maruti1

me

7/25/2020

```r
5+5
```

```
## [1] 10
```

```r
library(zoo)
```

```
##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```r
library(tseries)
```

```
## Warning: package 'tseries' was built under R version 4.0.2

## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```r
library(FinTS)
```

```
## Warning: package 'FinTS' was built under R version 4.0.2
```

```r
library(rugarch)
```

```
## Warning: package 'rugarch' was built under R version 4.0.2

## Loading required package: parallel

##
## Attaching package: 'rugarch'

## The following object is masked from 'package:stats':
##
##     sigma
```
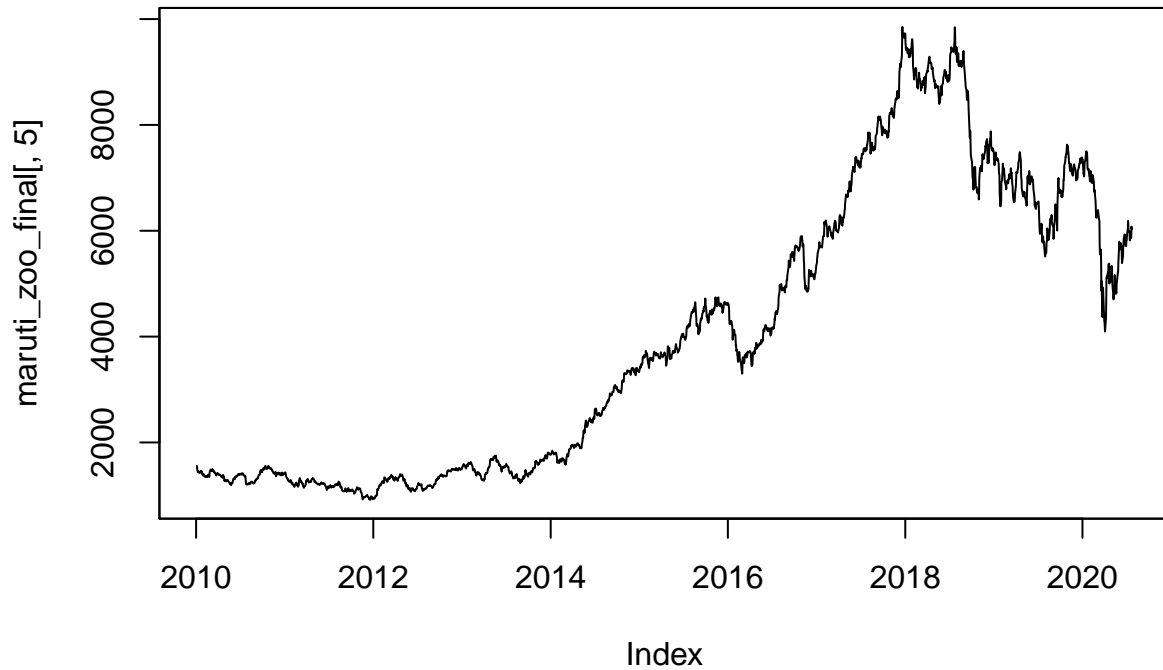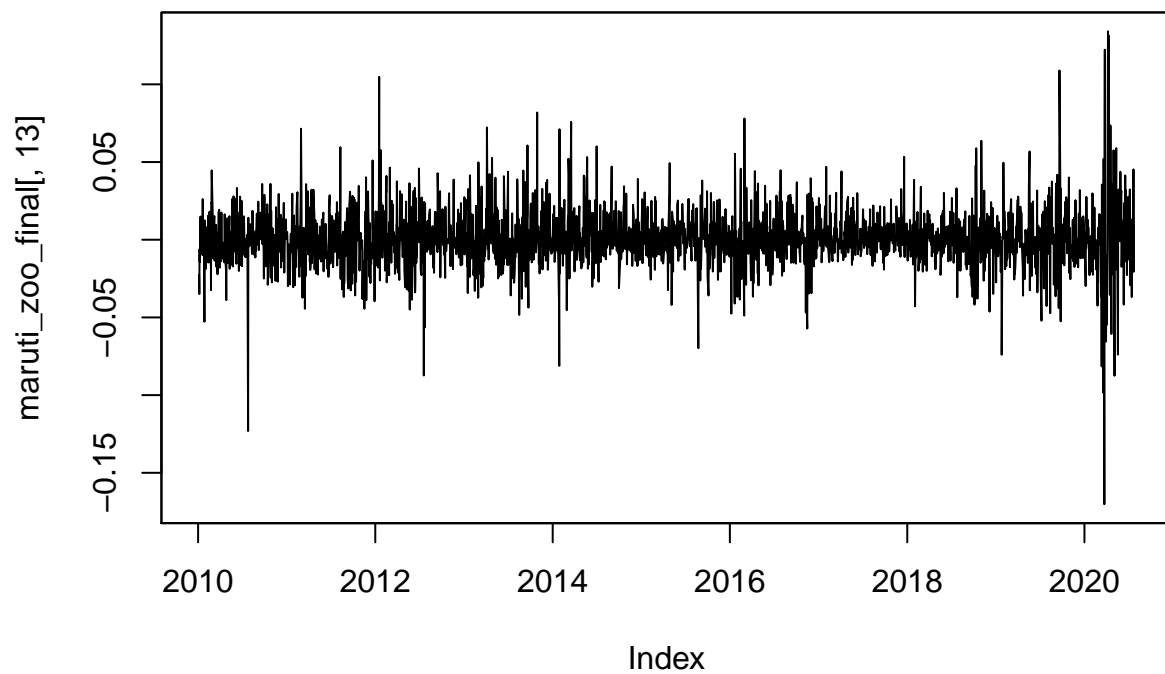
```r
maruti_zoo_final<-read.zoo("maruti suzuki.csv",header=TRUE,sep=",",format="%d-%b-%y",FUN = as.Date)
plot(maruti_zoo_final[,5])
```


there is a trend in the closing price hence i am taking the differnce and considering the log return.

```r
plot(maruti_zoo_final[,13])
```

the log return series seems to be constant at mean zero and volatility clustering is visible in graph

```
ret_maruti<- maruti_zoo_final[-1,13]
dfts_maruti<- ts(ret_maruti,start=c(2010,1),end=c(2020,300),frequency = 365)
hist(dfts_maruti)
```

Histogram of dfts_maruti
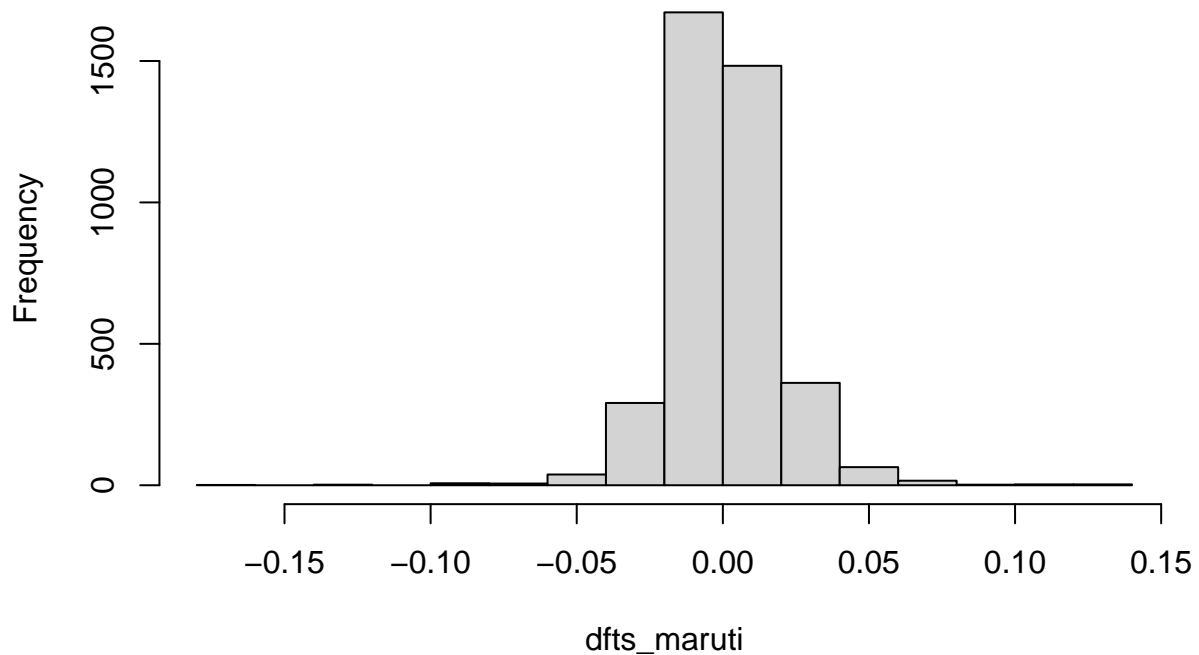
the log return appears to be noormally distributed.

```
shapiro.test(dfts_maruti)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  dfts_maruti
## W = 0.93759, p-value < 2.2e-16
```

the series is staionary.

```
mean(dfts_maruti)
```

```
## [1] 0.0007314703
```

```
adf.test(ret_maruti)
```

```
## Warning in adf.test(ret_maruti): p-value smaller than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  ret_maruti
## Dickey-Fuller = -13.28, Lag order = 13, p-value = 0.01
## alternative hypothesis: stationary
```

since p value is smaller than 0.05 hence we are rejecting the null hypothesis hence the series is stationary. also ther series is normal around mean 0.

```
acf(dfts_maruti)
```

Series dfts_maruti


```
acf(abs(dfts_maruti))
```

Series abs(dfts_maruti)


```r
acf(dfts_maruti^2)
```
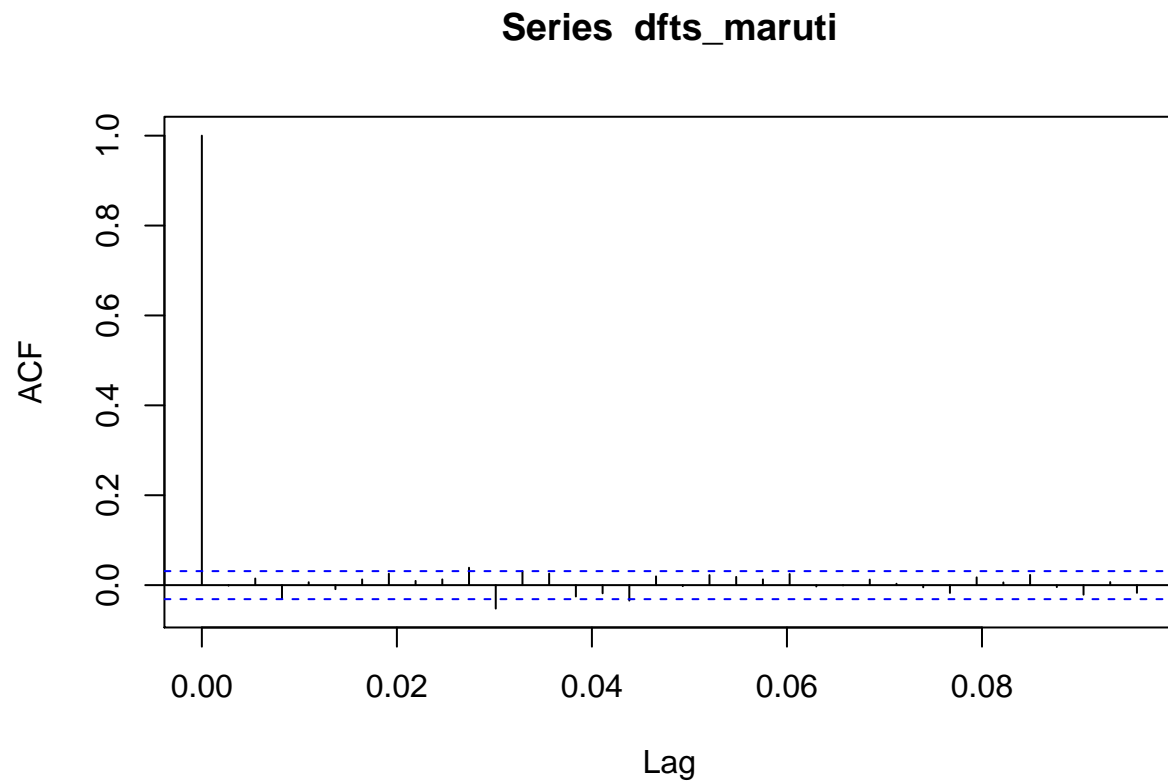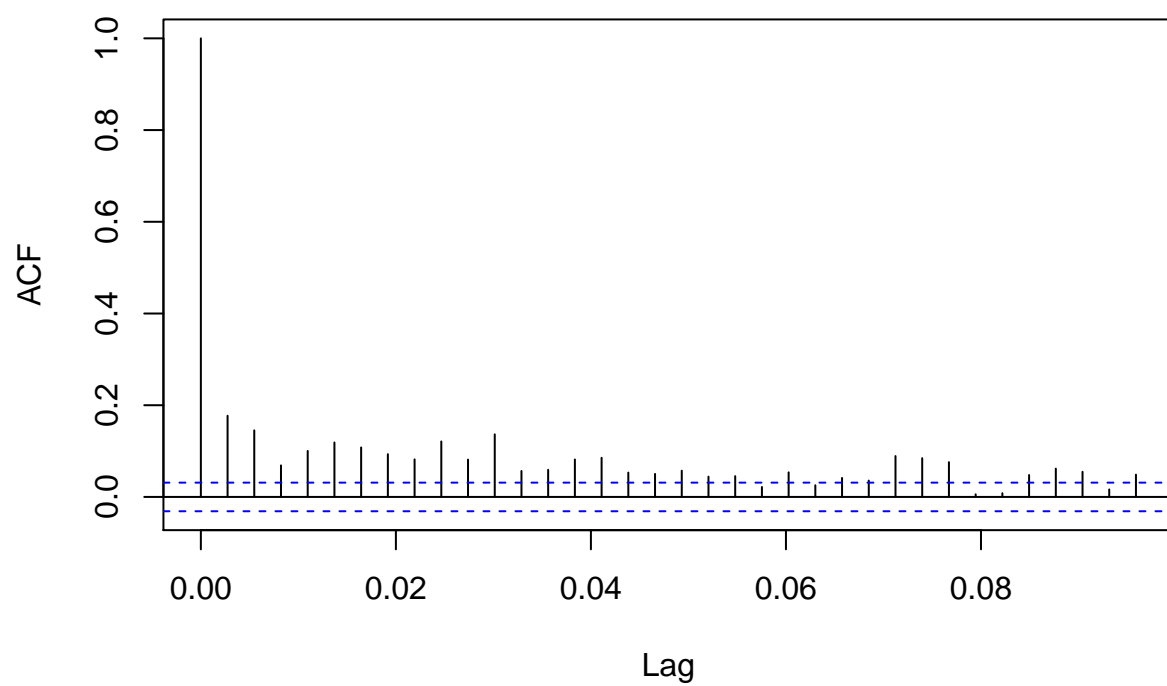
Series dfts_maruti^2
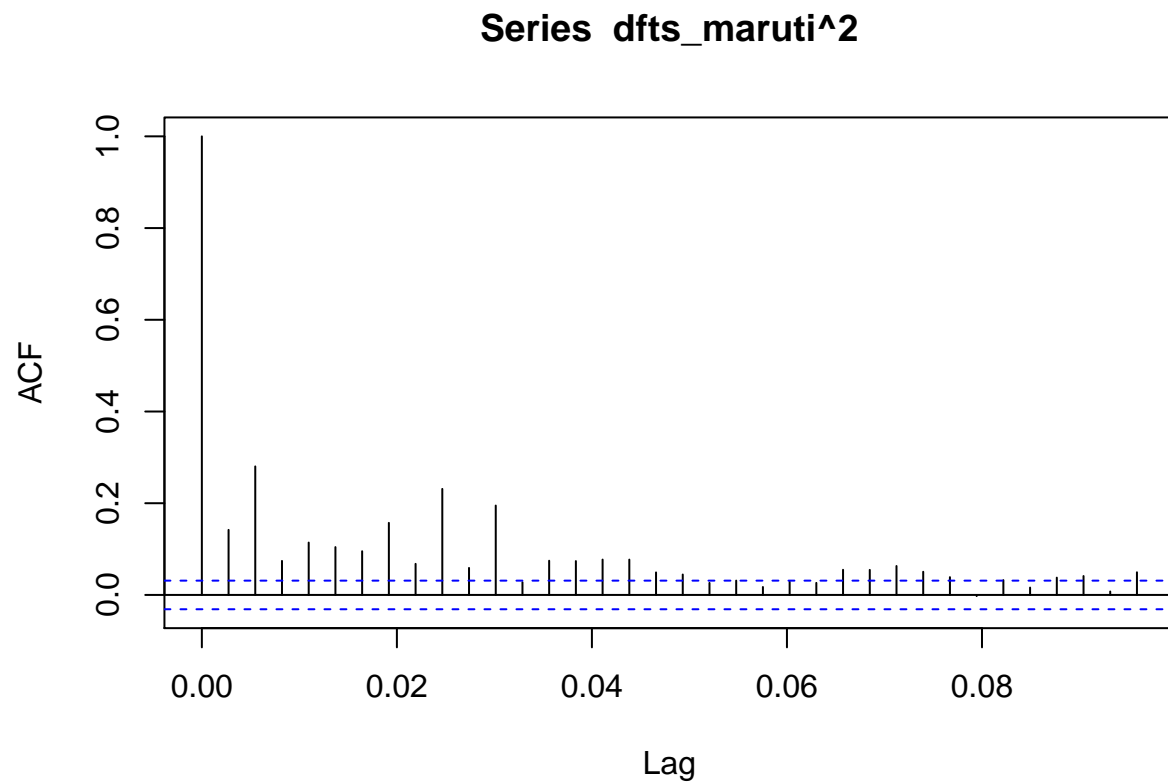
by acf function of log return we can say there is no auto correlation and there will be no need of MA model also by looking at the acf of absolute log return we can say that the large return are followed by large returns regardless of sign

```
pacf(dfts_maruti)
```
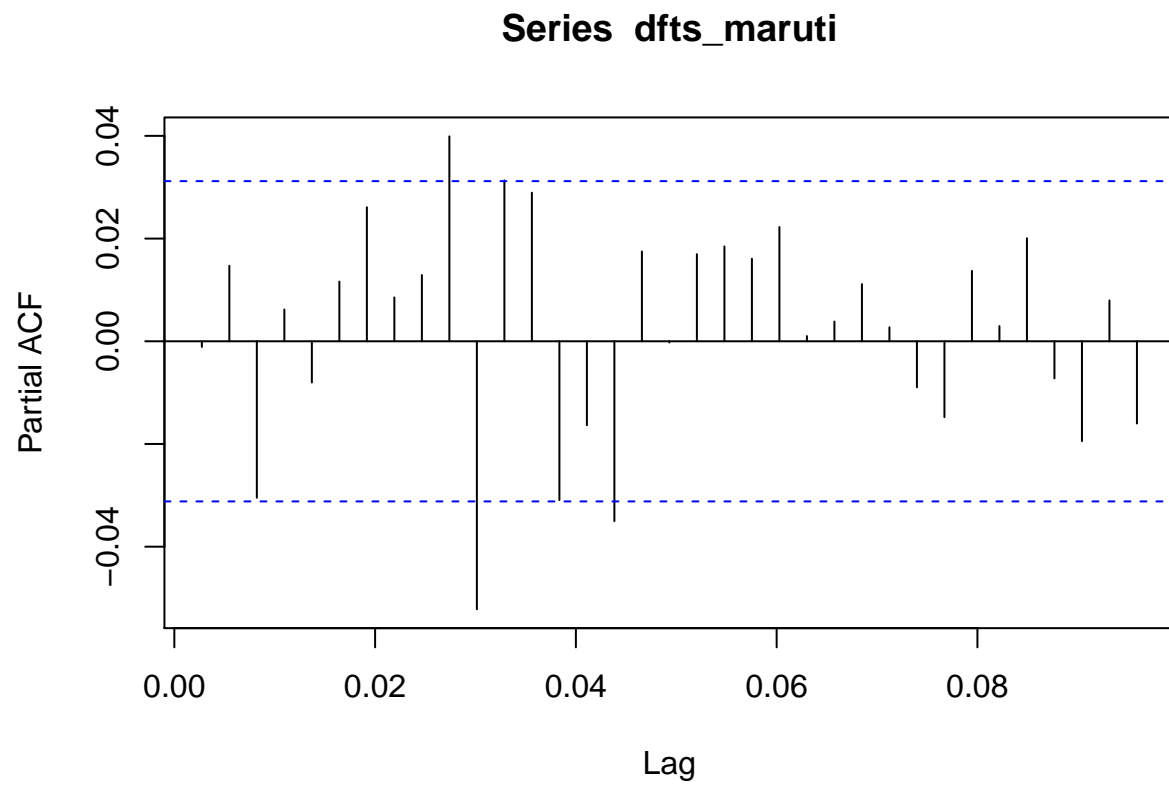
Series dfts_maruti


```
pacf(abs(dfts_maruti))
```

