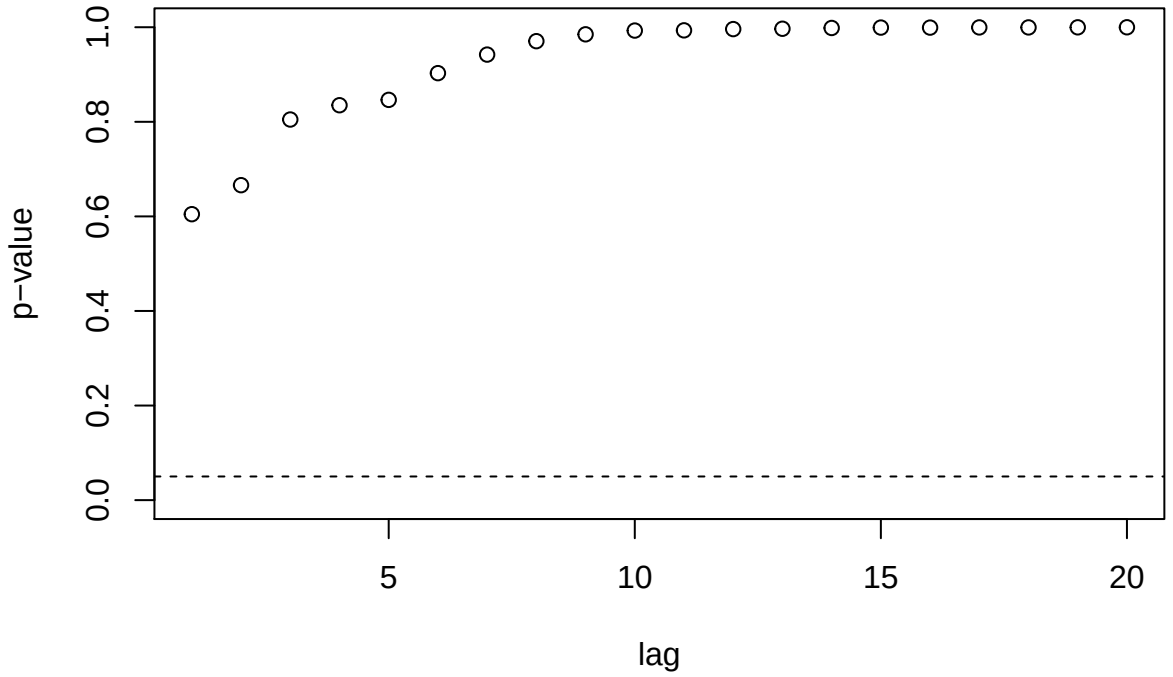
The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

```
##
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.87585, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 80267, df = 2, p-value < 2.2e-16
```

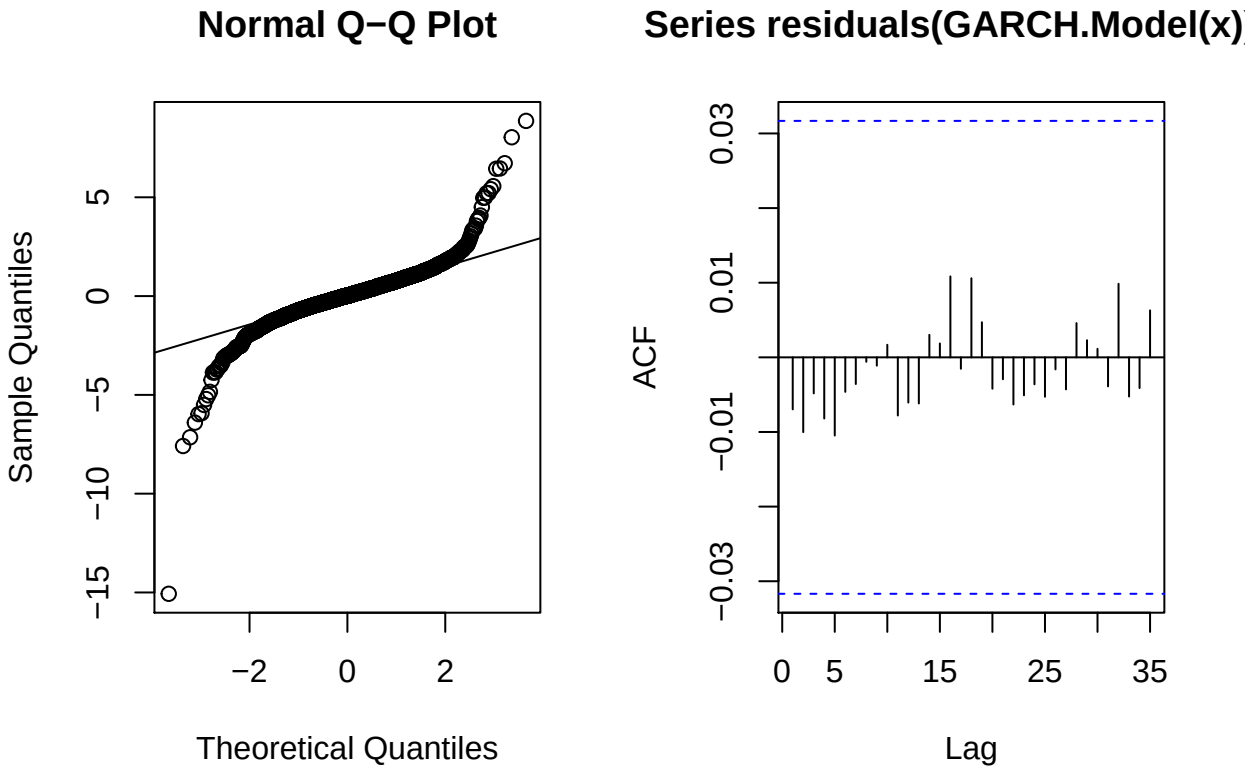
```
## [1] -0.8179775
```

```
## [1] 22.37621
```



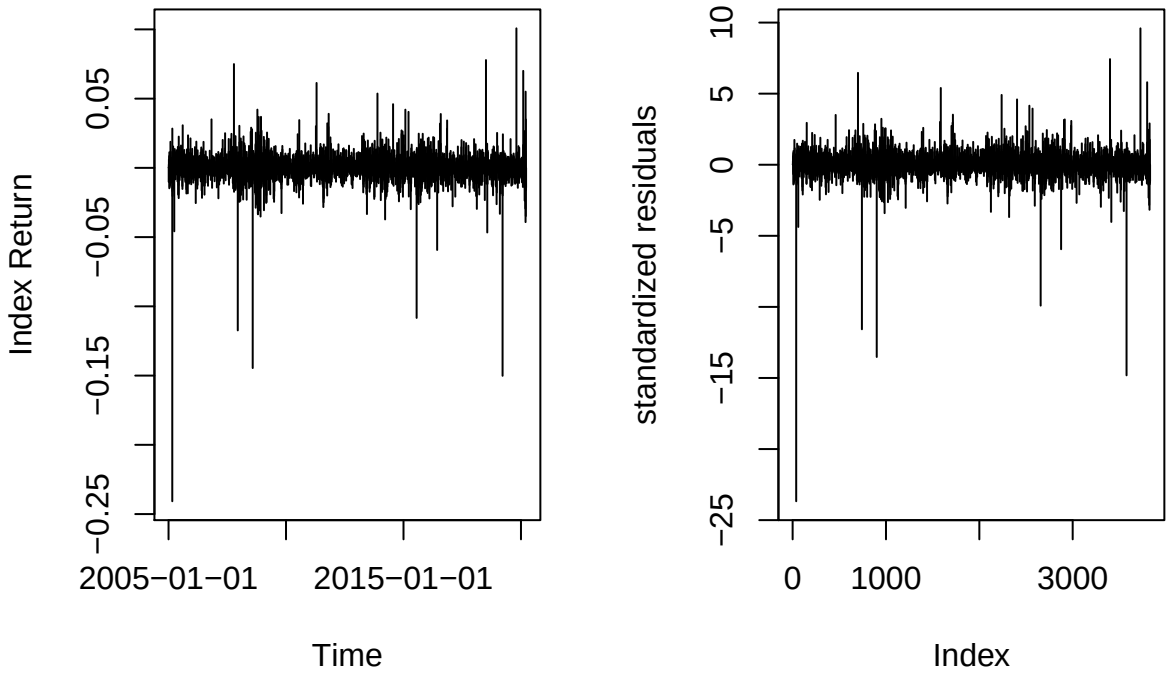

```
## [1] 0.9999029
```

QQ plot and ACF



BIIB

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(1,1) with the following estimated parameter values and standard errors.

```
##        Estimate   Std. Error   t value     Pr(>|t|)
## a0 8.091544e-05 4.487102e-06 18.032895 0.000000e+00
## a1 1.626183e-01 1.211945e-02 13.417959 0.000000e+00
## b1 1.848503e-01 4.260122e-02  4.339086 1.430764e-05
```

The sum of the squared error of the final model.

```
## [1] 3827.967
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3827.967    1    1
## [2,] 3840.514    1    2
## [3,] 3835.917    2    1
## [4,] 3839.849    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

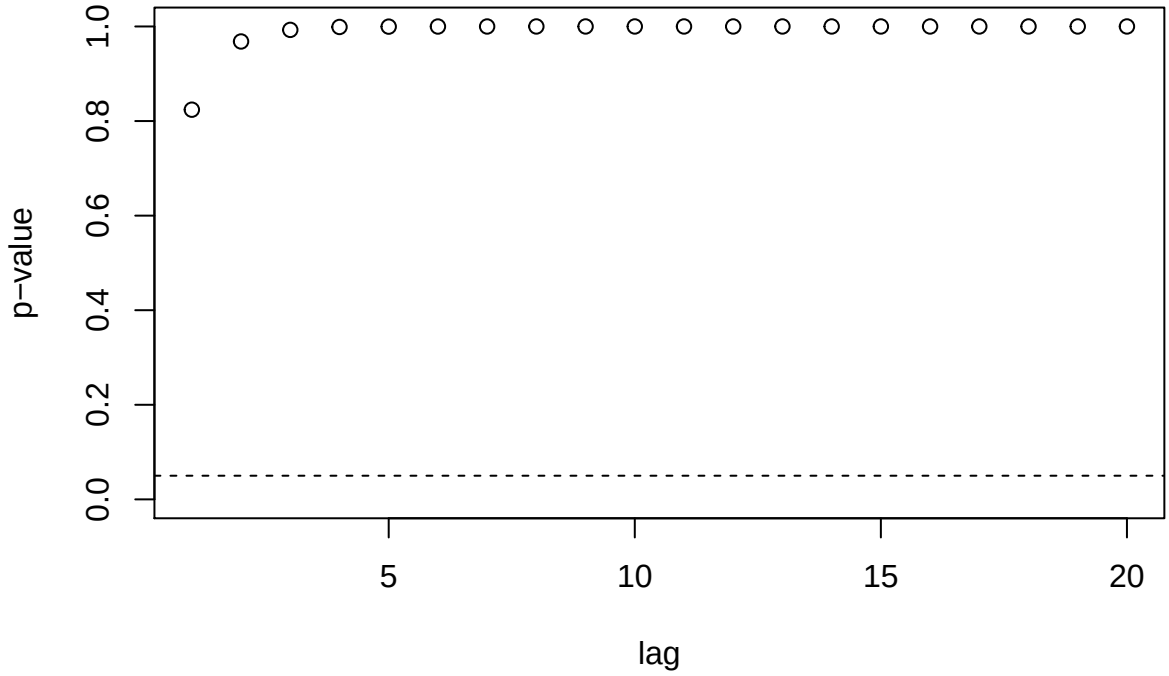
```
##
##  Shapiro-Wilk normality test
```