Series abs(dfts_maruti)
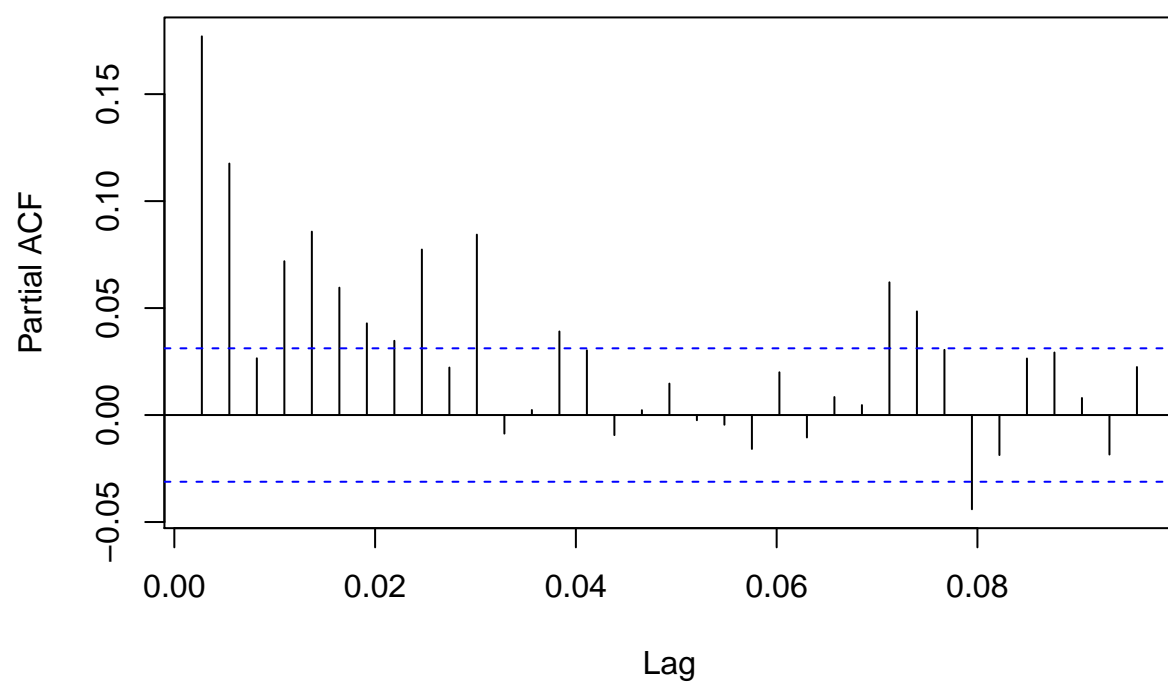

```r
pacf(dfts_maruti^2)
```

Series dfts_maruti^2
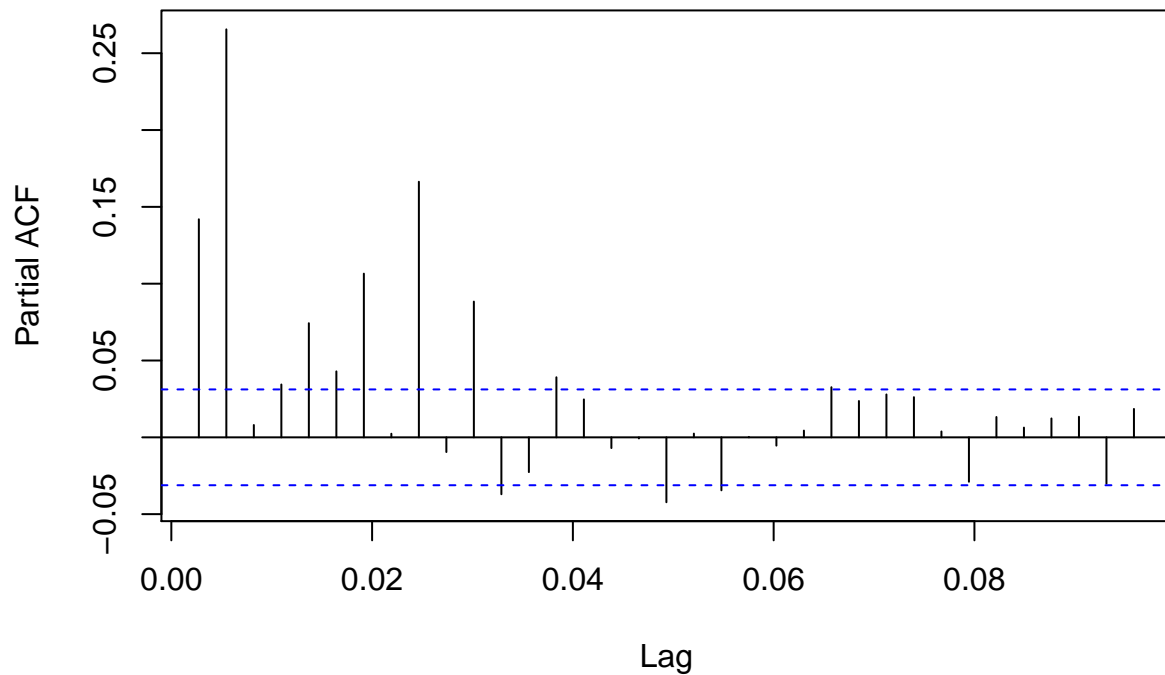
there seems to be no need of any AR model to predict the log return series.

```
Box.test(ret_maruti,lag=12,type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  ret_maruti
## X-squared = 33.062, df = 12, p-value = 0.0009468
```

```
ArchTest(ret_maruti)
```

```
##
##  ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  ret_maruti
## Chi-squared = 511.88, df = 12, p-value < 2.2e-16
```

since p value is less than 0.05 we are rejecting the null hypothesis and thus we can say there is arch effect in the series.

```
arima010=arima(ret_maruti,order=c(0,1,0))
AIC(arima010)
```

```
## [1] -11452.06
```

```r
arima110=arima(ret_maruti,order=c(1,1,0))
AIC(arima110)
```

```
## [1] -12257.03
```

```r
arima011=arima(ret_maruti,order=c(0,1,1))
AIC(arima011)
```

```
## [1] -13390.34
```

```r
arima111=arima(ret_maruti,order=c(1,1,1))
AIC(arima111)
```

```
## [1] -13388.33
```

```r
arima012=arima(ret_maruti,order=c(0,1,2))
AIC(arima012)
```

```
## [1] -13388.36
```

```r
arima210=arima(ret_maruti,order=c(2,1,0))
AIC(arima210)
```

```
## [1] -12573.3
```

```r
arima112=arima(ret_maruti,order=c(1,1,2))
AIC(arima112)
```

```
## [1] -13386.35
```

```r
arima211=arima(ret_maruti,order=c(2,1,1))
AIC(arima211)
```

```
## [1] -13386.51
```

```r
arima212=arima(ret_maruti,order=c(2,1,2))
AIC(arima212)
```

```
## [1] -13384.38
```

```r
arima020=arima(ret_maruti,order=c(0,2,0))
AIC(arima020)
```

```
## [1] -7957.519
```

```
arima120=arima(ret_maruti,order=c(1,2,0))
AIC(arima120)
```

[1] -9708.098

```
arima021=arima(ret_maruti,order=c(0,2,1))
AIC(arima021)
```

[1] -11436.17

```
arima121=arima(ret_maruti,order=c(1,2,1))
AIC(arima121)
```

[1] -12239.99

```
arima022=arima(ret_maruti,order=c(0,2,2))
AIC(arima022)
```

[1] -12804.06

```
arima220=arima(ret_maruti,order=c(2,2,0))
AIC(arima220)
```

[1] -10547.17

```
arima122=arima(ret_maruti,order=c(1,2,2))
AIC(arima122)
```

[1] -13326.16

```
arima221=arima(ret_maruti,order=c(2,2,1))
AIC(arima221)
```

[1] -12555.55

```
arima222=arima(ret_maruti,order=c(2,2,2))
AIC(arima222)
```

[1] -13325.63

if we want to take an ARMA model then (0,1,1) seems to be a best choice, but for now we will try to do the work by only garch model since in the pacf and acf function there was no AR and MA mdel recommended.

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(1,0)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
```

Warning in .sgarchfit(spec = spec, data = data, out.sample = out.sample, :
ugarchfit-->warning: solver failer to converge.

```
my_model_maruti
```

```
##
## *---------------------------------*
## *            GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(1,0)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : norm
##
## Convergence Problem:
## Solver Message:
```

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(0,1)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *            GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(0,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : norm
##
## Optimal Parameters
## -----------------------------------
##         Estimate  Std. Error   t value Pr(>|t|)
## mu      0.000752    0.000508     1.4808  0.13867
## omega   0.000001    0.000000    30.5262  0.00000
## beta1   0.996512    0.000085 11745.8019  0.00000
##
## Robust Standard Errors:
##         Estimate  Std. Error   t value Pr(>|t|)
## mu      0.000752    0.003793    0.19814 0.842937
## omega   0.000001    0.000000    4.97355 0.000001
## beta1   0.996512    0.000194 5136.75567 0.000000
##
## LogLikelihood : 6704.24
##
## Information Criteria
## -----------------------------------
##
## Akaike        -5.1213
## Bayes         -5.1146
## Shibata       -5.1213
```

```
## Hannan-Quinn -5.1189
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                     0.1316  0.7168
## Lag[2*(p+q)+(p+q)-1][2]    0.3685  0.7587
## Lag[4*(p+q)+(p+q)-1][5]    1.3383  0.7796
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                         statistic   p-value
## Lag[1]                      65.05  7.772e-16
## Lag[2*(p+q)+(p+q)-1][2]    224.16  0.000e+00
## Lag[4*(p+q)+(p+q)-1][5]    366.38  0.000e+00
## d.o.f=1
##
## Weighted ARCH LM Tests
## ------------------------------------
##              Statistic Shape Scale P-Value
## ARCH Lag[2]      317.7 0.500 2.000       0
## ARCH Lag[4]      364.4 1.397 1.611       0
## ARCH Lag[6]      410.5 2.222 1.500       0
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  71.0401
## Individual Statistics:
## mu     0.1589
## omega 67.4216
## beta1  1.8271
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:         0.846 1.01 1.35
## Individual Statistic:    0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                      t-value      prob sig
## Sign Bias              0.775 4.384e-01
## Negative Sign Bias     7.073 1.946e-12 ***
## Positive Sign Bias     6.485 1.056e-10 ***
## Joint Effect          93.154 4.603e-20 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     239.2    4.770e-40
## 2    30     264.5    7.850e-40
## 3    40     272.0    1.048e-36
## 4    50     284.9    5.304e-35
```

```
##
##
## Elapsed time : 0.5519981

spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(1,1)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti


##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(1,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : norm
##
## Optimal Parameters
## -----------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001089    0.000323    3.3675 0.000758
## omega   0.000015    0.000001   15.2857 0.000000
## alpha1  0.064982    0.005074   12.8074 0.000000
## beta1   0.888017    0.007318  121.3436 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001089    0.000335    3.2479 0.001162
## omega   0.000015    0.000003    6.1434 0.000000
## alpha1  0.064982    0.009640    6.7411 0.000000
## beta1   0.888017    0.019513   45.5090 0.000000
##
## LogLikelihood : 6899.474
##
## Information Criteria
## -----------------------------------
##
## Akaike        -5.2698
## Bayes         -5.2608
## Shibata       -5.2698
## Hannan-Quinn  -5.2665
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----------------------------------
##                          statistic p-value
## Lag[1]                       3.960  0.04658
## Lag[2*(p+q)+(p+q)-1][2]      4.349  0.06075
## Lag[4*(p+q)+(p+q)-1][5]      5.088  0.14622
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
```

```
## ------------------------------------
##                      statistic p-value
## Lag[1]                   1.372  0.2414
## Lag[2*(p+q)+(p+q)-1][5]  2.192  0.5738
## Lag[4*(p+q)+(p+q)-1][9]  2.956  0.7663
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]     0.941 0.500 2.000  0.3320
## ARCH Lag[5]     1.309 1.440 1.667  0.6438
## ARCH Lag[7]     1.640 2.315 1.543  0.7930
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  32.062
## Individual Statistics:
## mu     0.3247
## omega  2.4833
## alpha1 0.1829
## beta1  0.3138
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:        1.07 1.24 1.6
## Individual Statistic:   0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value    prob sig
## Sign Bias           1.3124 0.18949
## Negative Sign Bias  2.1975 0.02807  **
## Positive Sign Bias  0.7522 0.45199
## Joint Effect        6.2265 0.10109
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     144.0    3.168e-21
## 2    30     159.7    5.319e-20
## 3    40     177.0    1.746e-19
## 4    50     193.9    3.943e-19
##
##
## Elapsed time : 1.148998
```

```r
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(2,0)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
```

```
## Warning in .sgarchfit(spec = spec, data = data, out.sample = out.sample, :
## ugarchfit-->warning: solver failer to converge.
```

```
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(2,0)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : norm
##
## Convergence Problem:
## Solver Message:
```

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(0,2)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
```

```
## Warning in .sgarchfit(spec = spec, data = data, out.sample = out.sample, :
## ugarchfit-->warning: solver failer to converge.
```

```
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(0,2)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : norm
##
## Convergence Problem:
## Solver Message:
```

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(2,2)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(2,2)
## Mean Model   : ARFIMA(0,0,0)
```

```
## Distribution : norm
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001030    0.000326 3.157060 0.001594
## omega   0.000020    0.000002 8.449411 0.000000
## alpha1  0.093205    0.016280 5.725082 0.000000
## alpha2  0.000000    0.026766 0.000002 0.999999
## beta1   0.404373    0.233749 1.729943 0.083640
## beta2   0.440894    0.193405 2.279648 0.022629
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001030    0.000351 2.932296 0.003365
## omega   0.000020    0.000012 1.712910 0.086729
## alpha1  0.093205    0.035934 2.593780 0.009493
## alpha2  0.000000    0.025949 0.000002 0.999999
## beta1   0.404373    0.405553 0.997090 0.318721
## beta2   0.440894    0.390556 1.128889 0.258945
##
## LogLikelihood : 6903.098
##
## Information Criteria
## ------------------------------------
##
## Akaike        -5.2710
## Bayes         -5.2575
## Shibata       -5.2710
## Hannan-Quinn  -5.2661
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                      4.133 0.04207
## Lag[2*(p+q)+(p+q)-1][2]     4.596 0.05216
## Lag[4*(p+q)+(p+q)-1][5]     5.326 0.12900
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                          statistic p-value
## Lag[1]                      0.3382  0.5609
## Lag[2*(p+q)+(p+q)-1][11]    2.8945  0.8809
## Lag[4*(p+q)+(p+q)-1][19]    4.5445  0.9603
## d.o.f=4
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[5]    0.2630 0.500 2.000  0.6081
## ARCH Lag[7]    0.8432 1.473 1.746  0.8015
## ARCH Lag[9]    1.5339 2.402 1.619  0.8460
```

```
##
## Nyblom stability test
## ---------------------------------
## Joint Statistic:  5.2016
## Individual Statistics:
## mu     0.3649
## omega  0.4342
## alpha1 0.1785
## alpha2 0.3457
## beta1  0.2953
## beta2  0.3038
##
## 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            1.2180 0.22334
## Negative Sign Bias   1.6580 0.09744    *
## Positive Sign Bias   0.4645 0.64233
## Joint Effect         3.8269 0.28077
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ---------------------------------
##    group statistic p-value(g-1)
## 1     20    141.9    7.985e-21
## 2     30    159.2    6.439e-20
## 3     40    194.1    1.852e-22
## 4     50    196.9    1.247e-19
##
##
## Elapsed time : 1.508005
```

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(1,2)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## ---------------------------------
## GARCH Model  : sGARCH(1,2)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : norm
##
## Optimal Parameters
## ---------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
```

```
## mu       0.001031    0.000327   3.1546 0.001607
## omega    0.000020    0.000006   3.4276 0.000609
## alpha1   0.093205    0.016830   5.5379 0.000000
## beta1    0.404468    0.158460   2.5525 0.010696
## beta2    0.440802    0.148602   2.9663 0.003014
##
## Robust Standard Errors:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu       0.001031    0.000352   2.9266 0.003427
## omega    0.000020    0.000012   1.7443 0.081099
## alpha1   0.093205    0.034792   2.6789 0.007386
## beta1    0.404468    0.262952   1.5382 0.124004
## beta2    0.440802    0.270128   1.6318 0.102716
##
## LogLikelihood : 6903.098
##
## Information Criteria
## ---------------------------------
##
## Akaike       -5.2718
## Bayes        -5.2605
## Shibata      -5.2718
## Hannan-Quinn -5.2677
##
## Weighted Ljung-Box Test on Standardized Residuals
## ---------------------------------
##                            statistic p-value
## Lag[1]                         4.133 0.04206
## Lag[2*(p+q)+(p+q)-1][2]        4.596 0.05216
## Lag[4*(p+q)+(p+q)-1][5]        5.327 0.12899
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ---------------------------------
##                            statistic p-value
## Lag[1]                        0.3381  0.5609
## Lag[2*(p+q)+(p+q)-1][8]       2.2377  0.8208
## Lag[4*(p+q)+(p+q)-1][14]      3.6049  0.9148
## d.o.f=3
##
## Weighted ARCH LM Tests
## ---------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[4]    0.1692 0.500 2.000  0.6808
## ARCH Lag[6]    0.7255 1.461 1.711  0.8274
## ARCH Lag[8]    1.3825 2.368 1.583  0.8612
##
## Nyblom stability test
## ---------------------------------
## Joint Statistic:  1.9587
## Individual Statistics:
## mu     0.3649
## omega  0.4342
```

```
## alpha1 0.1785
## beta1  0.2954
## beta2  0.3038
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          1.28 1.47 1.88
## Individual Statistic:    0.35 0.47 0.75
##
## Sign Bias Test
## -------------------------------------
##                     t-value    prob sig
## Sign Bias            1.2180 0.22333
## Negative Sign Bias  1.6580 0.09744   *
## Positive Sign Bias  0.4644 0.64240
## Joint Effect         3.8267 0.28079
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -------------------------------------
##   group statistic p-value(g-1)
## 1    20     141.9    7.985e-21
## 2    30     159.2    6.439e-20
## 3    40     194.1    1.852e-22
## 4    50     196.9    1.247e-19
##
##
## Elapsed time : 0.891001
```

```r
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(2,1)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -------------------------------------
## GARCH Model  : sGARCH(2,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : norm
##
## Optimal Parameters
## -------------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001088    0.000324    3.3536 0.000798
## omega   0.000015    0.000001   15.9750 0.000000
## alpha1  0.064916    0.017826    3.6416 0.000271
## alpha2  0.000000    0.018631    0.0000 1.000000
## beta1   0.888125    0.007717  115.0932 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
```

```
## mu      0.001088    0.000343   3.1729 0.001509
## omega   0.000015    0.000003   6.1255 0.000000
## alpha1  0.064916    0.034759   1.8676 0.061814
## alpha2  0.000000    0.035668   0.0000 1.000000
## beta1   0.888125    0.019887  44.6579 0.000000
##
## LogLikelihood : 6899.458
##
## Information Criteria
## ---------------------------------
##
## Akaike        -5.2690
## Bayes         -5.2578
## Shibata       -5.2690
## Hannan-Quinn -5.2649
##
## Weighted Ljung-Box Test on Standardized Residuals
## ---------------------------------
##                          statistic p-value
## Lag[1]                       3.958 0.04666
## Lag[2*(p+q)+(p+q)-1][2]      4.348 0.06081
## Lag[4*(p+q)+(p+q)-1][5]      5.086 0.14634
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ---------------------------------
##                          statistic p-value
## Lag[1]                       1.375  0.2409
## Lag[2*(p+q)+(p+q)-1][8]      2.779  0.7259
## Lag[4*(p+q)+(p+q)-1][14]     4.037  0.8767
## d.o.f=3
##
## Weighted ARCH LM Tests
## ---------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[4]    0.3059 0.500 2.000  0.5802
## ARCH Lag[6]    0.7980 1.461 1.711  0.8063
## ARCH Lag[8]    1.3249 2.368 1.583  0.8715
##
## Nyblom stability test
## ---------------------------------
## Joint Statistic:  32.414
## Individual Statistics:
## mu     0.3257
## omega  2.4921
## alpha1 0.1833
## alpha2 0.4257
## beta1  0.3141
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          1.28 1.47 1.88
## Individual Statistic:     0.35 0.47 0.75
##
```

```
## Sign Bias Test
## -----------------------------------
##                    t-value    prob sig
## Sign Bias            1.3129 0.18932
## Negative Sign Bias   2.2007 0.02784   **
## Positive Sign Bias   0.7531 0.45147
## Joint Effect         6.2409 0.10046
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----------------------------------
##    group statistic p-value(g-1)
## 1     20     143.8    3.390e-21
## 2     30     159.0    7.017e-20
## 3     40     177.4    1.509e-19
## 4     50     194.0    3.830e-19
##
##
## Elapsed time : 1.538998
```

so the model of choice can be sGARCH(1,2) Akaike -5.2718 sGARCH(2,2) Akaike -5.2710 sGARCH(1,1) Akaike -5.2698 sGARCH(2,1) Akaike -5.2690 to keep the model simple lets try (1,2) then (2,2) and then (1,1) and in the end (2,1)

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(0,1)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(0,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## -----------------------------------
##         Estimate  Std. Error    t value Pr(>|t|)
## mu      0.000846    0.000332     2.5457 0.010906
## omega   0.000002    0.000000    69.8155 0.000000
## beta1   0.994956    0.000059 16843.5125 0.000000
## skew    1.100581    0.027051    40.6851 0.000000
## shape   3.515819    0.071029    49.4986 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error    t value Pr(>|t|)
## mu      0.000846    0.000386     2.1907 0.028473
## omega   0.000002    0.000000    61.7569 0.000000
## beta1   0.994956    0.000140  7092.5948 0.000000
```

```
## skew   1.100581    0.027177   40.4969 0.000000
## shape  3.515819    0.044979   78.1667 0.000000
##
## LogLikelihood : 6975.08
##
## Information Criteria
## ---------------------------------
##
## Akaike        -5.3268
## Bayes         -5.3156
## Shibata       -5.3268
## Hannan-Quinn  -5.3227
##
## Weighted Ljung-Box Test on Standardized Residuals
## ---------------------------------
##                           statistic p-value
## Lag[1]                       0.1314  0.7169
## Lag[2*(p+q)+(p+q)-1][2]      0.3693  0.7583
## Lag[4*(p+q)+(p+q)-1][5]      1.3394  0.7793
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ---------------------------------
##                           statistic   p-value
## Lag[1]                        64.66 8.882e-16
## Lag[2*(p+q)+(p+q)-1][2]      223.52 0.000e+00
## Lag[4*(p+q)+(p+q)-1][5]      365.67 0.000e+00
## d.o.f=1
##
## Weighted ARCH LM Tests
## ---------------------------------
##              Statistic Shape Scale P-Value
## ARCH Lag[2]      317.2 0.500 2.000       0
## ARCH Lag[4]      363.9 1.397 1.611       0
## ARCH Lag[6]      410.1 2.222 1.500       0
##
## Nyblom stability test
## ---------------------------------
## Joint Statistic:  229.7497
## Individual Statistics:
## mu      0.2861
## omega 187.6536
## beta1   1.7601
## skew    0.1254
## shape   2.1046
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:        1.28 1.47 1.88
## Individual Statistic:   0.35 0.47 0.75
##
## Sign Bias Test
## ---------------------------------
##                     t-value      prob sig
```

```
## Sign Bias                0.7998 4.239e-01
## Negative Sign Bias  7.0645 2.058e-12 ***
## Positive Sign Bias  6.4637 1.215e-10 ***
## Joint Effect        92.8482 5.354e-20 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----------------------------------
##   group statistic p-value(g-1)
## 1    20     17.05      0.58671
## 2    30     35.62      0.18486
## 3    40     46.37      0.19447
## 4    50     69.84      0.02686
##
##
## Elapsed time : 1.911999
```

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(1,0)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(1,0)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## -----------------------------------
##        Estimate  Std. Error  t value Pr(>|t|)
## mu     0.000792    0.000334   2.3735 0.017622
## omega  0.000272    0.000020  13.5188 0.000000
## alpha1 0.259857    0.048276   5.3827 0.000000
## skew   1.093785    0.027977  39.0954 0.000000
## shape  3.870118    0.319044  12.1303 0.000000
##
## Robust Standard Errors:
##        Estimate  Std. Error  t value Pr(>|t|)
## mu     0.000792    0.000355   2.2310 0.025681
## omega  0.000272    0.000023  11.7364 0.000000
## alpha1 0.259857    0.072192   3.5995 0.000319
## skew   1.093785    0.027262  40.1217 0.000000
## shape  3.870118    0.398024   9.7233 0.000000
##
## LogLikelihood : 7010.842
##
## Information Criteria
## -----------------------------------
##
```

```
## Akaike        -5.3541
## Bayes         -5.3429
## Shibata       -5.3541
## Hannan-Quinn -5.3500
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                             statistic p-value
## Lag[1]                          1.322  0.2502
## Lag[2*(p+q)+(p+q)-1][2]         1.745  0.3088
## Lag[4*(p+q)+(p+q)-1][5]         3.344  0.3479
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                             statistic   p-value
## Lag[1]                         0.3238 5.693e-01
## Lag[2*(p+q)+(p+q)-1][2]       17.8694 1.615e-05
## Lag[4*(p+q)+(p+q)-1][5]       39.5554 6.181e-11
## d.o.f=1
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale  P-Value
## ARCH Lag[2]     35.04 0.500 2.000 3.234e-09
## ARCH Lag[4]     45.88 1.397 1.611 1.853e-12
## ARCH Lag[6]     58.00 2.222 1.500 1.332e-15
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  3.8168
## Individual Statistics:
## mu     0.3441
## omega  1.4311
## alpha1 0.4099
## skew   0.1770
## shape  1.6850
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          1.28 1.47 1.88
## Individual Statistic:     0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value   prob sig
## Sign Bias           0.8081 0.4191
## Negative Sign Bias  0.9700 0.3321
## Positive Sign Bias  0.5751 0.5653
## Joint Effect        2.0746 0.5571
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
```

```
##    group statistic p-value(g-1)
## 1     20     14.89       0.7295
## 2     30     36.88       0.1493
## 3     40     34.11       0.6922
## 4     50     45.53       0.6145
##
##
## Elapsed time : 2.789999
```