```
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.7301, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 2108297, df = 2, p-value < 2.2e-16
```

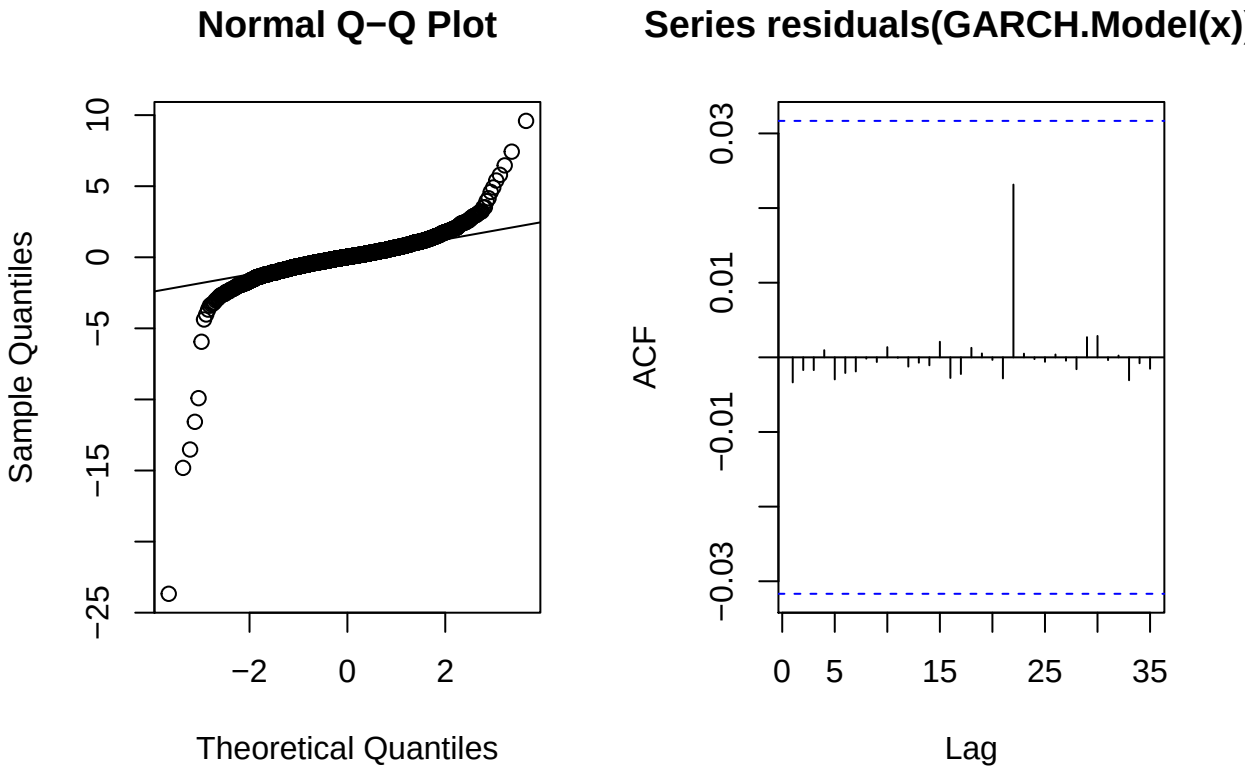
```
## [1] -5.109278
```

```
## [1] 114.5153
```



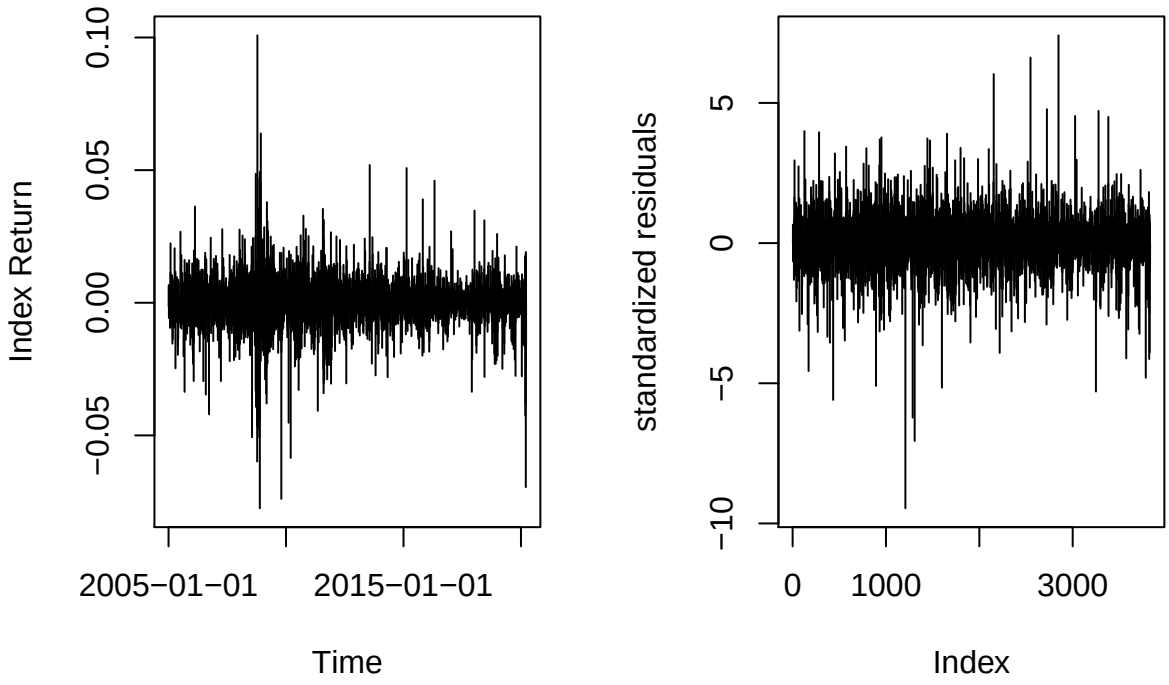

```
## [1] 1
```

QQ plot and ACF



BSX

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(1,2) with the following estimated parameter values and standard errors.

```
##        Estimate   Std. Error      t value     Pr(>|t|)
## a0 3.527550e-06 3.747294e-07 9.413593e+00 0.000000e+00
## a1 8.085760e-02 1.459741e-02 5.539174e+00 3.039015e-08
## a2 1.722779e-10 1.467870e-02 1.173659e-08 1.000000e+00
## b1 8.796580e-01 9.086423e-03 9.681016e+01 0.000000e+00
```

The sum of the squared error of the final model.

```
## [1] 3777.923
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3821.906    1    1
## [2,] 3777.923    1    2
## [3,] 3798.868    2    1
## [4,] 3791.028    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

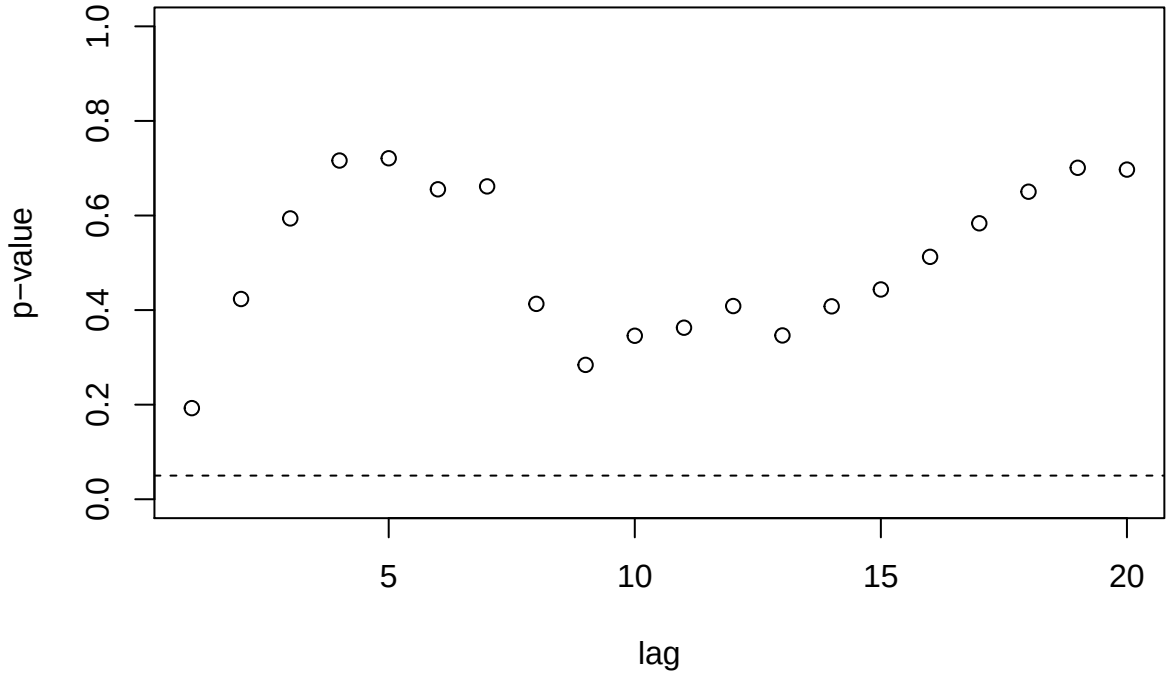
```
##
```

```
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.94167, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 7736.3, df = 2, p-value < 2.2e-16
```

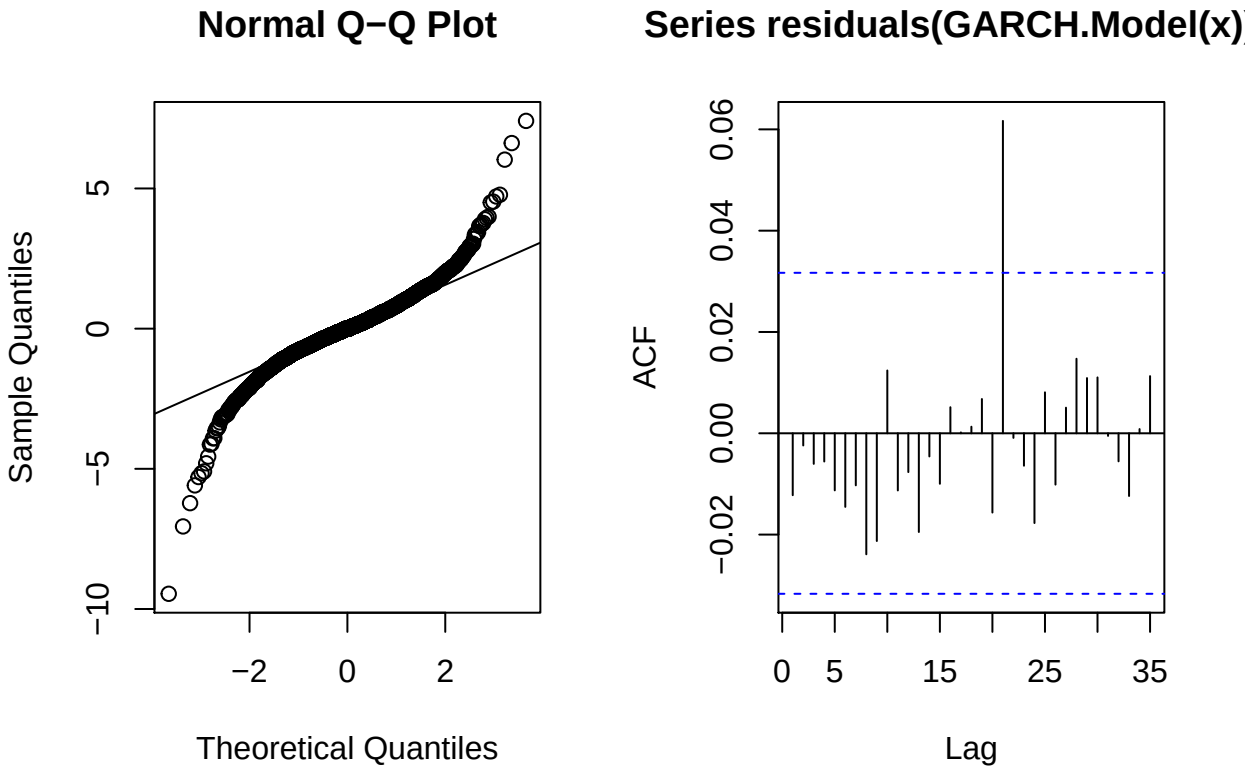
```
## [1] -0.2820315
```

```
## [1] 6.942454
```