```r
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(1,1)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(1,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001040    0.000318    3.2669 0.001087
## omega   0.000011    0.000001   15.0022 0.000000
## alpha1  0.065432    0.003326   19.6701 0.000000
## beta1   0.904677    0.008874  101.9424 0.000000
## skew    1.117659    0.028913   38.6565 0.000000
## shape   4.467426    0.383969   11.6349 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001040    0.000341    3.0526 0.002268
## omega   0.000011    0.000001    9.2832 0.000000
## alpha1  0.065432    0.004348   15.0495 0.000000
## beta1   0.904677    0.008952  101.0641 0.000000
## skew    1.117659    0.027925   40.0235 0.000000
## shape   4.467426    0.498386    8.9638 0.000000
##
## LogLikelihood : 7050.719
##
## Information Criteria
## ------------------------------------
##
## Akaike       -5.3838
## Bayes        -5.3704
## Shibata      -5.3838
## Hannan-Quinn -5.3789
##
## Weighted Ljung-Box Test on Standardized Residuals
```

```
## ------------------------------------
##                          statistic p-value
## Lag[1]                       4.509 0.03372
## Lag[2*(p+q)+(p+q)-1][2]      4.885 0.04367
## Lag[4*(p+q)+(p+q)-1][5]      5.560 0.11393
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                          statistic p-value
## Lag[1]                       1.512  0.2188
## Lag[2*(p+q)+(p+q)-1][5]      2.280  0.5538
## Lag[4*(p+q)+(p+q)-1][9]      3.089  0.7442
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##              Statistic Shape Scale P-Value
## ARCH Lag[3]     0.9225 0.500 2.000  0.3368
## ARCH Lag[5]     1.2683 1.440 1.667  0.6553
## ARCH Lag[7]     1.6758 2.315 1.543  0.7855
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  46.1522
## Individual Statistics:
## mu     0.3211
## omega  7.4335
## alpha1 0.3285
## beta1  0.5807
## skew   0.1289
## shape  0.6533
##
## 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            1.3385 0.18084
## Negative Sign Bias   2.1492 0.03171  **
## Positive Sign Bias   0.6122 0.54046
## Joint Effect         5.7602 0.12388
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##    group statistic p-value(g-1)
## 1     20     15.40       0.6971
## 2     30     31.88       0.3250
## 3     40     42.12       0.3374
## 4     50     57.91       0.1795
```

```
##
##
## Elapsed time : 1.832469

spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(2,0)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti


##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(2,0)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.000967    0.000328   2.9505 0.003173
## omega   0.000234    0.000018  13.3880 0.000000
## alpha1  0.207833    0.043529   4.7746 0.000002
## alpha2  0.143712    0.036489   3.9385 0.000082
## skew    1.107285    0.028412  38.9727 0.000000
## shape   4.121948    0.354683  11.6215 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.000967    0.000340   2.8482 0.004396
## omega   0.000234    0.000019  12.1594 0.000000
## alpha1  0.207833    0.047328   4.3913 0.000011
## alpha2  0.143712    0.051422   2.7947 0.005194
## skew    1.107285    0.025622  43.2162 0.000000
## shape   4.121948    0.391579  10.5265 0.000000
##
## LogLikelihood : 7026.692
##
## Information Criteria
## ------------------------------------
##
## Akaike       -5.3655
## Bayes        -5.3520
## Shibata      -5.3655
## Hannan-Quinn -5.3606
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                      1.891  0.1691
## Lag[2*(p+q)+(p+q)-1][2]     2.182  0.2343
## Lag[4*(p+q)+(p+q)-1][5]     3.273  0.3594
```

```
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                             statistic p-value
## Lag[1]                       0.007327  0.9318
## Lag[2*(p+q)+(p+q)-1][5]      1.844611  0.6556
## Lag[4*(p+q)+(p+q)-1][9]      6.383639  0.2565
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##              Statistic Shape Scale P-Value
## ARCH Lag[3]     0.1565 0.500 2.000 0.69240
## ARCH Lag[5]     3.8776 1.440 1.667 0.18531
## ARCH Lag[7]     7.2177 2.315 1.543 0.07793
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  3.7822
## Individual Statistics:
## mu      0.3247
## omega  1.3603
## alpha1 0.1699
## alpha2 0.7047
## skew   0.1552
## shape  1.4108
##
## 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           1.3095 0.1905
## Negative Sign Bias  1.2817 0.2001
## Positive Sign Bias  0.6256 0.5316
## Joint Effect        2.3217 0.5084
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20    15.73      0.67507
## 2    30    39.91      0.08544
## 3    40    37.81      0.52403
## 4    50    58.49      0.16626
##
##
## Elapsed time : 2.780345
```

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(0,2)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(0,2)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##        Estimate  Std. Error   t value Pr(>|t|)
## mu     0.000806    0.000340    2.3704 0.017768
## omega  0.000001    0.000000   17.4658 0.000000
## beta1  0.490306    0.000099 4939.3218 0.000000
## beta2  0.507206    0.000098 5180.6869 0.000000
## skew   1.099121    0.027294   40.2700 0.000000
## shape  3.668514    0.152469   24.0607 0.000000
##
## Robust Standard Errors:
##        Estimate  Std. Error   t value Pr(>|t|)
## mu     0.000806    0.000392    2.0536 0.040019
## omega  0.000001    0.000000   16.6466 0.000000
## beta1  0.490306    0.000153 3202.1533 0.000000
## beta2  0.507206    0.000154 3292.7626 0.000000
## skew   1.099121    0.029150   37.7063 0.000000
## shape  3.668514    0.202443   18.1212 0.000000
##
## LogLikelihood : 6974.967
##
## Information Criteria
## ------------------------------------
##
## Akaike       -5.3259
## Bayes        -5.3125
## Shibata      -5.3259
## Hannan-Quinn -5.3210
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                           statistic p-value
## Lag[1]                       0.1347  0.7136
## Lag[2*(p+q)+(p+q)-1][2]      0.3663  0.7599
## Lag[4*(p+q)+(p+q)-1][5]      1.3251  0.7828
## d.o.f=0
## H0 : No serial correlation
##
```

```
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                               statistic   p-value
## Lag[1]                            65.87  4.441e-16
## Lag[2*(p+q)+(p+q)-1][5]          372.52  0.000e+00
## Lag[4*(p+q)+(p+q)-1][9]          518.63  0.000e+00
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##              Statistic Shape Scale    P-Value
## ARCH Lag[3]      27.90 0.500 2.000  1.276e-07
## ARCH Lag[5]      99.28 1.440 1.667  0.000e+00
## ARCH Lag[7]     173.97 2.315 1.543  0.000e+00
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  1.8661
## Individual Statistics:
## mu    0.2733
## omega 3.8771
## beta1 1.7761
## beta2 1.7761
## skew  0.1276
## shape 1.9760
##
## 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           0.7471 4.551e-01
## Negative Sign Bias  7.0741 1.924e-12 ***
## Positive Sign Bias  6.5124 8.841e-11 ***
## Joint Effect       93.5144 3.851e-20 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     17.09      0.58360
## 2    30     36.77      0.15226
## 3    40     50.28      0.10645
## 4    50     68.80      0.03243
##
##
## Elapsed time : 0.9689789
```

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(2,2)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(2,2)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error   t value Pr(>|t|)
## mu      0.001018    0.000319  3.194653 0.001400
## omega   0.000014    0.000001 25.131612 0.000000
## alpha1  0.087391    0.033162  2.635322 0.008406
## alpha2  0.000000    0.031831  0.000003 0.999997
## beta1   0.521463    0.179722  2.901500 0.003714
## beta2   0.353195    0.173647  2.033985 0.041953
## skew    1.115728    0.028934 38.560650 0.000000
## shape   4.489381    0.406023 11.056974 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error   t value Pr(>|t|)
## mu      0.001018    0.000341  2.984153 0.002844
## omega   0.000014    0.000001 11.526674 0.000000
## alpha1  0.087391    0.044155  1.979195 0.047794
## alpha2  0.000000    0.042161  0.000002 0.999998
## beta1   0.521463    0.287000  1.816943 0.069226
## beta2   0.353195    0.285283  1.238051 0.215697
## skew    1.115728    0.027901 39.988408 0.000000
## shape   4.489381    0.488795  9.184580 0.000000
##
## LogLikelihood : 7052.097
##
## Information Criteria
## ------------------------------------
##
## Akaike       -5.3833
## Bayes        -5.3654
## Shibata      -5.3834
## Hannan-Quinn -5.3768
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                      4.638 0.03128
## Lag[2*(p+q)+(p+q)-1][2]     5.061 0.03917
## Lag[4*(p+q)+(p+q)-1][5]     5.737 0.10367
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
```

```
## -------------------------------------
##                           statistic p-value
## Lag[1]                        0.5823  0.4454
## Lag[2*(p+q)+(p+q)-1][11]      2.7412  0.8976
## Lag[4*(p+q)+(p+q)-1][19]      4.3308  0.9682
## d.o.f=4
##
## Weighted ARCH LM Tests
## -------------------------------------
##              Statistic Shape Scale P-Value
## ARCH Lag[5]     0.1774 0.500 2.000  0.6736
## ARCH Lag[7]     0.7779 1.473 1.746  0.8200
## ARCH Lag[9]     1.4373 2.402 1.619  0.8630
##
## Nyblom stability test
## -------------------------------------
## Joint Statistic:  103.7518
## Individual Statistics:
## mu     0.3296
## omega  4.8629
## alpha1 0.3200
## alpha2 0.3767
## beta1  0.5568
## beta2  0.5642
## skew   0.1311
## shape  0.6408
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:         1.89 2.11 2.59
## Individual Statistic:    0.35 0.47 0.75
##
## Sign Bias Test
## -------------------------------------
##                    t-value    prob sig
## Sign Bias           1.2683 0.20479
## Negative Sign Bias  1.7449 0.08112    *
## Positive Sign Bias  0.3882 0.69790
## Joint Effect        3.9853 0.26305
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -------------------------------------
##    group statistic p-value(g-1)
## 1     20     16.14      0.64759
## 2     30     40.48      0.07636
## 3     40     42.52      0.32203
## 4     50     49.85      0.43927
##
##
## Elapsed time : 1.661993
```

```r
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(1,2)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit         *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(1,2)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001018    0.000319    3.1953 0.001397
## omega   0.000014    0.000001   12.2729 0.000000
## alpha1  0.087382    0.004216   20.7282 0.000000
## beta1   0.521514    0.147703    3.5308 0.000414
## beta2   0.353118    0.144327    2.4467 0.014419
## skew    1.115705    0.028910   38.5922 0.000000
## shape   4.490869    0.394609   11.3806 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001018    0.000340    2.9978 0.002719
## omega   0.000014    0.000001    9.4130 0.000000
## alpha1  0.087382    0.008254   10.5868 0.000000
## beta1   0.521514    0.211613    2.4645 0.013722
## beta2   0.353118    0.214992    1.6425 0.100492
## skew    1.115705    0.027613   40.4046 0.000000
## shape   4.490869    0.479636    9.3631 0.000000
##
## LogLikelihood : 7052.097
##
## Information Criteria
## ------------------------------------
##
## Akaike        -5.3841
## Bayes         -5.3684
## Shibata       -5.3841
## Hannan-Quinn  -5.3784
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                          statistic p-value
## Lag[1]                       4.638 0.03127
## Lag[2*(p+q)+(p+q)-1][2]      5.061 0.03917
## Lag[4*(p+q)+(p+q)-1][5]      5.737 0.10366
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                          statistic p-value
```

```
## Lag[1]                           0.5817  0.4456
## Lag[2*(p+q)+(p+q)-1][8]          2.1514  0.8350
## Lag[4*(p+q)+(p+q)-1][14]         3.3782  0.9319
## d.o.f=3
##
## Weighted ARCH LM Tests
## ------------------------------------
##              Statistic Shape Scale P-Value
## ARCH Lag[4]     0.2543 0.500 2.000  0.6141
## ARCH Lag[6]     0.8402 1.461 1.711  0.7940
## ARCH Lag[8]     1.4103 2.368 1.583  0.8562
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  42.526
## Individual Statistics:
## mu      0.3296
## omega   4.8709
## alpha1  0.3198
## beta1   0.5576
## beta2   0.5650
## skew    0.1313
## shape   0.6407
##
## 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            1.2683 0.20479
## Negative Sign Bias   1.7445 0.08119    *
## Positive Sign Bias   0.3879 0.69813
## Joint Effect         3.9839 0.26321
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     16.14      0.64759
## 2    30     40.48      0.07636
## 3    40     42.52      0.32203
## 4    50     51.11      0.39068
##
##
## Elapsed time : 1.535994
```

```
spec_of_garch_maruti<- ugarchspec(variance.model = list(garchOrder=c(2,1)),mean.model =list(armaOrder=c
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
```

```
## *          GARCH Model Fit          *
## *-------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(2,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error    t value Pr(>|t|)
## mu      0.001039    0.000319   3.261617 0.001108
## omega   0.000011    0.000001  15.893374 0.000000
## alpha1  0.065286    0.024748   2.638045 0.008339
## alpha2  0.000000    0.025449   0.000005 0.999996
## beta1   0.904865    0.009051  99.975395 0.000000
## skew    1.117614    0.028953  38.601211 0.000000
## shape   4.469802    0.384189  11.634375 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error    t value Pr(>|t|)
## mu      0.001039    0.000344   3.020800 0.002521
## omega   0.000011    0.000001   9.318590 0.000000
## alpha1  0.065286    0.026725   2.442886 0.014570
## alpha2  0.000000    0.027220   0.000005 0.999996
## beta1   0.904865    0.009094  99.497747 0.000000
## skew    1.117614    0.028295  39.498858 0.000000
## shape   4.469802    0.498200   8.971897 0.000000
##
## LogLikelihood : 7050.697
##
## Information Criteria
## ------------------------------------
##
## Akaike       -5.3830
## Bayes        -5.3673
## Shibata      -5.3830
## Hannan-Quinn -5.3773
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                        statistic p-value
## Lag[1]                     4.503 0.03384
## Lag[2*(p+q)+(p+q)-1][2]    4.880 0.04379
## Lag[4*(p+q)+(p+q)-1][5]    5.555 0.11423
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                        statistic p-value
## Lag[1]                     1.519  0.2177
## Lag[2*(p+q)+(p+q)-1][8]    2.907  0.7025
```

```
## Lag[4*(p+q)+(p+q)-1][14]     4.116  0.8690
## d.o.f=3
##
## Weighted ARCH LM Tests
## -----------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[4]    0.3399 0.500 2.000  0.5599
## ARCH Lag[6]    0.8754 1.461 1.711  0.7838
## ARCH Lag[8]    1.4103 2.368 1.583  0.8562
##
## Nyblom stability test
## -----------------------------------
## Joint Statistic:  46.2305
## Individual Statistics:
## mu     0.3224
## omega  7.3981
## alpha1 0.3284
## alpha2 0.4291
## beta1  0.5811
## skew   0.1283
## shape  0.6550
##
## 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           1.3394 0.18056
## Negative Sign Bias  2.1546 0.03129  **
## Positive Sign Bias  0.6143 0.53908
## Joint Effect        5.7844 0.12258
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----------------------------------
##   group statistic p-value(g-1)
## 1    20     15.26       0.7060
## 2    30     31.56       0.3394
## 3    40     41.85       0.3483
## 4    50     56.35       0.2193
##
##
## Elapsed time : 1.215999
```

so the model of choice can be sGARCH(2,1) Akaike -5.2690 norm sGARCH(1,1) Akaike -5.2698 norm sGARCH(2,2) Akaike -5.2710 norm sGARCH(1,2) Akaike -5.2718 norm sGARCH(0,2) Akaike -5.3259 sstd sGARCH(0,1) Akaike -5.3268 sstd sGARCH(1,0) Akaike -5.3541 sstd sGARCH(2,0) Akaike -5.3655 sstd sGARCH(2,1) Akaike -5.3830 sstd sGARCH(2,2) Akaike -5.3833 sstd sGARCH(1,1) Akaike -5.3838 sstd sGARCH(1,2) Akaike -5.3841 sstd

```
spec_of_garch_maruti<-ugarchspec(variance.model =list(model="eGARCH",garchOrder=c(1,1)),mean.model = l:
my_model_maruti<- ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : eGARCH(1,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error   t value Pr(>|t|)
## mu       0.000793    0.000321    2.4665 0.013642
## omega   -0.161513    0.003073  -52.5572 0.000000
## alpha1  -0.064182    0.010565   -6.0748 0.000000
## beta1    0.980096    0.000488 2009.5954 0.000000
## gamma1   0.104488    0.014584    7.1645 0.000000
## skew     1.122105    0.029662   37.8298 0.000000
## shape    4.668840    0.422010   11.0633 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error   t value Pr(>|t|)
## mu       0.000793    0.000377    2.1036 0.035415
## omega   -0.161513    0.006848  -23.5841 0.000000
## alpha1  -0.064182    0.013734   -4.6732 0.000003
## beta1    0.980096    0.000841 1165.5177 0.000000
## gamma1   0.104488    0.016942    6.1676 0.000000
## skew     1.122105    0.030274   37.0654 0.000000
## shape    4.668840    0.496367    9.4060 0.000000
##
## LogLikelihood : 7074.405
##
## Information Criteria
## ------------------------------------
##
## Akaike       -5.4012
## Bayes        -5.3854
## Shibata      -5.4012
## Hannan-Quinn -5.3955
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                        statistic p-value
## Lag[1]                     4.529 0.03332
## Lag[2*(p+q)+(p+q)-1][2]    4.564 0.05322
## Lag[4*(p+q)+(p+q)-1][5]    5.108 0.14471
## d.o.f=0
```

```
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                           statistic p-value
## Lag[1]                        3.314 0.06868
## Lag[2*(p+q)+(p+q)-1][5]       3.963 0.25869
## Lag[4*(p+q)+(p+q)-1][9]       4.280 0.54199
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]    0.7118 0.500 2.000  0.3988
## ARCH Lag[5]    0.7273 1.440 1.667  0.8152
## ARCH Lag[7]    0.8722 2.315 1.543  0.9334
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  2.1251
## Individual Statistics:
## mu     0.1486
## omega  0.1762
## alpha1 1.0171
## beta1  0.1908
## gamma1 0.4313
## skew   0.1529
## shape  0.1076
##
## 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            1.446 0.14840
## Negative Sign Bias   1.912 0.05600    *
## Positive Sign Bias   1.677 0.09361    *
## Joint Effect        10.260 0.01648   **
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     26.11      0.12714
## 2    30     40.32      0.07882
## 3    40     43.34      0.29130
## 4    50     53.33      0.31138
##
##
## Elapsed time : 1.753005
```

this model is rejected since there is no leverage effect.

```
  spec_of_garch_maruti<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(1,1)),mean.model =
my_model_maruti<- ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit         *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : gjrGARCH(1,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## mu       0.000815    0.000308   2.6495 0.008061
## omega    0.000008    0.000001  11.5434 0.000000
## alpha1   0.015414    0.004261   3.6173 0.000298
## beta1    0.921862    0.007634 120.7626 0.000000
## gamma1   0.085651    0.016235   5.2757 0.000000
## skew     1.116255    0.028966  38.5361 0.000000
## shape    4.721579    0.430861  10.9585 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu       0.000815    0.000331   2.4643 0.013727
## omega    0.000008    0.000001   8.6513 0.000000
## alpha1   0.015414    0.007054   2.1851 0.028879
## beta1    0.921862    0.007639 120.6768 0.000000
## gamma1   0.085651    0.022673   3.7776 0.000158
## skew     1.116255    0.028659  38.9491 0.000000
## shape    4.721579    0.530857   8.8943 0.000000
##
## LogLikelihood : 7066.88
##
## Information Criteria
## ------------------------------------
##
## Akaike       -5.3954
## Bayes        -5.3797
## Shibata      -5.3954
## Hannan-Quinn -5.3897
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                      4.836 0.02788
## Lag[2*(p+q)+(p+q)-1][2]     4.882 0.04374
## Lag[4*(p+q)+(p+q)-1][5]     5.635 0.10948
## d.o.f=0
```

```
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                             statistic p-value
## Lag[1]                          1.151  0.2832
## Lag[2*(p+q)+(p+q)-1][5]         1.983  0.6226
## Lag[4*(p+q)+(p+q)-1][9]         2.756  0.7984
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]     1.111 0.500 2.000  0.2918
## ARCH Lag[5]     1.236 1.440 1.667  0.6645
## ARCH Lag[7]     1.694 2.315 1.543  0.7817
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  21.9784
## Individual Statistics:
## mu     0.1674
## omega  4.6449
## alpha1 0.3953
## beta1  0.4438
## gamma1 0.1270
## skew   0.1388
## shape  0.3454
##
## 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             1.272 0.2035
## Negative Sign Bias    1.220 0.2224
## Positive Sign Bias    1.085 0.2781
## Joint Effect          5.697 0.1273
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     21.02       0.3357
## 2    30     30.99       0.3659
## 3    40     38.39       0.4974
## 4    50     56.73       0.2091
##
##
## Elapsed time : 3.22
```

```
spec_of_garch_maruti<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(1,2)),mean.model =
my_model_maruti<- ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : gjrGARCH(1,2)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## -----------------------------------
##          Estimate  Std. Error  t value Pr(>|t|)
## mu       0.000812    0.000308   2.6353 0.008405
## omega    0.000010    0.000001  13.5807 0.000000
## alpha1   0.019871    0.005504   3.6106 0.000306
## beta1    0.693677    0.062897  11.0287 0.000000
## beta2    0.212693    0.062035   3.4286 0.000607
## gamma1   0.101131    0.019443   5.2015 0.000000
## skew     1.115760    0.028964  38.5220 0.000000
## shape    4.738359    0.432731  10.9499 0.000000
##
## Robust Standard Errors:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu       0.000812    0.000331   2.4497 0.014298
## omega    0.000010    0.000001  11.0999 0.000000
## alpha1   0.019871    0.008272   2.4022 0.016295
## beta1    0.693677    0.026927  25.7616 0.000000
## beta2    0.212693    0.031383   6.7774 0.000000
## gamma1   0.101131    0.026544   3.8100 0.000139
## skew     1.115760    0.028700  38.8771 0.000000
## shape    4.738359    0.524970   9.0260 0.000000
##
## LogLikelihood : 7067.247
##
## Information Criteria
## -----------------------------------
##
## Akaike       -5.3949
## Bayes        -5.3770
## Shibata      -5.3949
## Hannan-Quinn -5.3884
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----------------------------------
##                          statistic p-value
## Lag[1]                       4.909 0.02672
## Lag[2*(p+q)+(p+q)-1][2]      4.966 0.04153
```

```
## Lag[4*(p+q)+(p+q)-1][5]      5.701 0.10568
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                              statistic p-value
## Lag[1]                          0.6919  0.4055
## Lag[2*(p+q)+(p+q)-1][8]         2.0492  0.8513
## Lag[4*(p+q)+(p+q)-1][14]        3.1217  0.9486
## d.o.f=3
##
## Weighted ARCH LM Tests
## ------------------------------------
##              Statistic Shape Scale P-Value
## ARCH Lag[4]    0.09555 0.500 2.000  0.7572
## ARCH Lag[6]    0.54424 1.461 1.711  0.8796
## ARCH Lag[8]    1.06534 2.368 1.583  0.9145
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  50.162
## Individual Statistics:
## mu     0.1707
## omega  5.7224
## alpha1 0.3865
## beta1  0.4365
## beta2  0.4443
## gamma1 0.1227
## skew   0.1408
## shape  0.3404
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:        1.89 2.11 2.59
## Individual Statistic:   0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value    prob sig
## Sign Bias           1.2516 0.2108
## Negative Sign Bias  0.9726 0.3308
## Positive Sign Bias  1.0184 0.3086
## Joint Effect        5.3176 0.1500
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##    group statistic p-value(g-1)
## 1     20     19.57       0.4209
## 2     30     32.46       0.3002
## 3     40     36.92       0.5649
## 4     50     59.56       0.1435
##
##
```

```
## Elapsed time : 3.088002
```

```
 spec_of_garch_maruti<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(2,1)),mean.model =
my_model_maruti<- ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : gjrGARCH(2,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##          Estimate  Std. Error    t value Pr(>|t|)
## mu       0.000806    0.000307    2.629331 0.008555
## omega    0.000007    0.000001    8.779425 0.000000
## alpha1   0.014183    0.020919    0.677973 0.497789
## alpha2   0.000000    0.020826    0.000018 0.999986
## beta1    0.929460    0.007559 122.967714 0.000000
## gamma1   0.126577    0.052346    2.418090 0.015602
## gamma2  -0.048090    0.052374   -0.918205 0.358511
## skew     1.115654    0.028919   38.578386 0.000000
## shape    4.749013    0.438127   10.839356 0.000000
##
## Robust Standard Errors:
##          Estimate  Std. Error    t value Pr(>|t|)
## mu       0.000806    0.000330    2.446026 0.014444
## omega    0.000007    0.000001    6.157586 0.000000
## alpha1   0.014183    0.020682    0.685739 0.492877
## alpha2   0.000000    0.019886    0.000019 0.999985
## beta1    0.929460    0.007726 120.299580 0.000000
## gamma1   0.126577    0.065878    1.921402 0.054681
## gamma2  -0.048090    0.068688   -0.700121 0.483852
## skew     1.115654    0.028670   38.913397 0.000000
## shape    4.749013    0.542276    8.757549 0.000000
##
## LogLikelihood : 7067.268
##
## Information Criteria
## ------------------------------------
##
## Akaike       -5.3942
## Bayes        -5.3740
## Shibata      -5.3942
## Hannan-Quinn -5.3869
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----------------------------------
```

```
##                             statistic p-value
## Lag[1]                          4.867 0.02737
## Lag[2*(p+q)+(p+q)-1][2]         4.917 0.04279
## Lag[4*(p+q)+(p+q)-1][5]         5.658 0.10815
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                             statistic p-value
## Lag[1]                         0.6321  0.4266
## Lag[2*(p+q)+(p+q)-1][8]        1.8150  0.8863
## Lag[4*(p+q)+(p+q)-1][14]       2.7819  0.9665
## d.o.f=3
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[4]   0.08037 0.500 2.000  0.7768
## ARCH Lag[6]   0.47536 1.461 1.711  0.8989
## ARCH Lag[8]   0.92569 2.368 1.583  0.9350
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  14.1097
## Individual Statistics:
## mu      0.1698
## omega  2.8235
## alpha1 0.3960
## alpha2 0.3447
## beta1  0.4459
## gamma1 0.1314
## gamma2 0.1501
## skew   0.1419
## shape  0.3371
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:        2.1 2.32 2.82
## Individual Statistic:   0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value   prob sig
## Sign Bias           1.2045 0.2285
## Negative Sign Bias  0.7845 0.4328
## Positive Sign Bias  1.1961 0.2318
## Joint Effect        6.0805 0.1078
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##    group statistic p-value(g-1)
## 1    20     19.77        0.4087
## 2    30     34.43        0.2239
```

```
## 3    40     40.23        0.4158
## 4    50     54.86        0.2623
##
##
## Elapsed time : 3.669
```

```
 spec_of_garch_maruti<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(2,2)),mean.model =
my_model_maruti<- ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : gjrGARCH(2,2)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error   t value Pr(>|t|)
## mu      0.000815    0.000311  2.623400 0.008706
## omega   0.000013    0.000000 30.558927 0.000000
## alpha1  0.028115    0.028437  0.988687 0.322816
## alpha2  0.000000    0.024387  0.000009 0.999993
## beta1   0.315594    0.290268  1.087251 0.276926
## beta2   0.556018    0.284014  1.957712 0.050264
## gamma1  0.070198    0.039156  1.792786 0.073007
## gamma2  0.065444    0.040346  1.622051 0.104792
## skew    1.116464    0.029063 38.415972 0.000000
## shape   4.732665    0.441602 10.717032 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error   t value Pr(>|t|)
## mu      0.000815    0.000334  2.437855 0.014775
## omega   0.000013    0.000001 15.241263 0.000000
## alpha1  0.028115    0.041368  0.679627 0.496741
## alpha2  0.000000    0.034887  0.000006 0.999995
## beta1   0.315594    0.398770  0.791419 0.428699
## beta2   0.556018    0.395588  1.405547 0.159859
## gamma1  0.070198    0.043858  1.600584 0.109469
## gamma2  0.065444    0.043969  1.488418 0.136641
## skew    1.116464    0.028693 38.910852 0.000000
## shape   4.732665    0.512825  9.228624 0.000000
##
## LogLikelihood : 7067.505
##
## Information Criteria
## -----------------------------------
##
## Akaike        -5.3936
```

```
## Bayes         -5.3712
## Shibata       -5.3936
## Hannan-Quinn -5.3855
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                           statistic p-value
## Lag[1]                        4.926 0.02646
## Lag[2*(p+q)+(p+q)-1][2]       4.987 0.04100
## Lag[4*(p+q)+(p+q)-1][5]       5.718 0.10470
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                           statistic p-value
## Lag[1]                        0.803  0.3702
## Lag[2*(p+q)+(p+q)-1][11]      2.950  0.8746
## Lag[4*(p+q)+(p+q)-1][19]      4.623  0.9571
## d.o.f=4
##
## Weighted ARCH LM Tests
## ------------------------------------
##              Statistic Shape Scale P-Value
## ARCH Lag[5]     0.1174 0.500 2.000  0.7318
## ARCH Lag[7]     0.8554 1.473 1.746  0.7981
## ARCH Lag[9]     1.4497 2.402 1.619  0.8609
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  117.9657
## Individual Statistics:
## mu     0.1697
## omega  6.7610
## alpha1 0.3793
## alpha2 0.3467
## beta1  0.4343
## beta2  0.4398
## gamma1 0.1142
## gamma2 0.1430
## skew   0.1372
## shape  0.3460
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:        2.29 2.54 3.05
## Individual Statistic:   0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                      t-value   prob sig
## Sign Bias             1.3173 0.1878
## Negative Sign Bias    1.2521 0.2106
## Positive Sign Bias    0.7872 0.4313
## Joint Effect          4.6586 0.1986
```

```
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ---------------------------------
##   group statistic p-value(g-1)
## 1    20    21.85       0.2920
## 2    30    35.71       0.1821
## 3    40    43.50       0.2858
## 4    50    56.23       0.2224
##
##
## Elapsed time : 5.798002
```

so the model of choice can be sGARCH(2,1) Akaike -5.2690 norm sGARCH(1,1) Akaike -5.2698 norm sGARCH(2,2) Akaike -5.2710 norm sGARCH(1,2) Akaike -5.2718 norm sGARCH(0,2) Akaike -5.3259 sstd sGARCH(0,1) Akaike -5.3268 sstd sGARCH(1,0) Akaike -5.3541 sstd sGARCH(2,0) Akaike -5.3655 sstd sGARCH(2,1) Akaike -5.3830 sstd sGARCH(2,2) Akaike -5.3833 sstd sGARCH(1,1) Akaike -5.3838 sstd sGARCH(1,2) Akaike -5.3841 sstd gjrGARCH(2,2) Akaike -5.3936 sstd gjrGARCH(2,1) Akaike -5.3942 sstd gjrGARCH(1,2) Akaike -5.3949 sstd gjrGARCH(1,1) Akaike -5.3954 sstd

```r
 spec_of_garch_maruti<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(1,1)),mean.model =
my_model_maruti<-ugarchfit(spec=spec_of_garch_maruti,data=ret_maruti,out.sample = 500)
my_model_maruti
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : gjrGARCH(1,1)
## Mean Model   : ARFIMA(0,0,0)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error    t value Pr(>|t|)
## mu      0.001154    0.000304    3.79847 0.000146
## omega   0.000005    0.000005    0.95369 0.340241
## alpha1  0.013045    0.009561    1.36442 0.172434
## beta1   0.946407    0.006426  147.28030 0.000000
## gamma1  0.055971    0.013144    4.25817 0.000021
## skew    1.148909    0.032730   35.10267 0.000000
## shape   4.822222    0.468013   10.30361 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001154    0.000778   1.48479 0.137600
## omega   0.000005    0.000027   0.16973 0.865220
## alpha1  0.013045    0.065926   0.19787 0.843143
## beta1   0.946407    0.029796  31.76293 0.000000
## gamma1  0.055971    0.042338   1.32199 0.186173
```