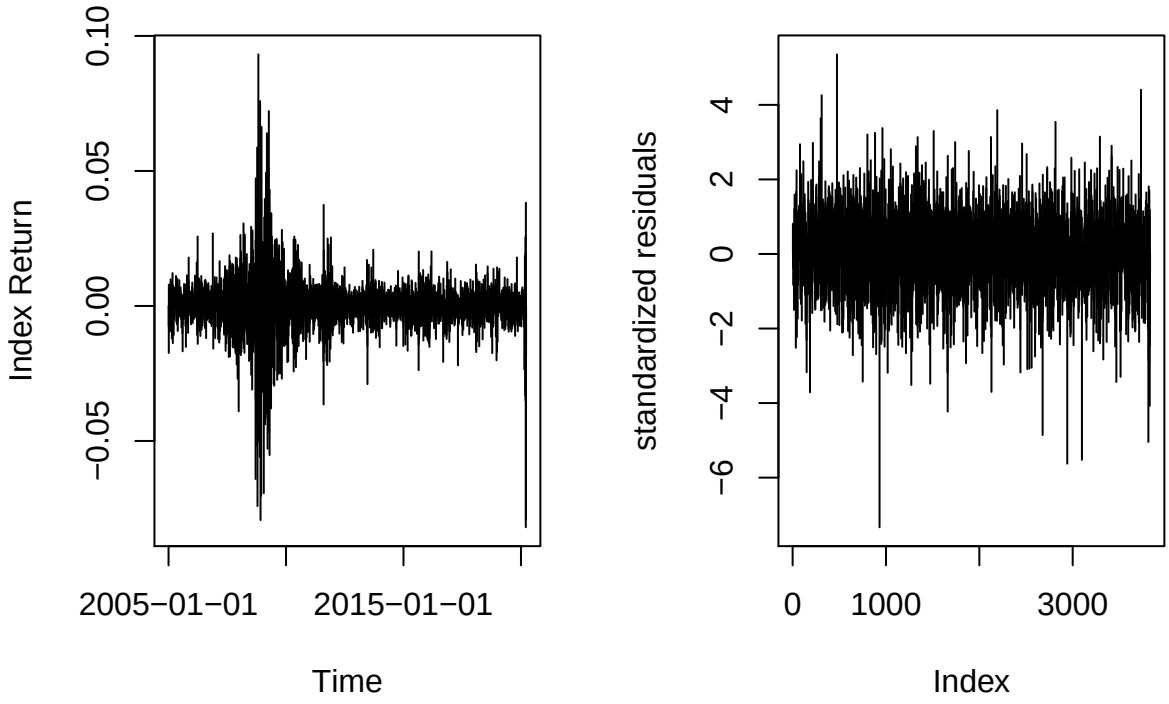

```
## [1] 0.6970833
```

QQ plot and ACF



BXP

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(2,1) with the following estimated parameter values and standard errors.

```
##        Estimate  Std. Error  t value Pr(>|t|)
## a0 7.134203e-07          NA       NA       NA
## a1 1.013427e-01          NA       NA       NA
## b1 8.476667e-01          NA       NA       NA
## b2 4.091904e-02          NA       NA       NA
```

The sum of the squared error of the final model.

```
## [1] 3822.43
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3827.182    1    1
## [2,] 3831.161    1    2
## [3,] 3822.430    2    1
## [4,] 3822.980    2    2
```

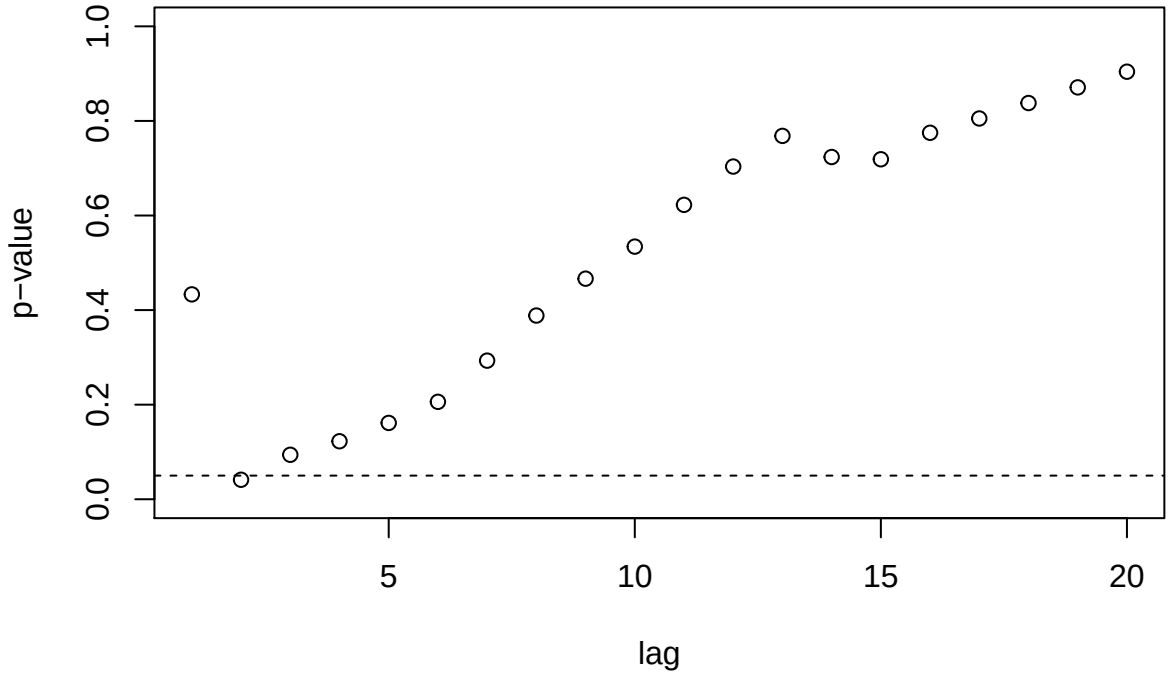
As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

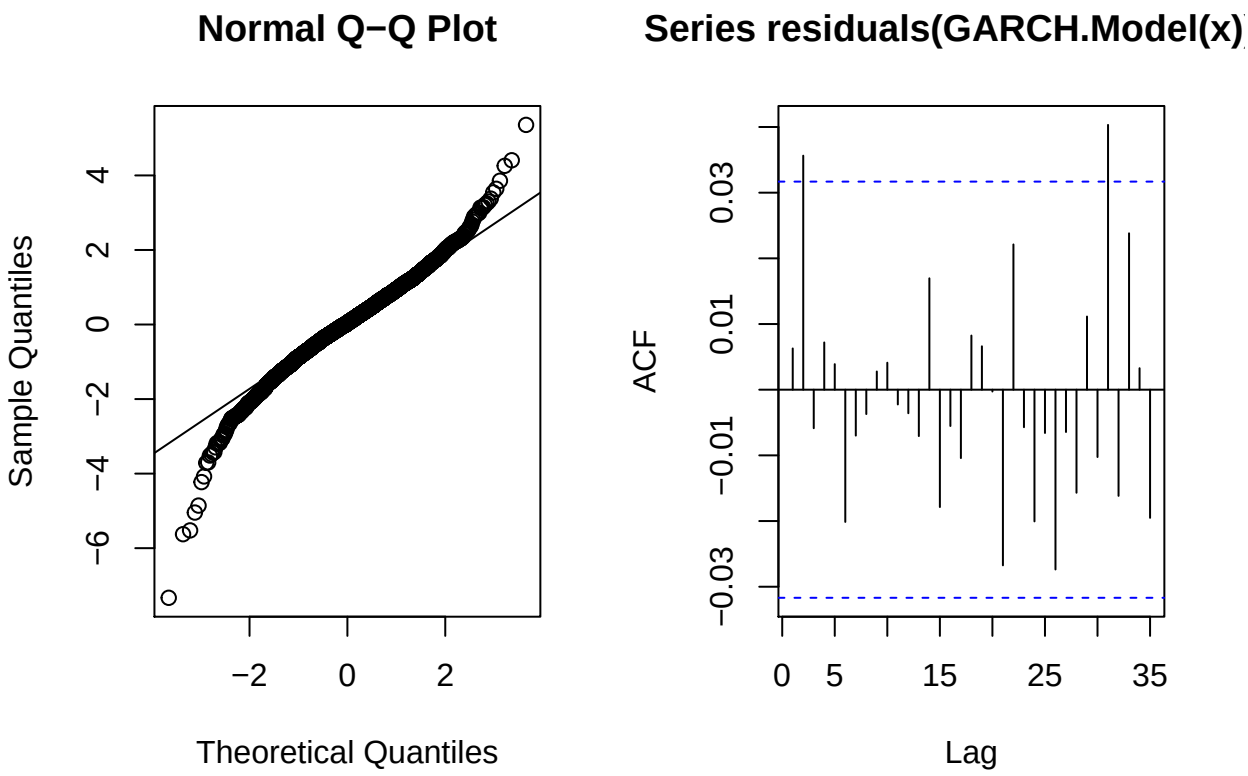
##

```
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.98232, p-value < 2.2e-16

##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 943.8, df = 2, p-value < 2.2e-16

## [1] -0.3151032

## [1] 2.34981
```



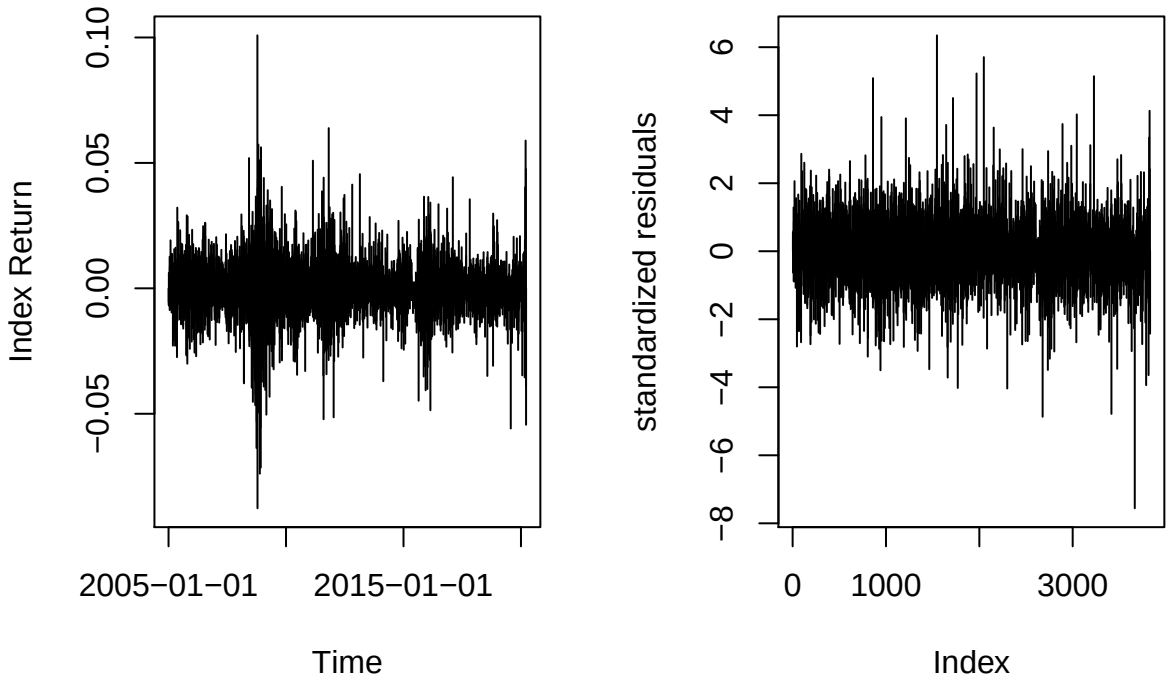

```
## [1] 0.9041067
```

QQ plot and ACF



COG

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(1,2) with the following estimated parameter values and standard errors.

```
##        Estimate   Std. Error    t value     Pr(>|t|)
## a0 1.816847e-06 2.488606e-07   7.300661 2.864375e-13
## a1 3.730023e-02 1.328849e-02   2.806957 5.001197e-03
## a2 1.427307e-02 1.319211e-02   1.081940 2.792791e-01
## b1 9.345660e-01 6.250424e-03 149.520415 0.000000e+00
```

The sum of the squared error of the final model.

```
## [1] 3820.385
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3820.995    1    1
## [2,] 3820.385    1    2
## [3,] 3826.708    2    1
## [4,] 3820.499    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

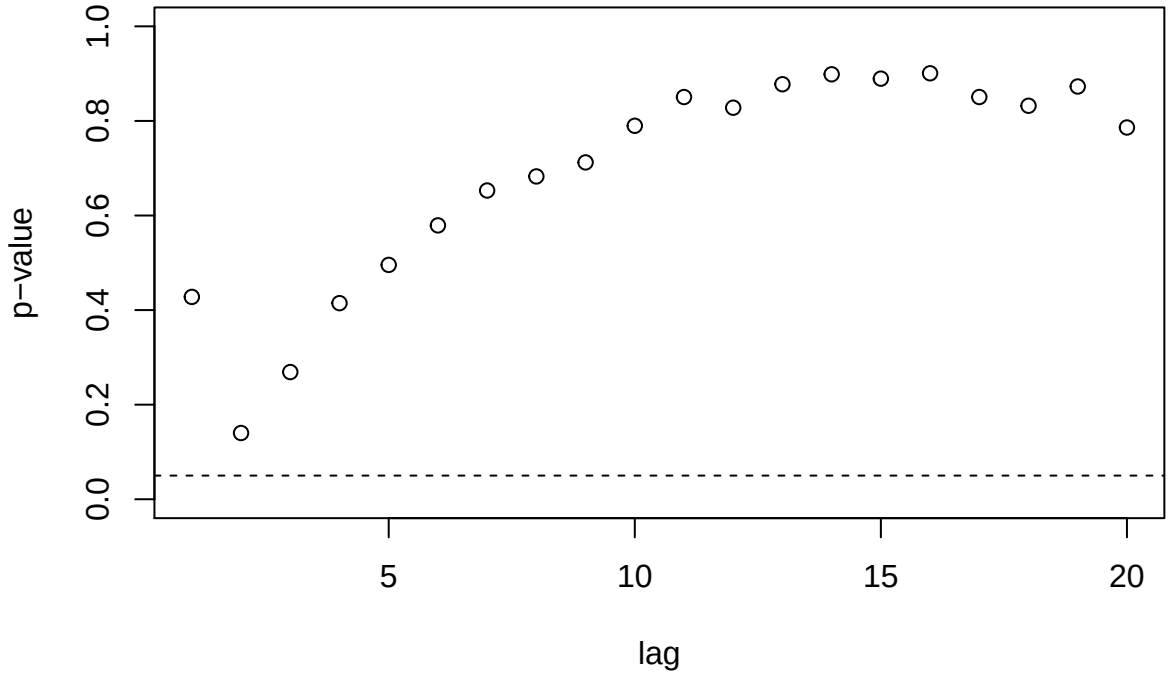
```
##
```

```
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.97718, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 1419.5, df = 2, p-value < 2.2e-16
```

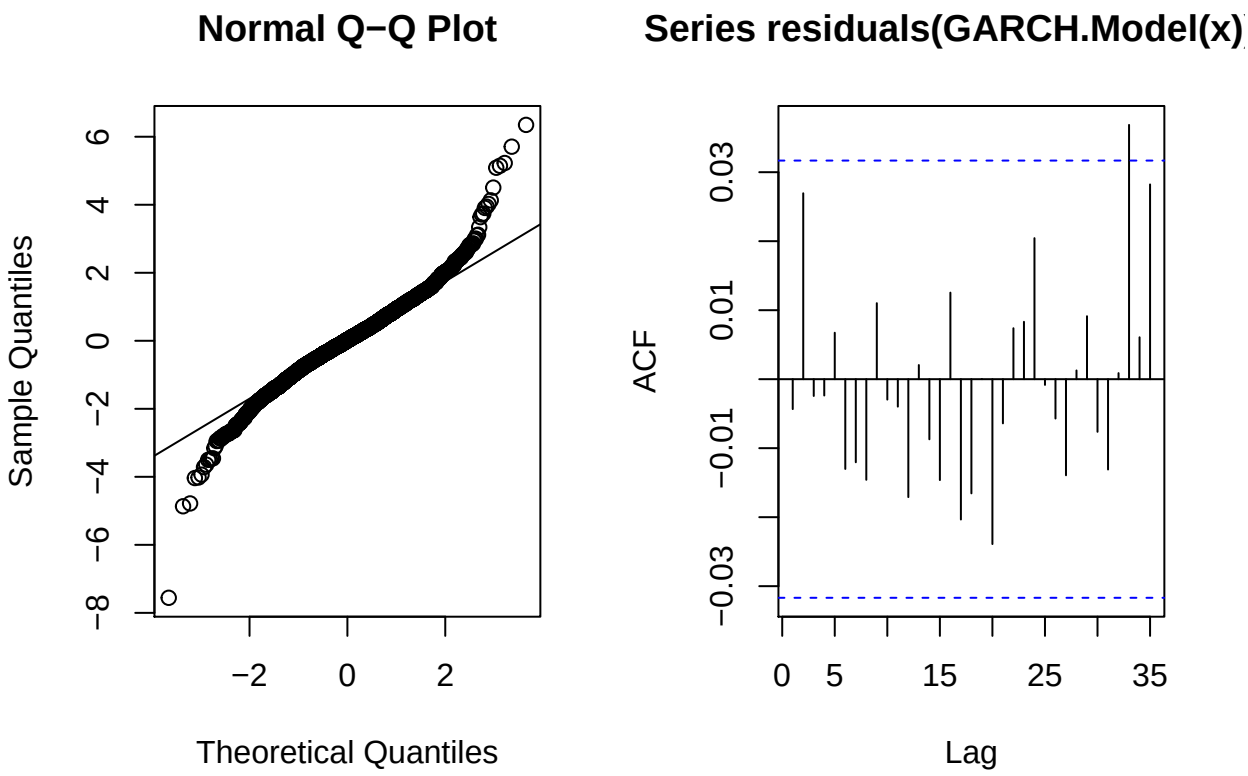
```
## [1] -0.005478548
```

```
## [1] 2.983551
```



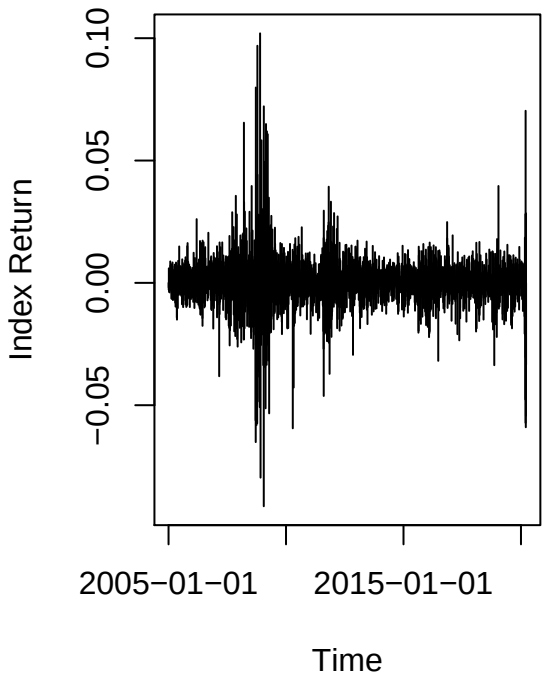

```
## [1] 0.7861235
```

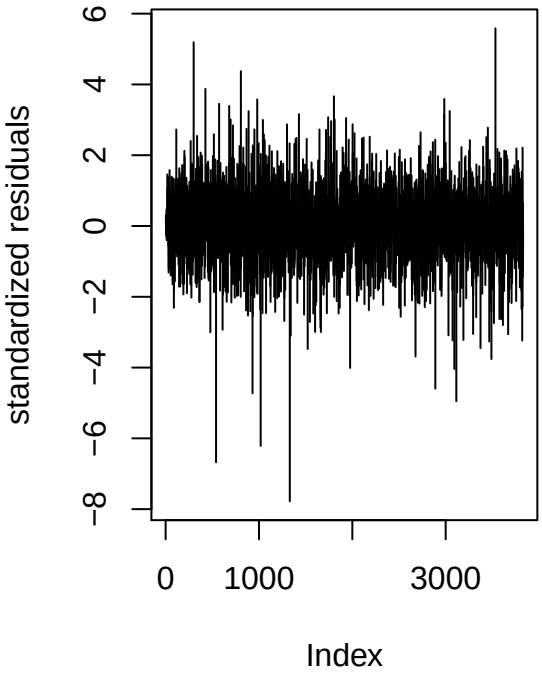
QQ plot and ACF



GS

The original log return series and the fitted residuals are plotted.





The best fitted model is GARCH(2,2) with the following estimated parameter values and standard errors.

```
##        Estimate  Std. Error  t value Pr(>|t|)
## a0 3.048383e-06          NA       NA       NA
## a1 1.283943e-01          NA       NA       NA
## a2 1.306462e-01          NA       NA       NA
## b1 3.288642e-01          NA       NA       NA
## b2 4.055791e-01          NA       NA       NA
```

The sum of the squared error of the final model.

```
## [1] 3676.513
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3817.042    1    1
## [2,] 3798.002    1    2
## [3,] 3816.201    2    1
## [4,] 3676.513    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

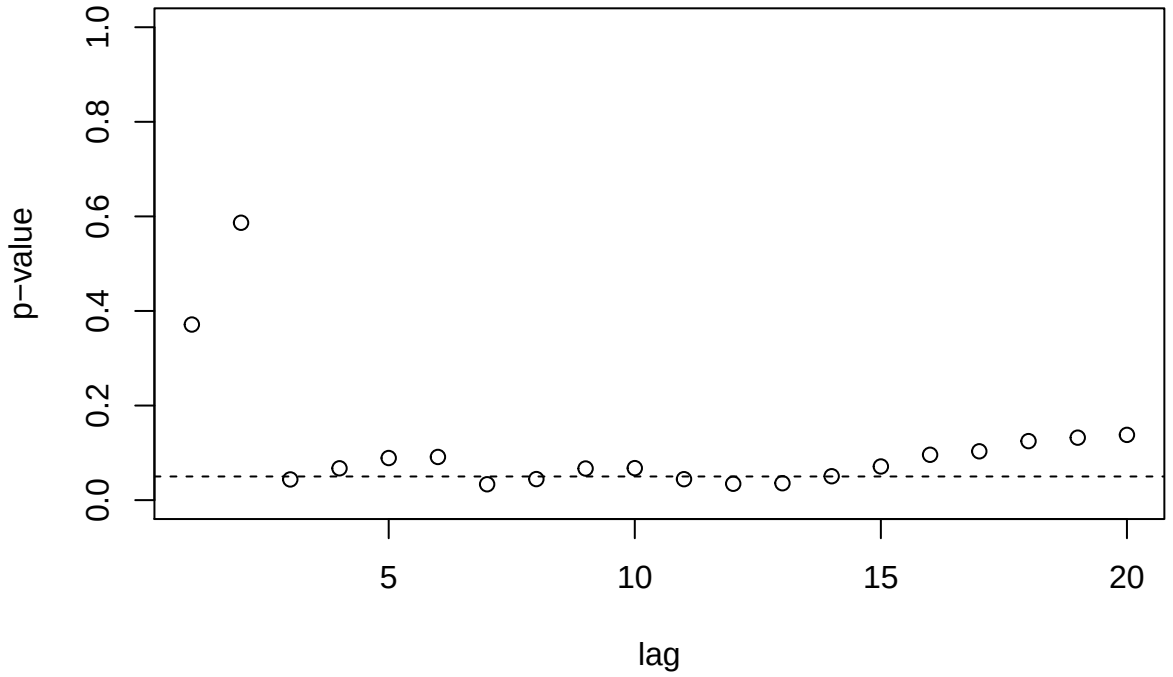
The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

```
##
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.97303, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 2022.9, df = 2, p-value < 2.2e-16
```

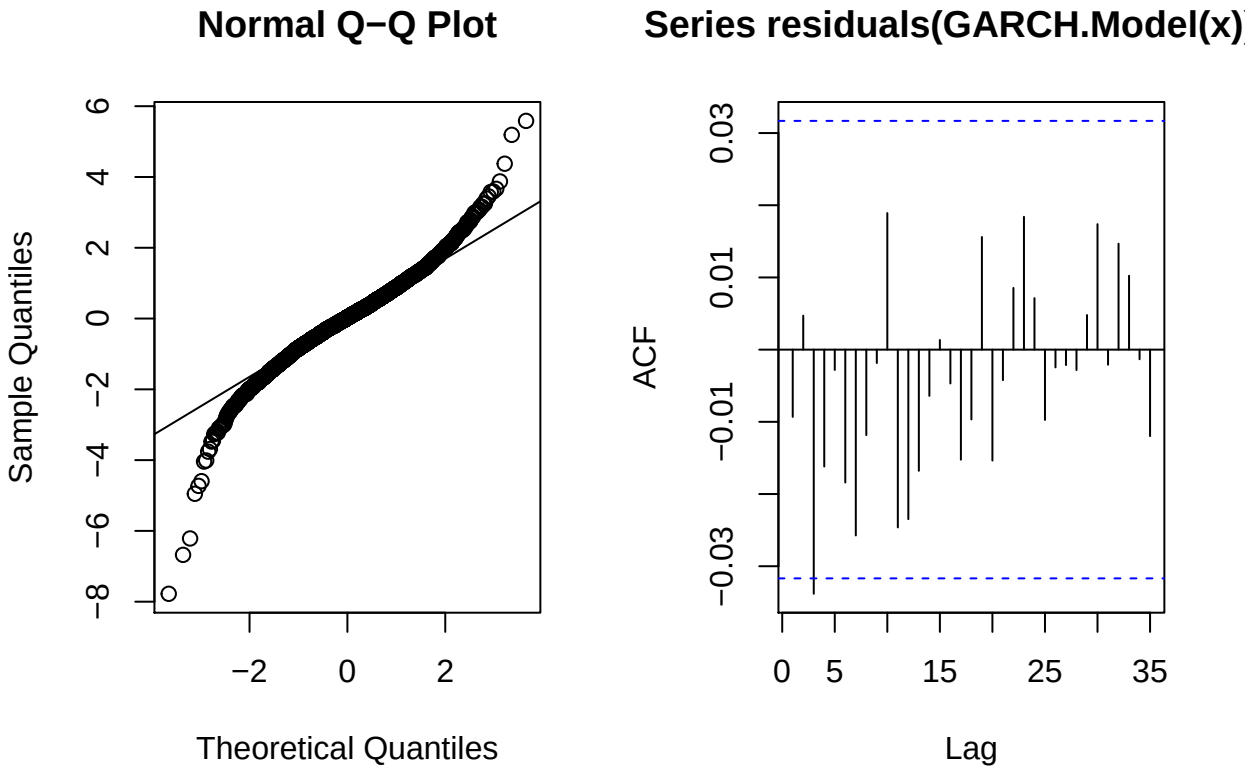
```
## [1] -0.3038991
```

```
## [1] 3.50952
```