```
## skew    1.148909    0.054294 21.16092 0.000000
## shape   4.822222    1.206012  3.99849 0.000064
##
## LogLikelihood : 5831.363
##
## Information Criteria
## ---------------------------------
##
## Akaike        -5.5025
## Bayes         -5.4838
## Shibata       -5.5025
## Hannan-Quinn  -5.4956
##
## Weighted Ljung-Box Test on Standardized Residuals
## ---------------------------------
##                          statistic p-value
## Lag[1]                       4.806 0.02836
## Lag[2*(p+q)+(p+q)-1][2]      4.816 0.04555
## Lag[4*(p+q)+(p+q)-1][5]      5.055 0.14879
## d.o.f=0
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ---------------------------------
##                          statistic p-value
## Lag[1]                       2.038  0.1534
## Lag[2*(p+q)+(p+q)-1][5]      3.335  0.3492
## Lag[4*(p+q)+(p+q)-1][9]      4.255  0.5463
## d.o.f=2
##
## Weighted ARCH LM Tests
## ---------------------------------
##            Statistic Shape Scale P-Value
## ARCH Lag[3]    1.629 0.500 2.000  0.2019
## ARCH Lag[5]    1.858 1.440 1.667  0.5034
## ARCH Lag[7]    2.429 2.315 1.543  0.6271
##
## Nyblom stability test
## ---------------------------------
## Joint Statistic:  4.5751
## Individual Statistics:
## mu     0.2090
## omega  0.3086
## alpha1 0.7568
## beta1  0.8493
## gamma1 0.4100
## skew   0.1764
## shape  0.5951
##
## 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            2.2521 0.02442  **
## Negative Sign Bias   2.3493 0.01890  **
## Positive Sign Bias   0.3925 0.69475
## Joint Effect         9.1590 0.02725  **
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##    group statistic p-value(g-1)
## 1     20     16.76       0.6058
## 2     30     29.72       0.4280
## 3     40     36.14       0.6010
## 4     50     41.88       0.7546
##
##
## Elapsed time : 4.268385
```

```r
back_testing<-ugarchroll(spec_of_garch_maruti,ret_maruti,n.ahead=1,n.start = 2000,refit.every  =30,refi
```

```
##
## Iter: 1 fn: -5478.1504    Pars:  0.001222819 0.000004494 0.011009623 0.948723787 0.056430229 1.147216
## Iter: 2 fn: -5478.1504    Pars:  0.001222819 0.000004494 0.011009623 0.948723787 0.056430229 1.147216
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5479.7460    Pars:  0.00124474 0.00000608 0.01354665 0.93724519 0.06563691 1.15382110 4
## Iter: 2 fn: -5479.7460    Pars:  0.00124474 0.00000608 0.01354665 0.93724519 0.06563691 1.15382110 4
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5494.2331    Pars:  0.001268605 0.000006154 0.015449979 0.935389957 0.065254723 1.151255
## Iter: 2 fn: -5494.2331    Pars:  0.001268605 0.000006154 0.015449979 0.935389957 0.065254723 1.151255
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5501.5982    Pars:  0.001281426 0.000006523 0.017980126 0.930636268 0.067355583 1.152846
## Iter: 2 fn: -5501.5982    Pars:  0.001281426 0.000006523 0.017980126 0.930636268 0.067355583 1.152846
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5516.4137    Pars:  0.001273043 0.000006756 0.019034338 0.928208732 0.070316017 1.150072
## Iter: 2 fn: -5516.4137    Pars:  0.001273043 0.000006756 0.019034338 0.928208732 0.070316017 1.150072
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5528.6653    Pars:  0.001317844 0.000006246 0.017050830 0.927301052 0.080950787 1.160352
## Iter: 2 fn: -5528.6653    Pars:  0.001317844 0.000006246 0.017050830 0.927301052 0.080950787 1.160352
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5506.9629    Pars:  0.001114304 0.000006376 0.014901486 0.923163838 0.096401144 1.163230
## Iter: 2 fn: -5506.9629    Pars:  0.001114304 0.000006376 0.014901486 0.923163838 0.096401144 1.163230
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5506.4758    Pars:  0.001117589 0.000006851 0.014933732 0.920099175 0.099631125 1.167461
## Iter: 2 fn: -5506.4758    Pars:  0.001117589 0.000006851 0.014933732 0.920099175 0.099631125 1.167461
## solnp--> Completed in 2 iterations
##
```

```
## Iter: 1 fn: -5501.5090    Pars:   0.001129945 0.000006418 0.014655118 0.924777647 0.092892998 1.156133
## Iter: 2 fn: -5501.5090    Pars:   0.001129945 0.000006418 0.014655118 0.924777648 0.092892998 1.156133
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5495.4222    Pars:   0.001142620 0.000006748 0.015439640 0.923588081 0.090542537 1.153579
## Iter: 2 fn: -5495.4222    Pars:   0.001142620 0.000006748 0.015439640 0.923588081 0.090542537 1.153579
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5505.9874    Pars:   0.001151327 0.000007177 0.014572322 0.920946734 0.092678124 1.150292
## Iter: 2 fn: -5505.9874    Pars:   0.001151319 0.000007178 0.014573048 0.920945603 0.092683533 1.150287
## Iter: 3 fn: -5505.9874    Pars:   0.001151319 0.000007178 0.014573048 0.920945603 0.092683533 1.150287
## solnp--> Completed in 3 iterations
##
## Iter: 1 fn: -5511.0265    Pars:   0.00113991 0.00000689 0.01482790 0.92495001 0.08766823 1.14879635 4
## Iter: 2 fn: -5511.0265    Pars:   0.00113991 0.00000689 0.01482790 0.92495001 0.08766823 1.14879635 4
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5501.4308    Pars:   0.001108163 0.000006614 0.012969630 0.928217282 0.087975677 1.143578
## Iter: 2 fn: -5501.4308    Pars:   0.001108163 0.000006614 0.012969630 0.928217282 0.087975677 1.143578
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5486.4429    Pars:   0.001127947 0.000005552 0.011288982 0.936536121 0.079966999 1.137843
## Iter: 2 fn: -5486.4429    Pars:   0.001127947 0.000005552 0.011288982 0.936536121 0.079966999 1.137843
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5471.6168    Pars:   0.001147409 0.000005786 0.012170620 0.932756127 0.086140838 1.138265
## Iter: 2 fn: -5471.6168    Pars:   0.001147409 0.000005786 0.012170620 0.932756127 0.086140838 1.138265
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5484.8390    Pars:   0.001192271 0.000006397 0.012356987 0.930440950 0.086880997 1.147709
## Iter: 2 fn: -5484.8390    Pars:   0.001192271 0.000006397 0.012356987 0.930440950 0.086880997 1.147709
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5501.3580    Pars:   0.001218794 0.000006654 0.013773127 0.927833975 0.086688729 1.155934
## Iter: 2 fn: -5501.3580    Pars:   0.001218794 0.000006654 0.013773127 0.927833975 0.086688729 1.155934
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5504.2566    Pars:   0.001191407 0.000006944 0.013624823 0.925739541 0.087757807 1.155268
## Iter: 2 fn: -5504.2566    Pars:   0.001191412 0.000006944 0.013624954 0.925739557 0.087758787 1.155270
## Iter: 3 fn: -5504.2566    Pars:   0.001191412 0.000006944 0.013624954 0.925739557 0.087758787 1.155270
## solnp--> Completed in 3 iterations
##
## Iter: 1 fn: -5490.0051    Pars:   0.001007588 0.000008325 0.006583455 0.918100395 0.117731748 1.132500
## Iter: 2 fn: -5490.0051    Pars:   0.001007588 0.000008325 0.006583455 0.918100395 0.117731748 1.132500
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5459.3624    Pars:   0.000999389 0.000007873 0.006363620 0.922000630 0.112023959 1.128993
## Iter: 2 fn: -5459.3624    Pars:   0.000999389 0.000007873 0.006363620 0.922000630 0.112023959 1.128993
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -5456.1478    Pars:   0.001080166 0.000009305 0.009393520 0.913085489 0.111499936 1.129410
## Iter: 2 fn: -5456.1478    Pars:   0.001080166 0.000009305 0.009393520 0.913085489 0.111499936 1.129410
## solnp--> Completed in 2 iterations
```

```r
report(back_testing)
```

```
## VaR Backtest Report
## ===========================================
## Model:               gjrGARCH-sstd
## Backtest Length: 617
## Data:
##
## ===========================================
## alpha:               1%
## Expected Exceed: 6.2
## Actual VaR Exceed:   11
## Actual %:            1.8%
##
## Unconditional Coverage (Kupiec)
## Null-Hypothesis: Correct Exceedances
## LR.uc Statistic: 3.099
## LR.uc Critical:      3.841
## LR.uc p-value:       0.078
## Reject Null:     NO
##
## Conditional Coverage (Christoffersen)
## Null-Hypothesis: Correct Exceedances and
##                  Independence of Failures
## LR.cc Statistic: 3.499
## LR.cc Critical:      5.991
## LR.cc p-value:       0.174
## Reject Null:     NO
```