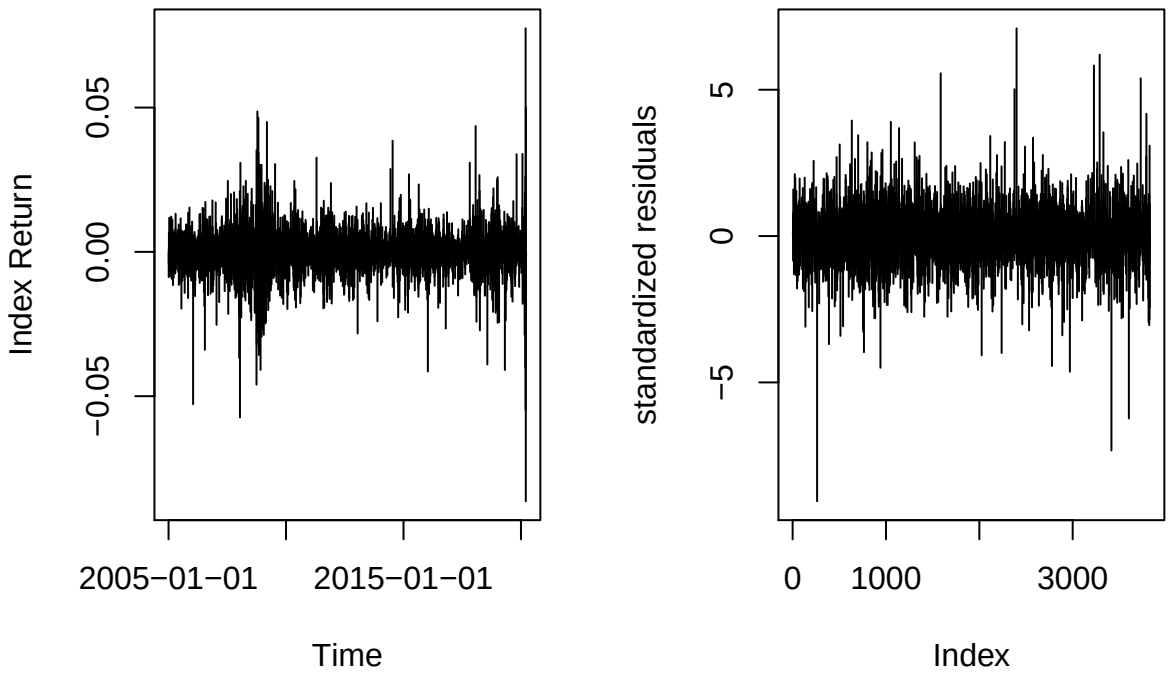

```
## [1] 0.1379889
```

QQ plot and ACF



INTC

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(2,2) with the following estimated parameter values and standard errors.

```
##        Estimate   Std. Error      t value    Pr(>|t|)
## a0 5.731495e-06 5.748454e-07 9.970499e+00 0.00000e+00
## a1 8.833319e-02 1.211255e-02 7.292701e+00 3.03757e-13
## a2 1.557319e-01 1.379339e-02 1.129033e+01 0.00000e+00
## b1 2.146567e-13 3.574124e-02 6.005854e-12 1.00000e+00
## b2 6.907778e-01 3.650124e-02 1.892478e+01 0.00000e+00
```

The sum of the squared error of the final model.

```
## [1] 3707.578
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3823.980    1    1
## [2,] 3746.508    1    2
## [3,] 3823.165    2    1
## [4,] 3707.578    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

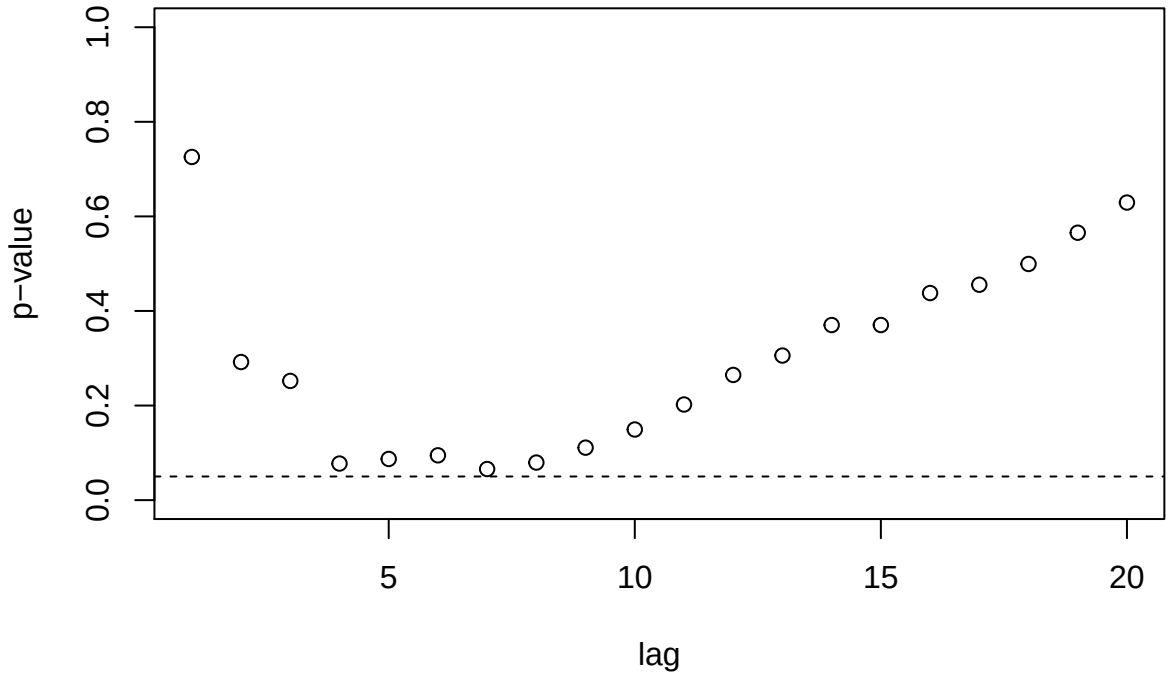
The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

```
##
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.95597, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 5583.1, df = 2, p-value < 2.2e-16
```

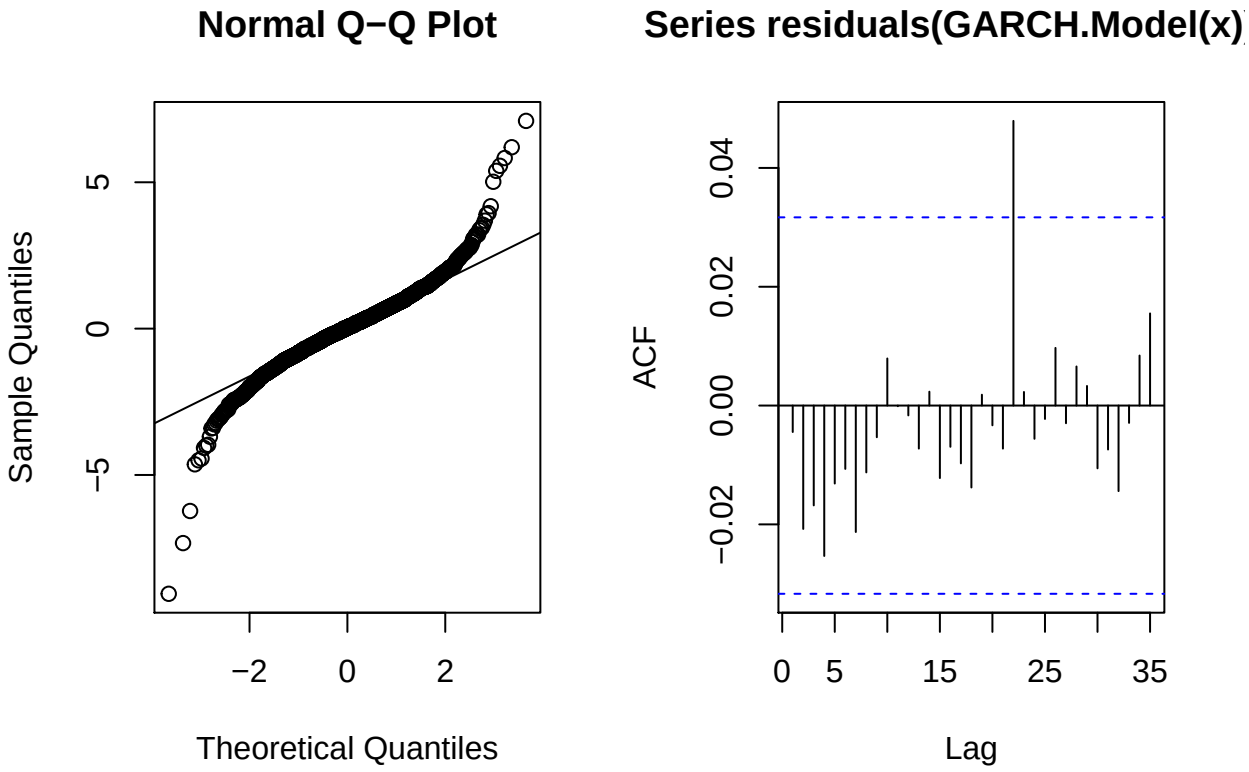
```
## [1] -0.173488
```

```
## [1] 5.907009
```



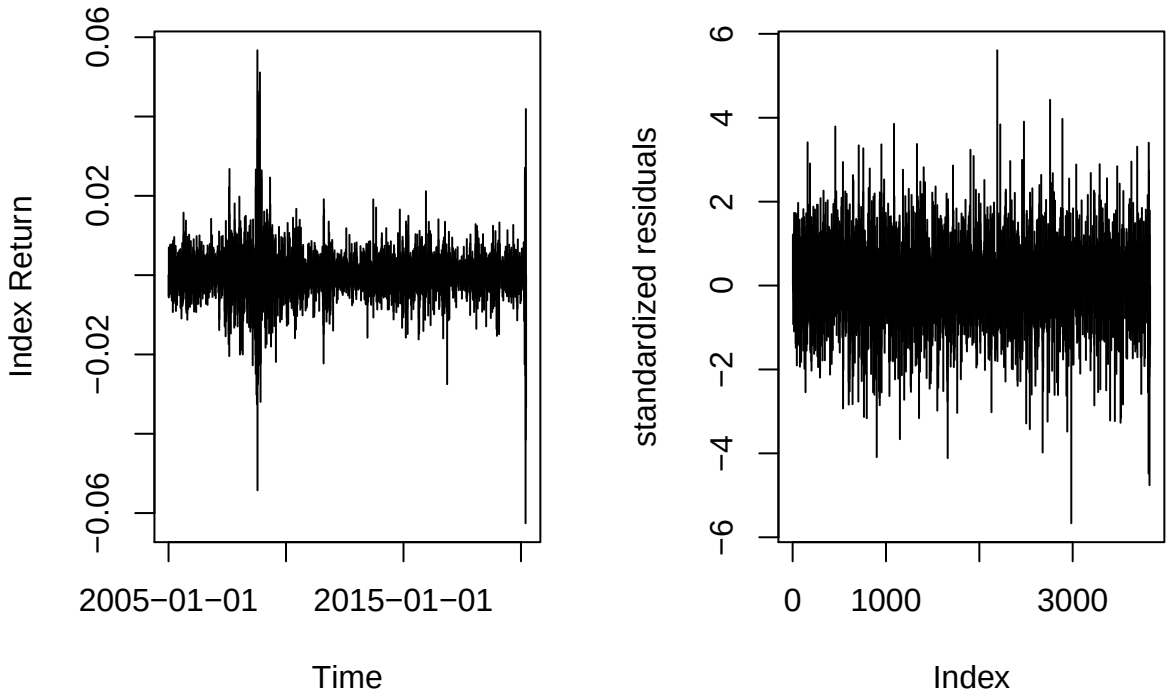

```
## [1] 0.6293079
```

QQ plot and ACF



NEE

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(2,1) with the following estimated parameter values and standard errors.

```
##        Estimate  Std. Error  t value Pr(>|t|)
## a0 4.364523e-07          NA       NA       NA
## a1 7.617196e-02          NA       NA       NA
## b1 8.883497e-01          NA       NA       NA
## b2 2.234496e-02          NA       NA       NA
```

The sum of the squared error of the final model.

```
## [1] 3822.87
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3824.251    1    1
## [2,] 3827.763    1    2
## [3,] 3822.870    2    1
## [4,] 3823.210    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

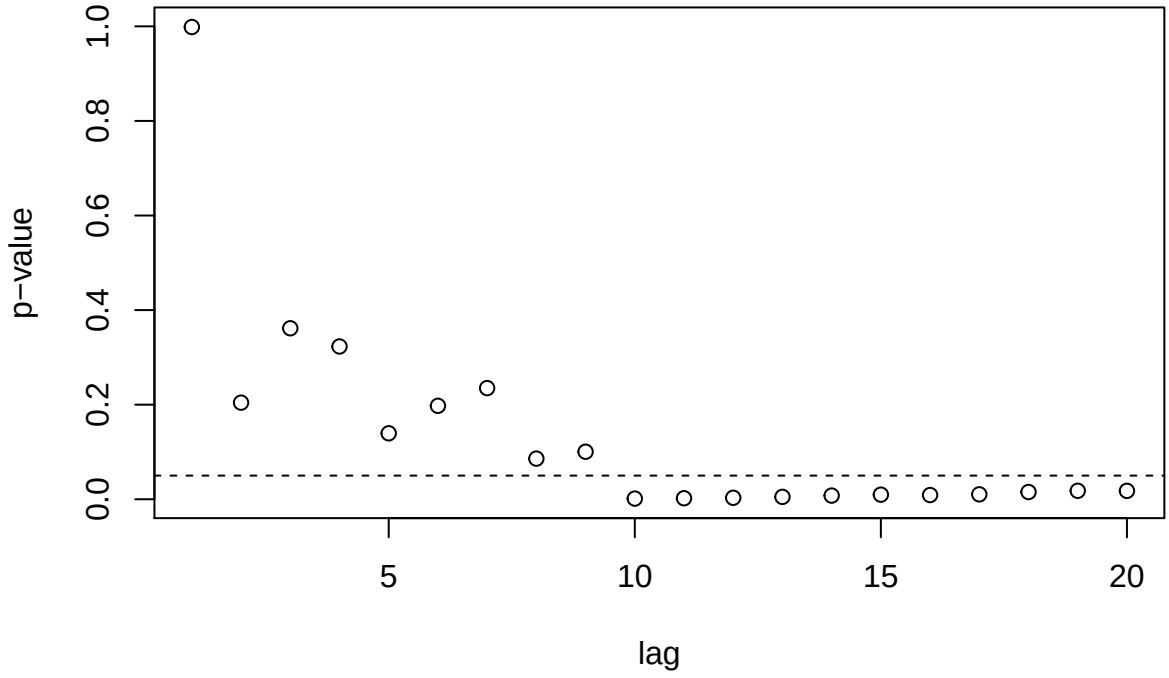
##

```
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.98697, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 429.18, df = 2, p-value < 2.2e-16
```

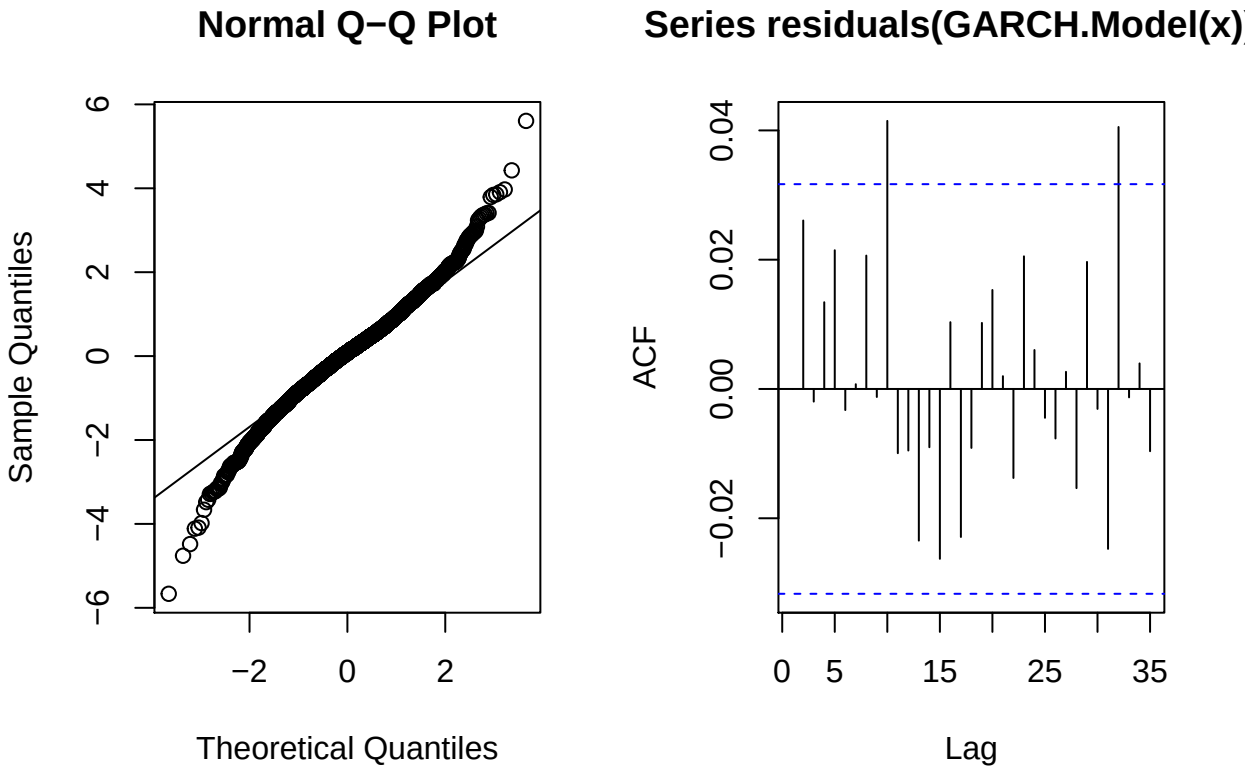
```
## [1] -0.1354809
```

```
## [1] 1.618039
```



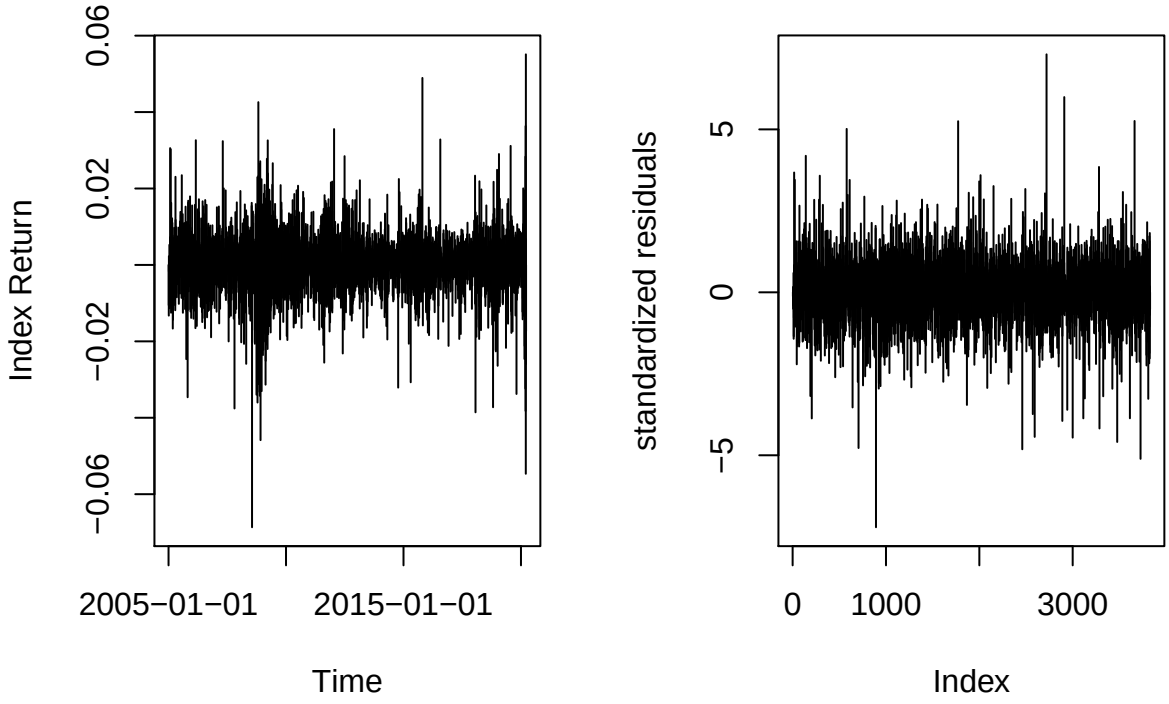

```
## [1] 0.01769078
```

QQ plot and ACF



TXN

The original log return series and the fitted residuals are plotted.



The best fitted model is GARCH(2,2) with the following estimated parameter values and standard errors.

```
##        Estimate   Std. Error   t value     Pr(>|t|)
## a0 4.287572e-06 5.349520e-07  8.014872 1.110223e-15
## a1 8.083730e-02 1.668672e-02  4.844408 1.269896e-06
## a2 2.159458e-01 1.896716e-02 11.385247 0.000000e+00
## b1 1.004550e-01 4.184761e-02  2.400495 1.637292e-02
## b2 5.835013e-01 3.732673e-02 15.632263 0.000000e+00
```

The sum of the squared error of the final model.

```
## [1] 3655.002
```

Sum of Squared Error

```
##          [,1] [,2] [,3]
## [1,] 3829.868    1    1
## [2,] 3888.509    1    2
## [3,] 3830.750    2    1
## [4,] 3655.002    2    2
```

As we can see, the criterion SSE gives us the best model above.

Some Diagnostic Results

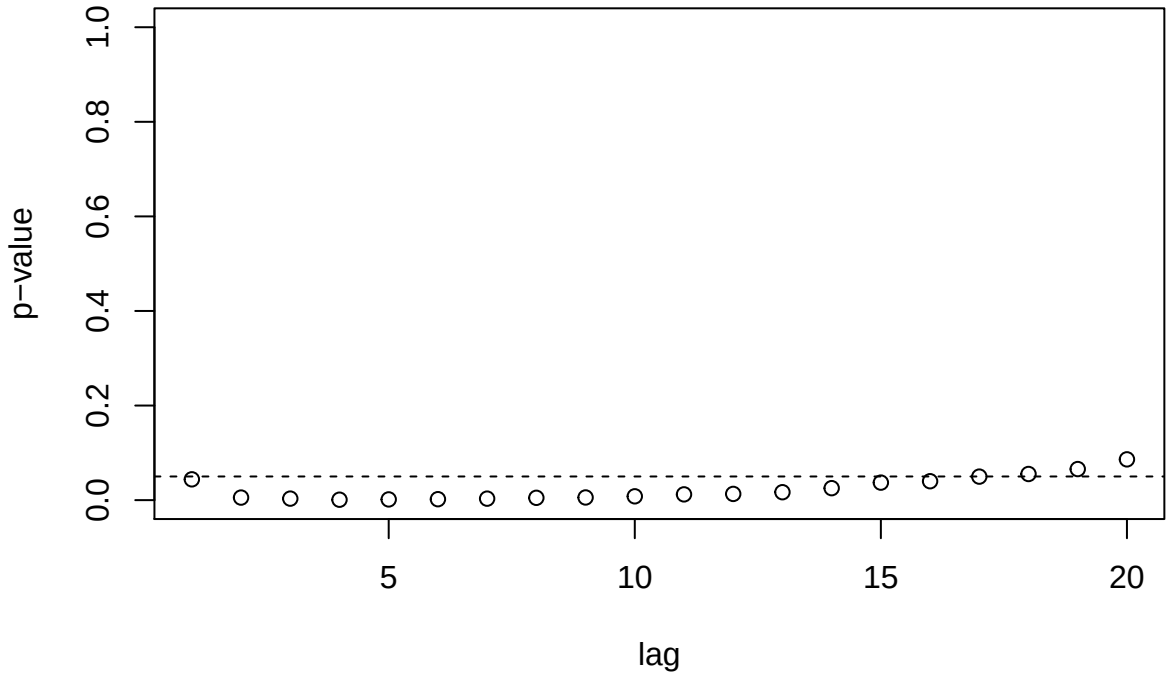
The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

```
##
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## W = 0.96717, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(x)))
## X-squared = 2487.4, df = 2, p-value < 2.2e-16
```