```r
forecast<- ugarchforecast(my_model_maruti,data=ret_maruti,n.ahead =100,n.roll = 100)
```

Series with 2 Conditional SD Superimposed

Returns

Time

GARCH model : gjrGARCH
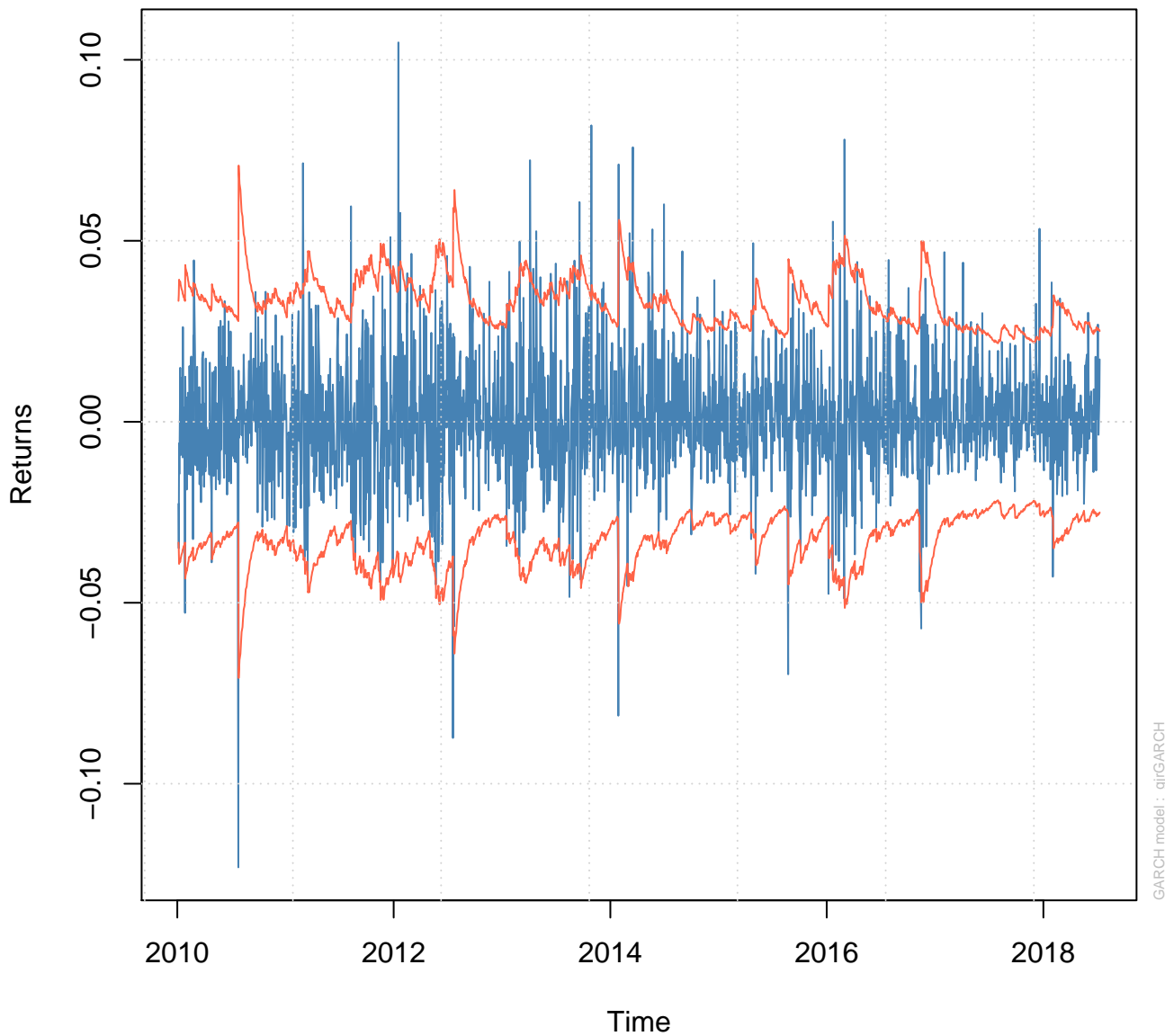
Series with with 1% VaR Limits

GARCH model : gjrGARCH
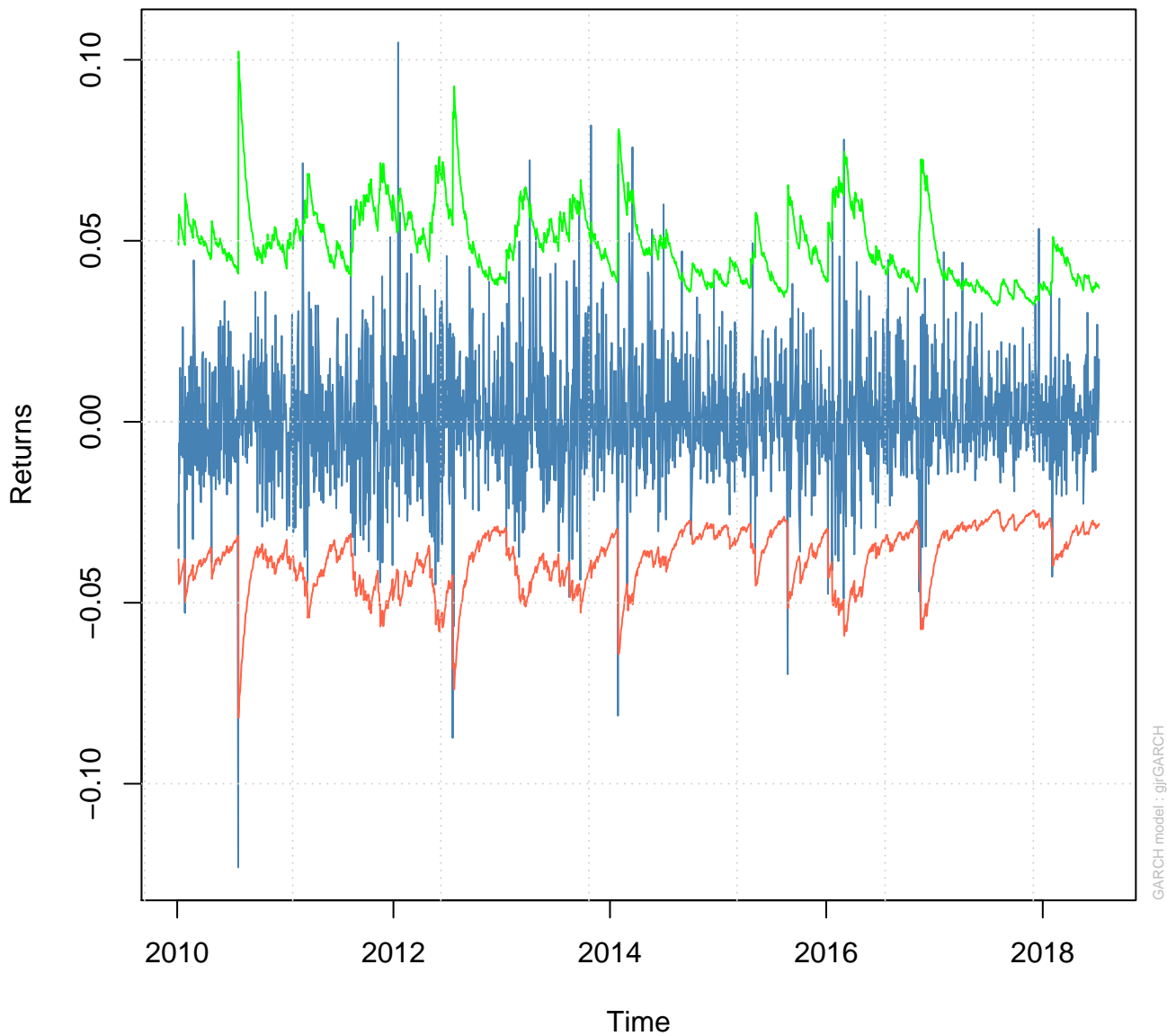
Conditional SD (vs |returns|)

Volatility

Time

GARCH model : gjrGARCH
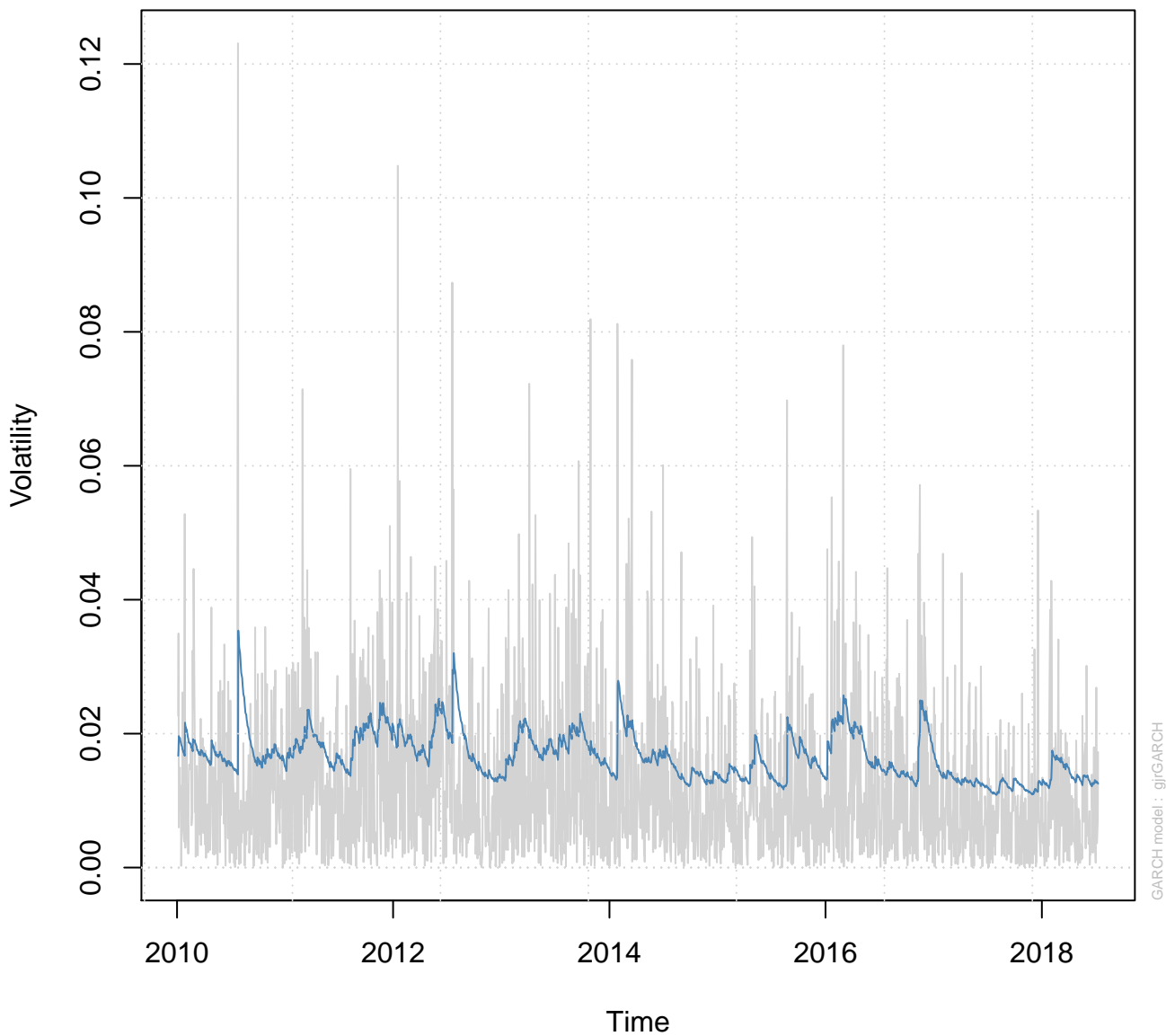
ACF of Observations

GARCH model : gjrGARCH
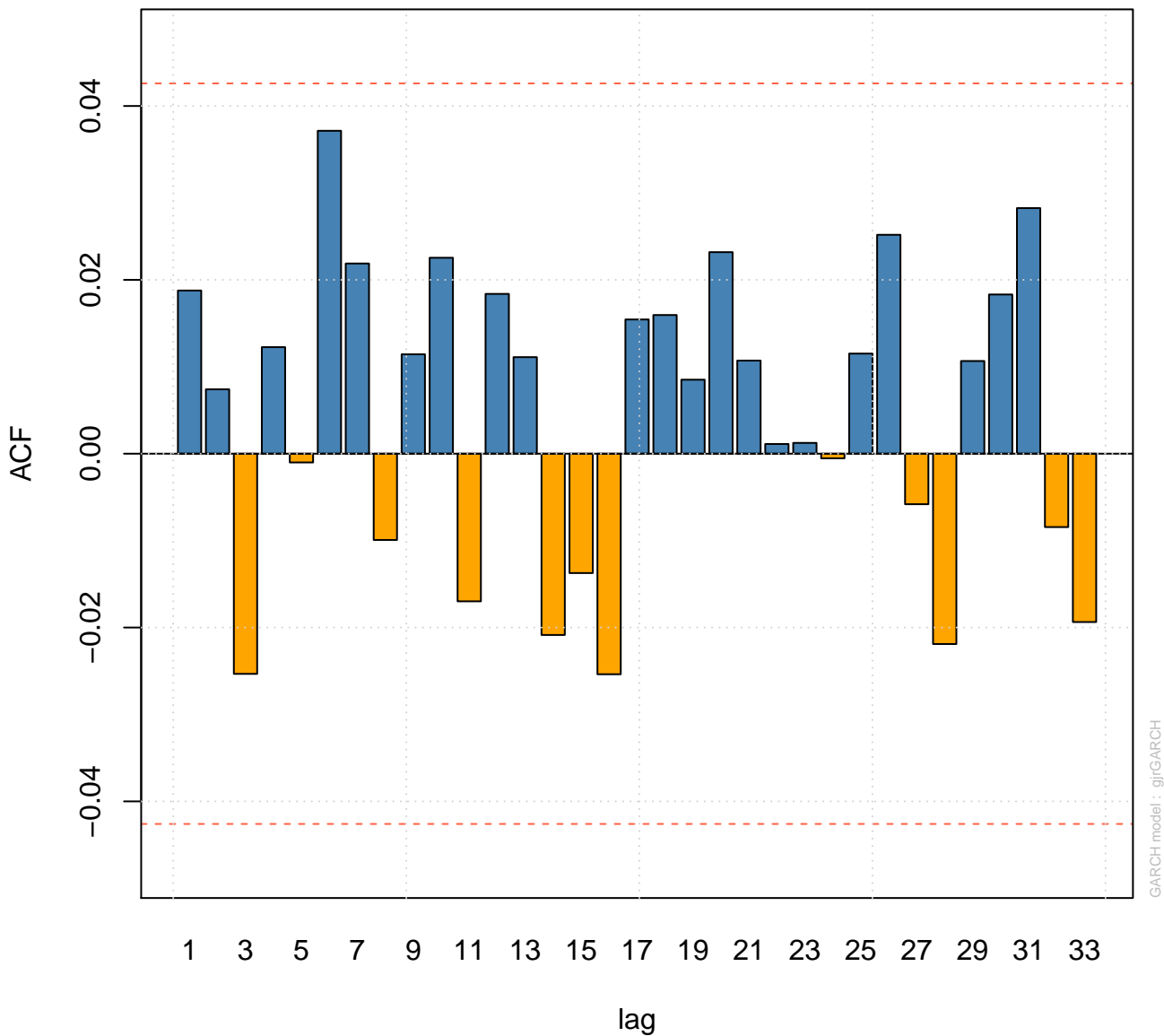
ACF of Squared Observations

GARCH model : gjrGARCH
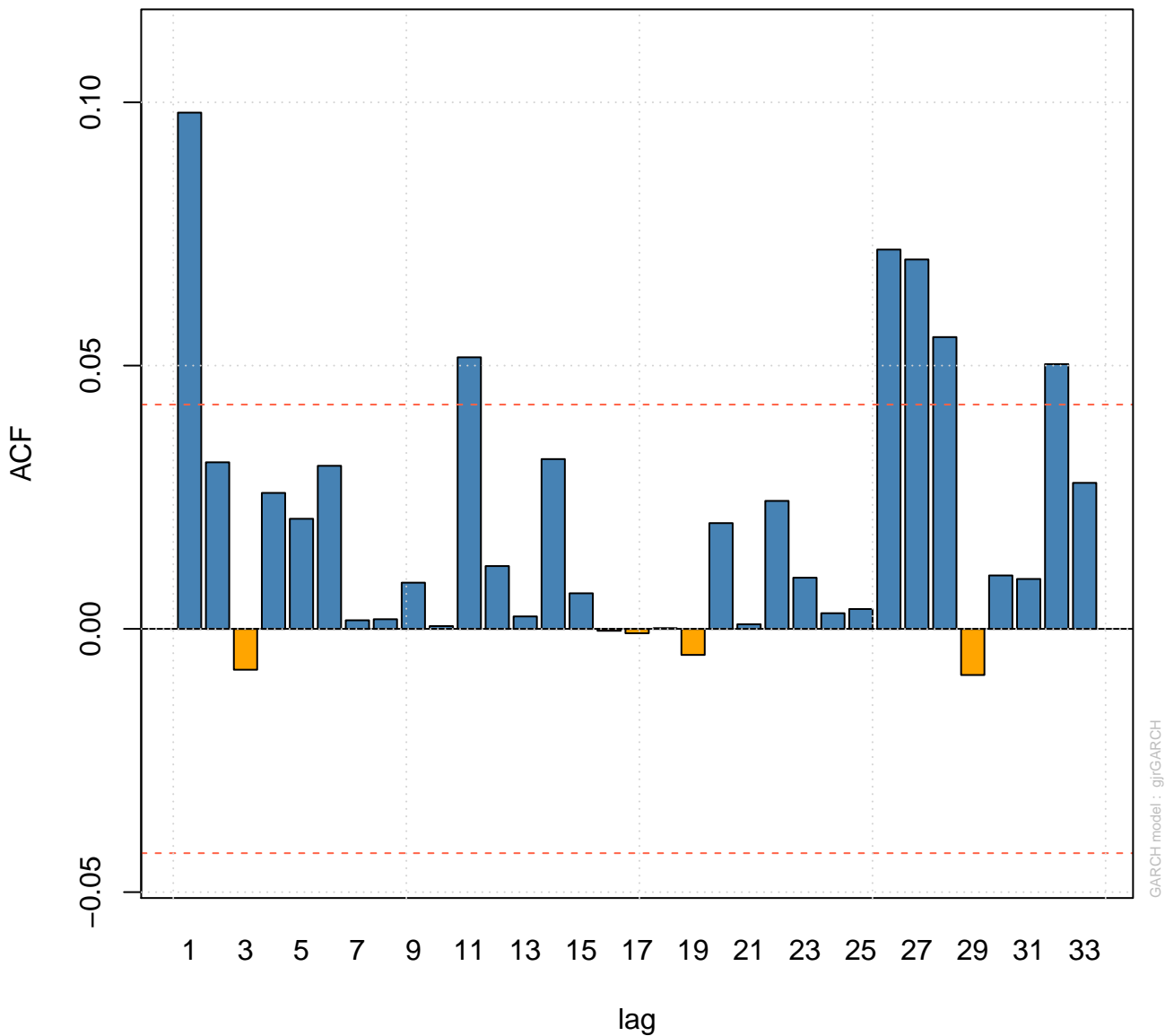
ACF of Absolute Observations