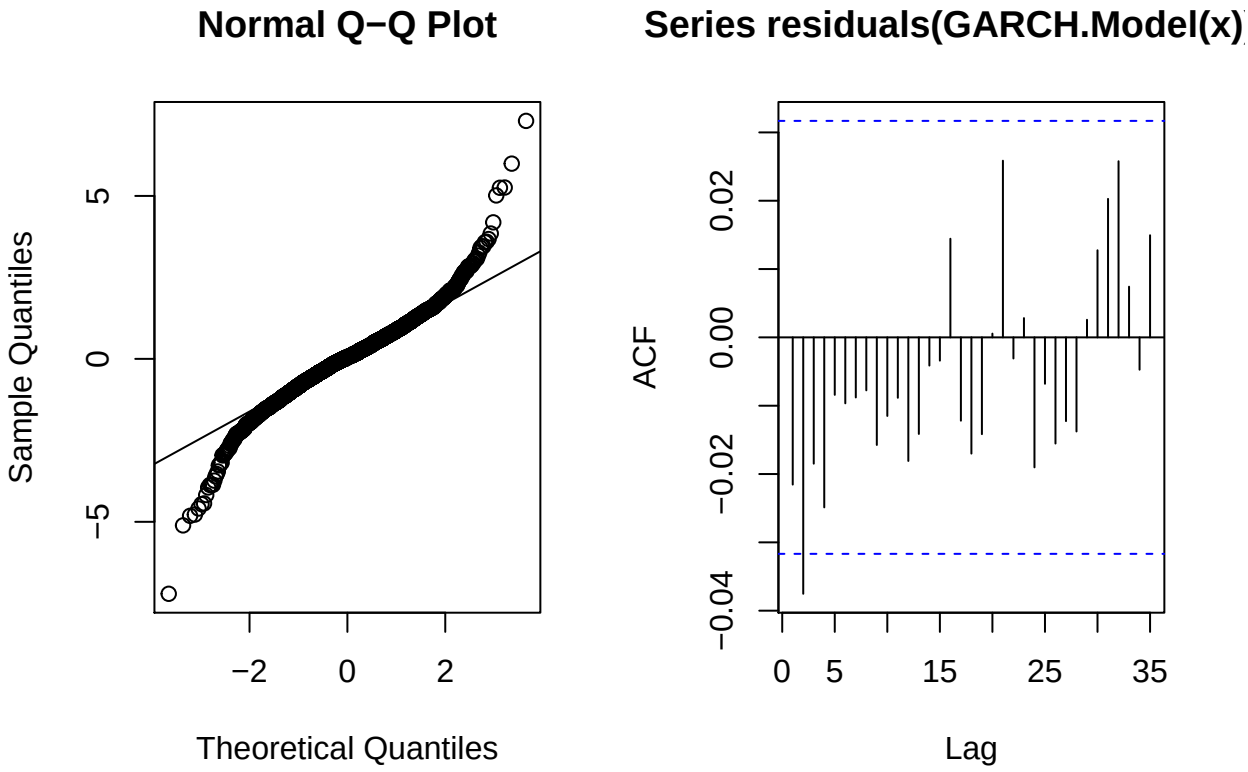
```
## [1] -0.08636008
```

```
## [1] 3.94575
```




```
## [1] 0.08619656
```

QQ plot and ACF



Step 5

Sample mean and standard deviation are:

```
## [1] 7.228984e-05
```

```
## [1] 0.006673997
```

the best (c1,c2,...,c10), the sample mean and standard deviation are:

```
##  [1] 2.737684e-18 5.942546e-18 5.265755e-01 0.000000e+00 0.000000e+00
##  [6] 0.000000e+00 3.421936e-21 1.763231e-18 4.734245e-01 2.382749e-18
```

```
## [1] 0.0002063432
```

```
## [1] 0.006673998
```

Step 6

Sample mean and standard deviation are:

```
## [1] 0.01544874
```

```
## [1] 0.5962868
```

the best (c1,c2,. . . ,c10), the sample mean and standard deviation are:

```
##  [1] 0.08063300 0.09822996 0.17130380 0.06988855 0.02490904 0.11237925
##  [7] 0.00000000 0.06690579 0.29074580 0.08500479
```

```
## [1] 0.023059
```

```
## [1] 0.5962868
```

Step 7

Sample mean and standard deviation are:

```
## [1] 0.0002182132
```

```
## [1] 0.01579521
```

the best (c1,c2,. . . ,c10), the sample mean and standard deviation are:

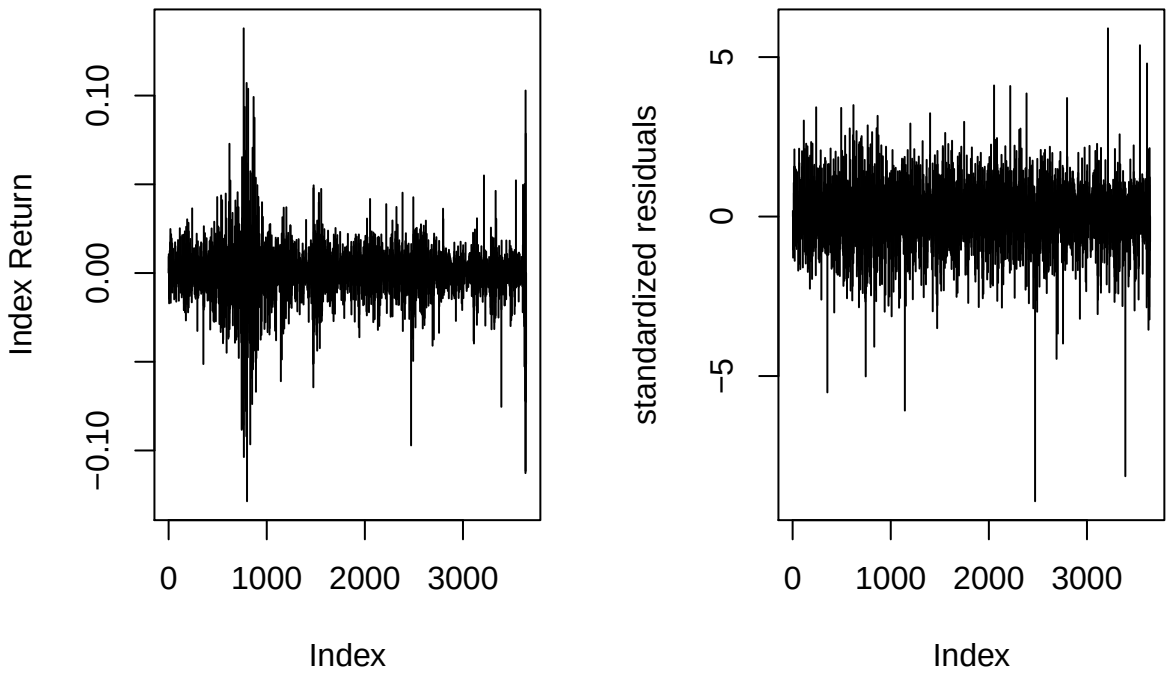
```
##  [1] 3.807322e-17 0.000000e+00 4.149367e-01 0.000000e+00 1.697141e-16
##  [6] 1.780691e-16 0.000000e+00 0.000000e+00 5.850633e-01 0.000000e+00
```

```
## [1] 0.0004563907
```

```
## [1] 0.01579522
```

Step 8

The original data and the fitted residuals are plotted.



The best fitted model is GARCH(2,2) with the following estimated parameter values and standard errors.

```
##        Estimate   Std. Error      t value     Pr(>|t|)
## a0 1.114882e-05 1.062813e-06 1.048992e+01 0.000000e+00
## a1 7.220797e-02 1.065764e-02 6.775234e+00 1.242051e-11
## a2 1.392372e-01 1.090079e-02 1.277313e+01 0.000000e+00
## b1 1.399832e-08 3.415831e-02 4.098074e-07 9.999997e-01
## b2 7.398222e-01 3.256827e-02 2.271604e+01 0.000000e+00
```

The sum of the squared error of the final model.

```
## [1] 3638.588
```

Sum of Squared Error.

```
##          [,1] [,2] [,3]
## [1,] 3640.068    1    1
## [2,] 3639.350    1    2
## [3,] 3657.774    2    1
## [4,] 3638.588    2    2
```

As we can see, the criterion SSE gives us the best model above.\
Sample mean and standard deviation are:

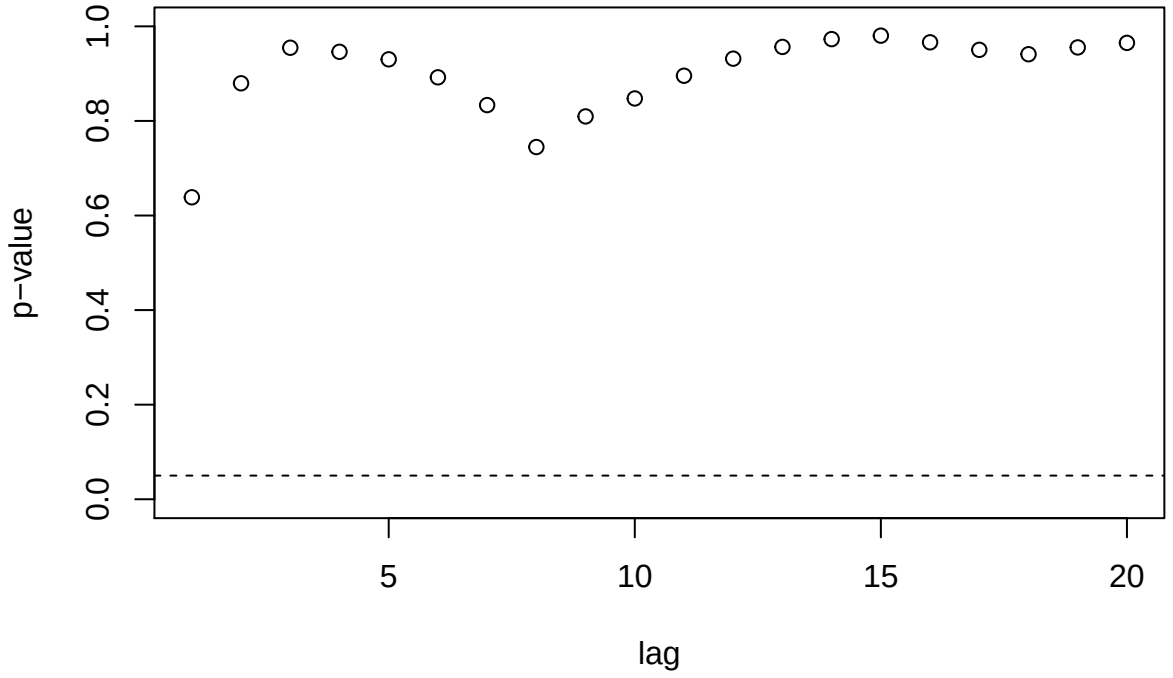
```
## [1] 0.02515505
```

```
## [1] 0.9994894
```

Some Diagnostic Results\
The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

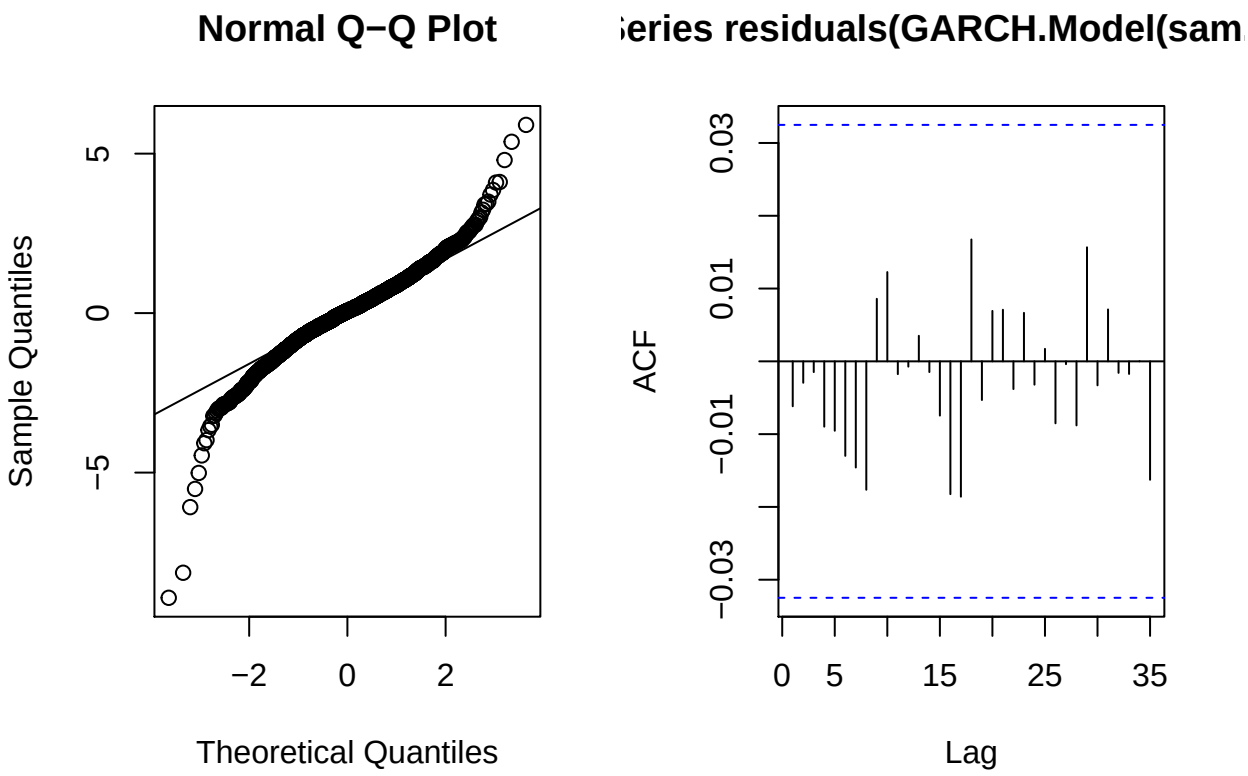
```
##
```

```
##  Shapiro-Wilk normality test
##
## data:  na.omit(residuals(GARCH.Model(sam.2)))
## W = 0.96273, p-value < 2.2e-16

##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(sam.2)))
## X-squared = 3936.6, df = 2, p-value < 2.2e-16

## [1] -0.5228151

## [1] 4.985467
```



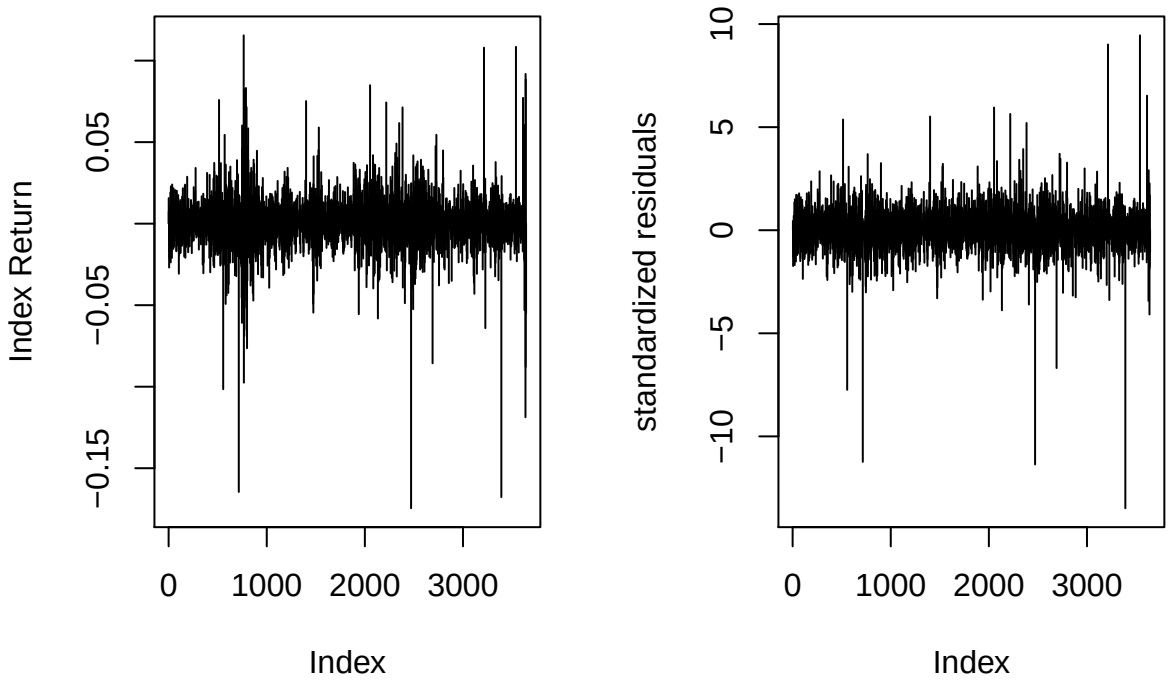

```
## [1] 0.965043
```

QQ plot and ACF



Step 9

The original data and the fitted residuals are plotted.



The best fitted model is GARCH(1,2) with the following estimated parameter values and standard errors.

```
##        Estimate   Std. Error    t value     Pr(>|t|)
## a0 1.251371e-05 8.477083e-07  14.761814 0.000000e+00
## a1 5.775020e-02 1.201365e-02   4.807047 1.531760e-06
## a2 2.899597e-02 1.371731e-02   2.113822 3.453044e-02
## b1 8.695881e-01 7.178962e-03 121.130059 0.000000e+00
```

The sum of the squared error of the final model.

```
## [1] 3639.334
```

Sum of Squared Error.

```
##          [,1] [,2] [,3]
## [1,] 3639.562    1    1
## [2,] 3639.334    1    2
## [3,] 3641.485    2    1
## [4,] 3639.375    2    2
```

As we can see, the criterion SSE gives us the best model above.\
Sample mean and standard deviation are:

```
## [1] 0.03818
```

```
## [1] 0.9991791
```

Some Diagnostic Results\
The followings are Shapiro Test, Jarque Bera Test, Skewness Test, Kurtosis and gBox respectively.

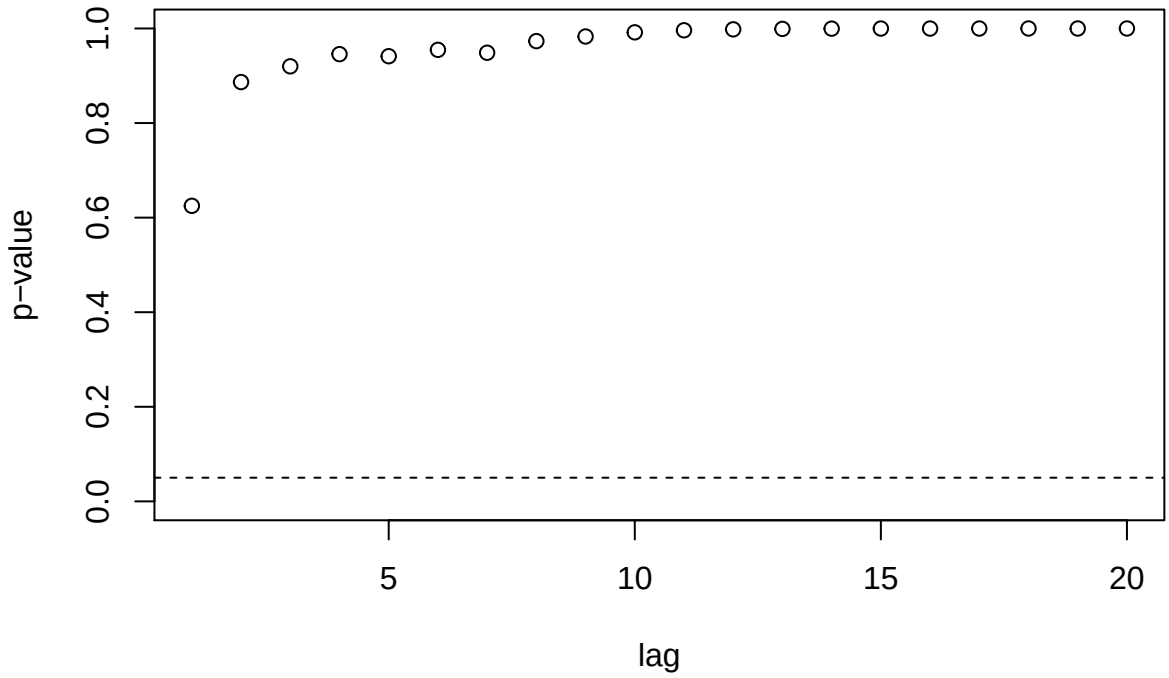
```
##
##  Shapiro-Wilk normality test
```

```
##
## data:  na.omit(residuals(GARCH.Model(Step9)))
## W = 0.87219, p-value < 2.2e-16
```

```
##
##  Jarque Bera Test
##
## data:  na.omit(residuals(GARCH.Model(Step9)))
## X-squared = 96940, df = 2, p-value < 2.2e-16
```

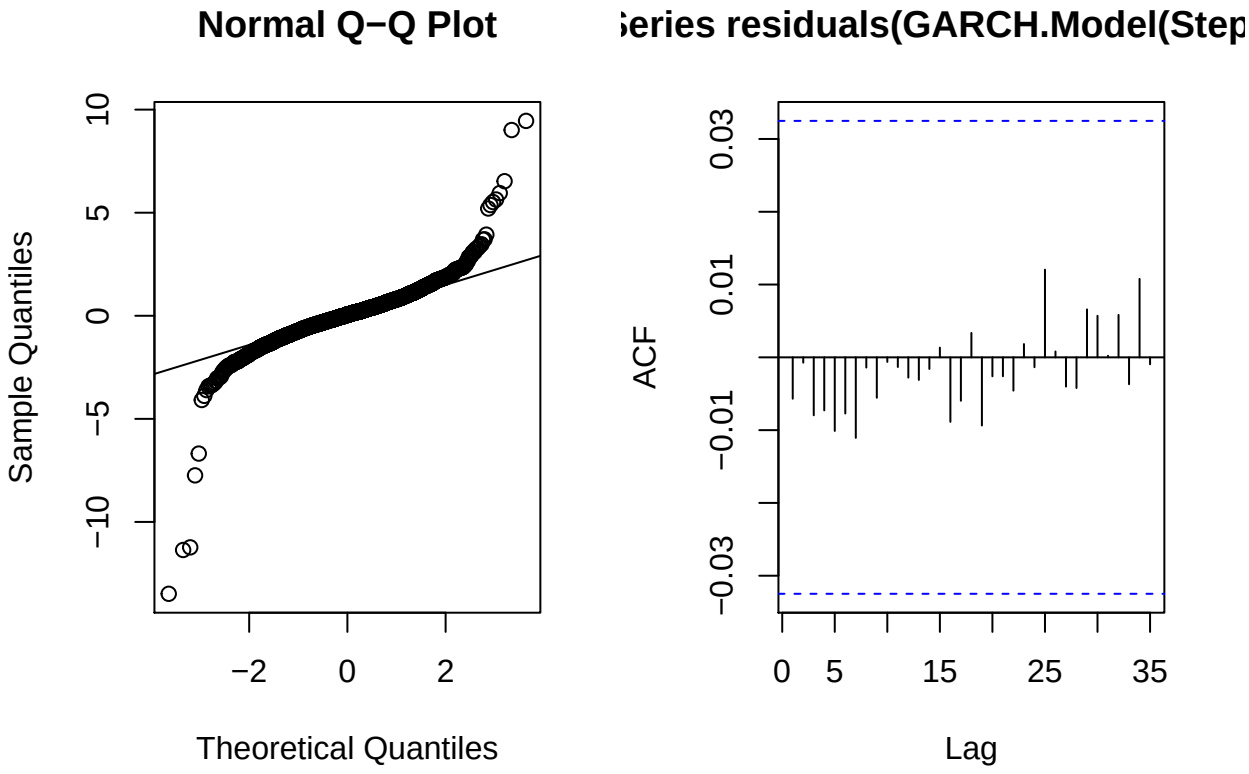
```
## [1] -0.9930669
```

```
## [1] 25.20011
```




```
## [1] 0.9999849
```

QQ plot and ACF



Step 10

We have noticed that, using donlp2 algorithm has one obvious problem from step 5 to step 10. The uppper bound of standard deviation violates our initial sample. After reading the document for this algorithm, we figure that we can set some parameter in the donlp() that alliviates the problem. Since the two standard deviations are close enough, we can accept the optimization results.\
Another way to avoid this is to set the upper bound a little bit smaller. That can ensure the portfolio's standard deviation is truly smaller then the original one.