GARCH model : gjrGARCH
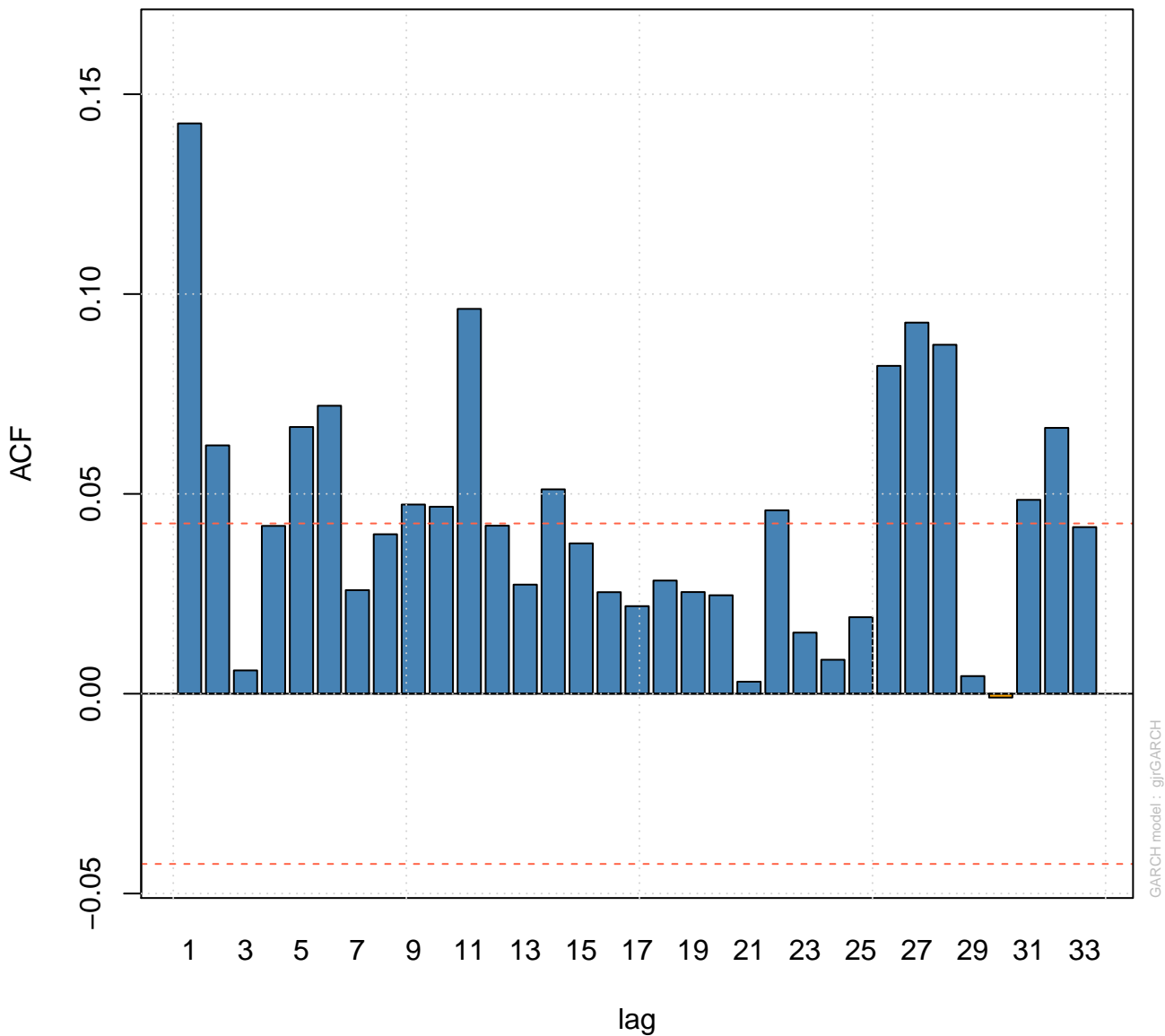
**Cross−Correlations of
Squared vs Actual Observations**

ACF

lag

GARCH model : gjrGARCH
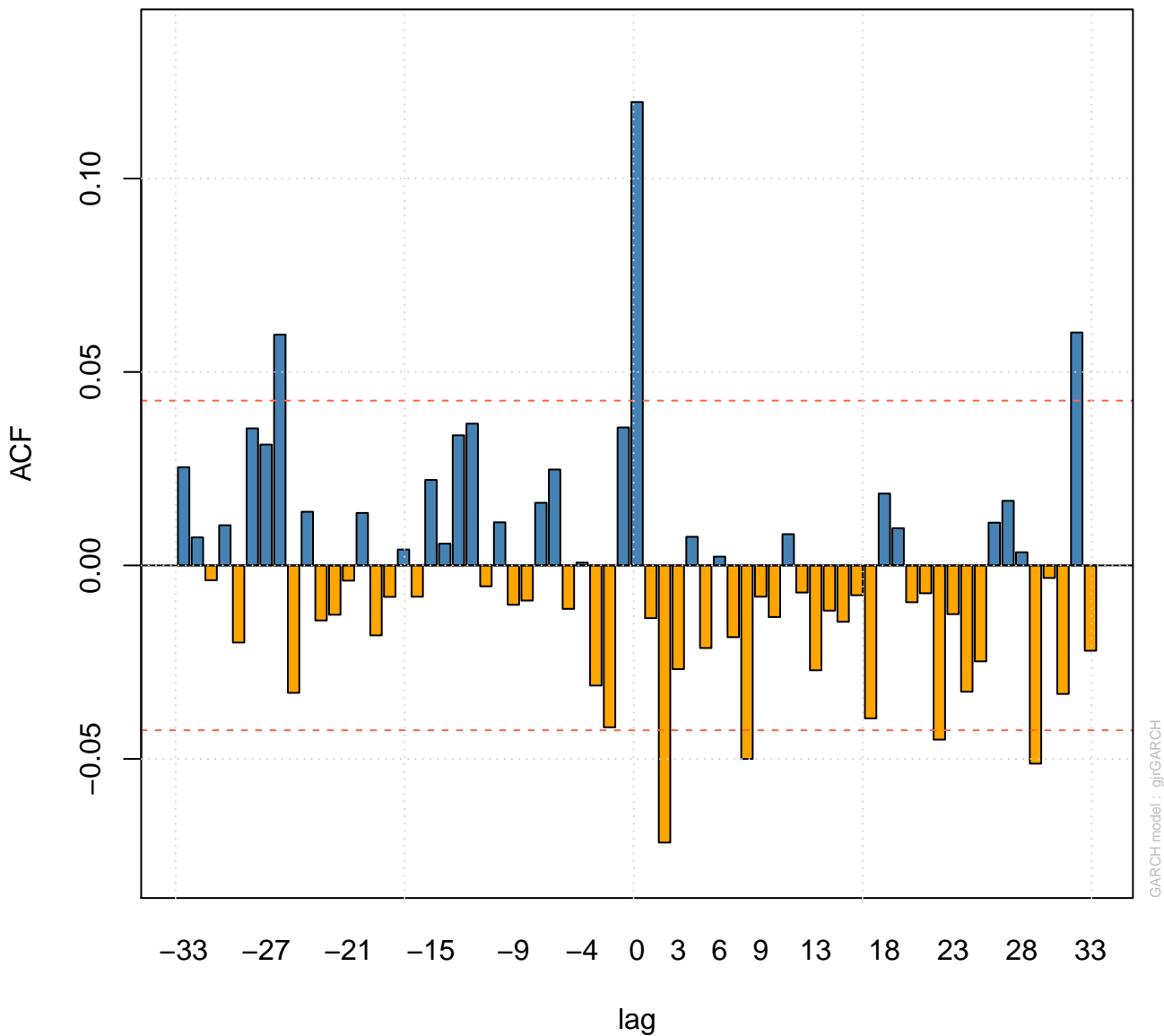
Empirical Density of Standardized Residuals

Median: −0.07 | Mean: −0.00976

GARCH model : gjrGARCH

sstd − QQ Plot

Sample Quantiles

Theoretical Quantiles

GARCH model : gjrGARCH
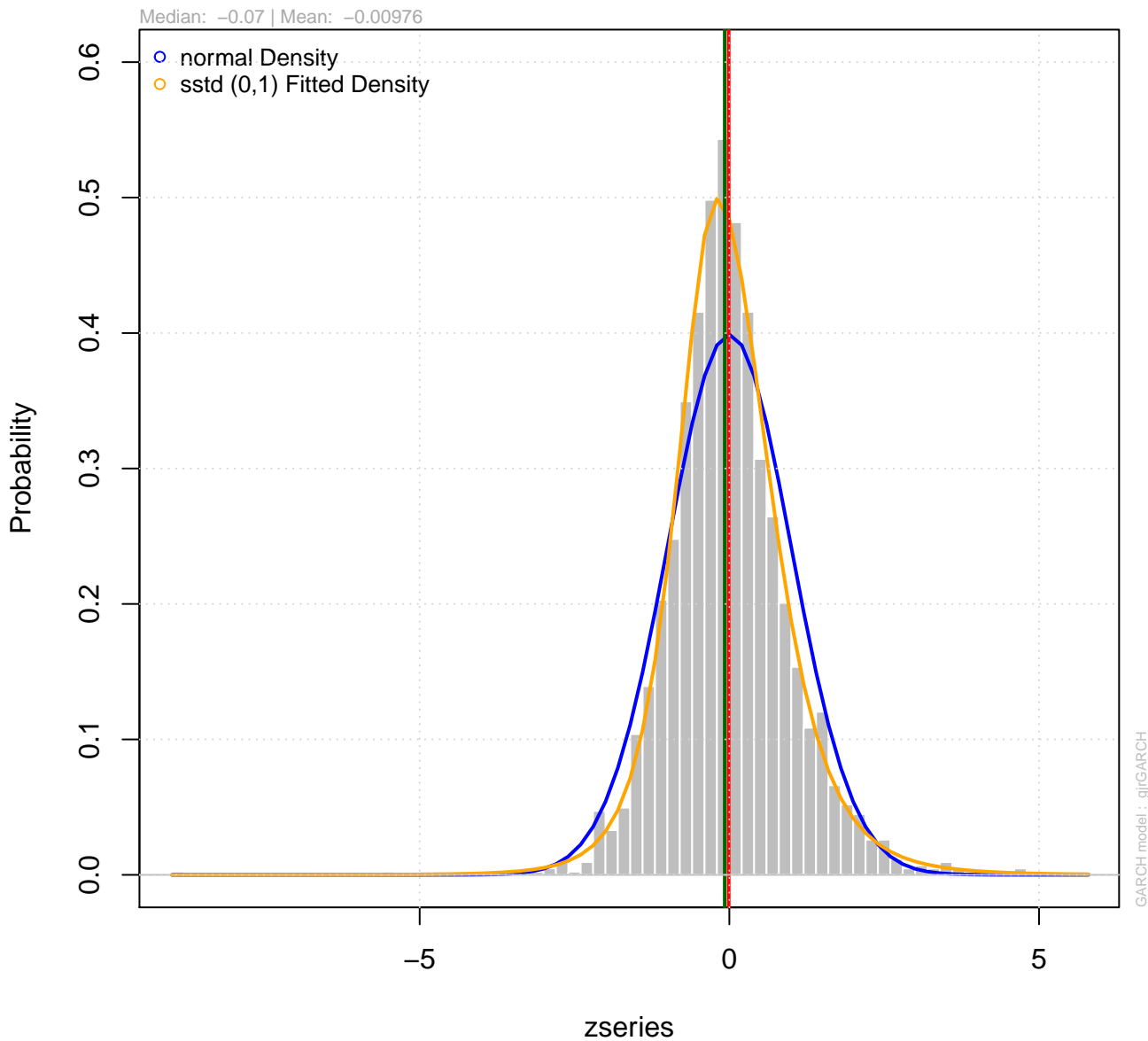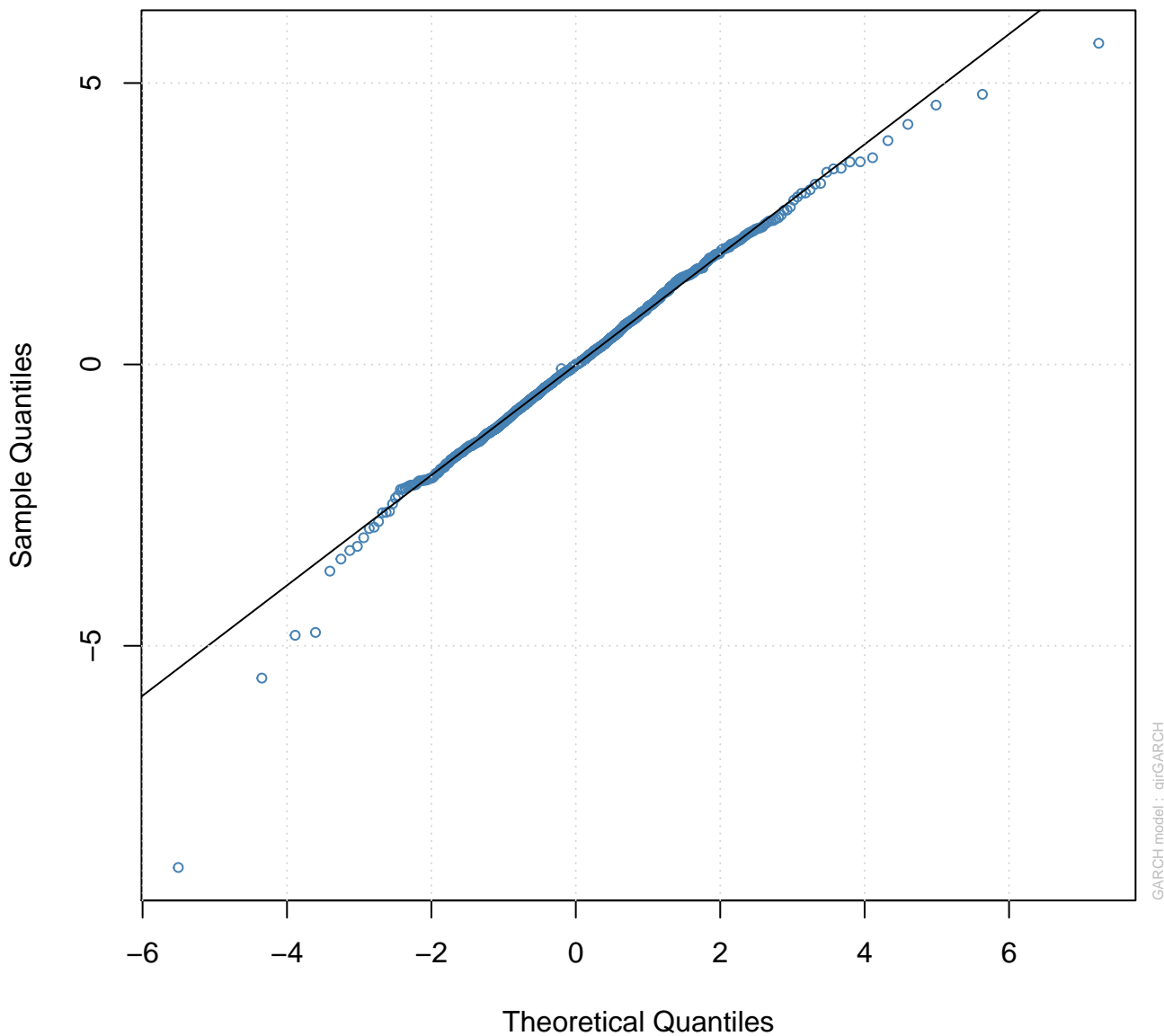
ACF of Standardized Residuals

GARCH model : gjrGARCH
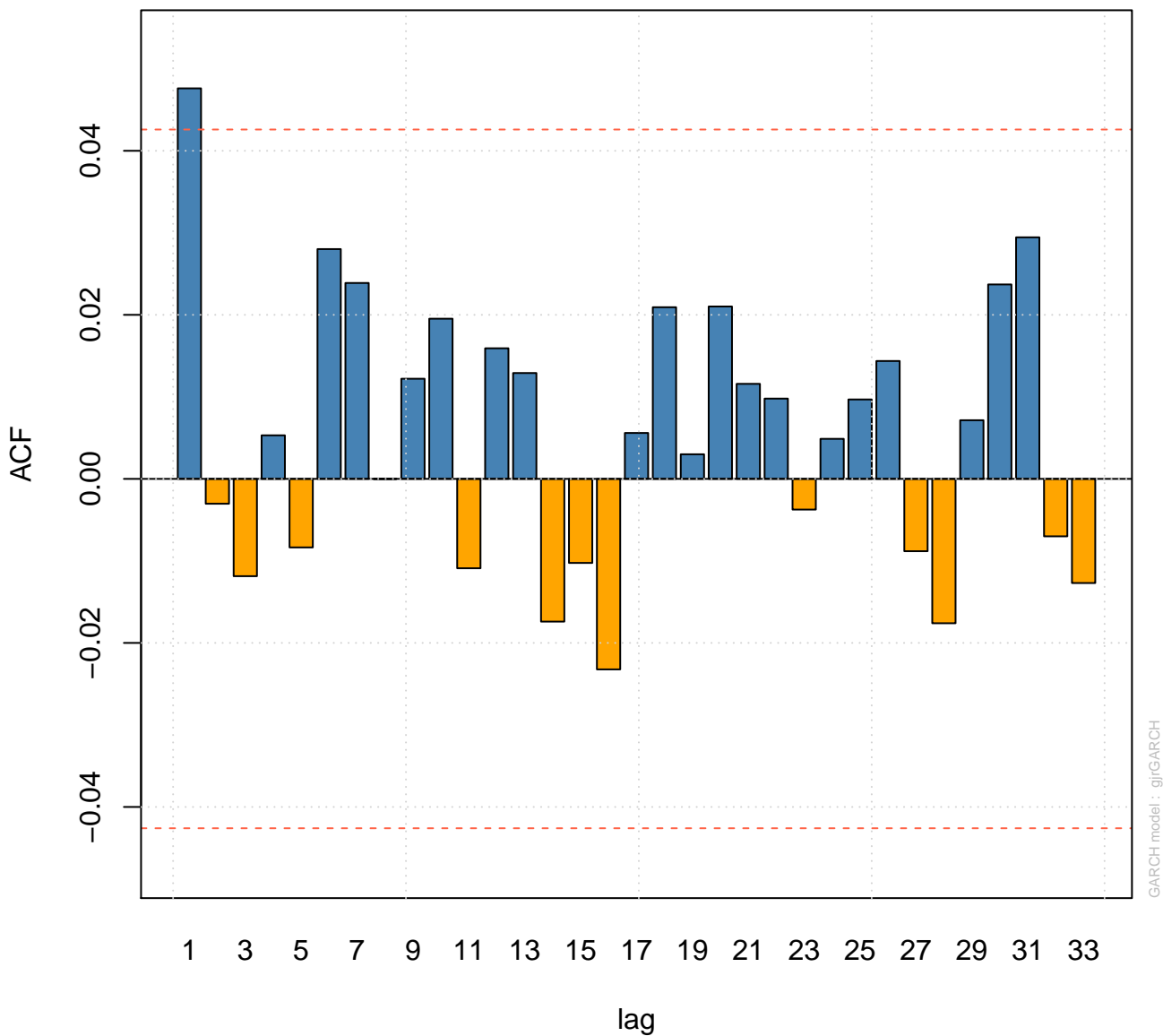
ACF of Squared Standardized Residuals

GARCH model : gjrGARCH

News Impact Curve
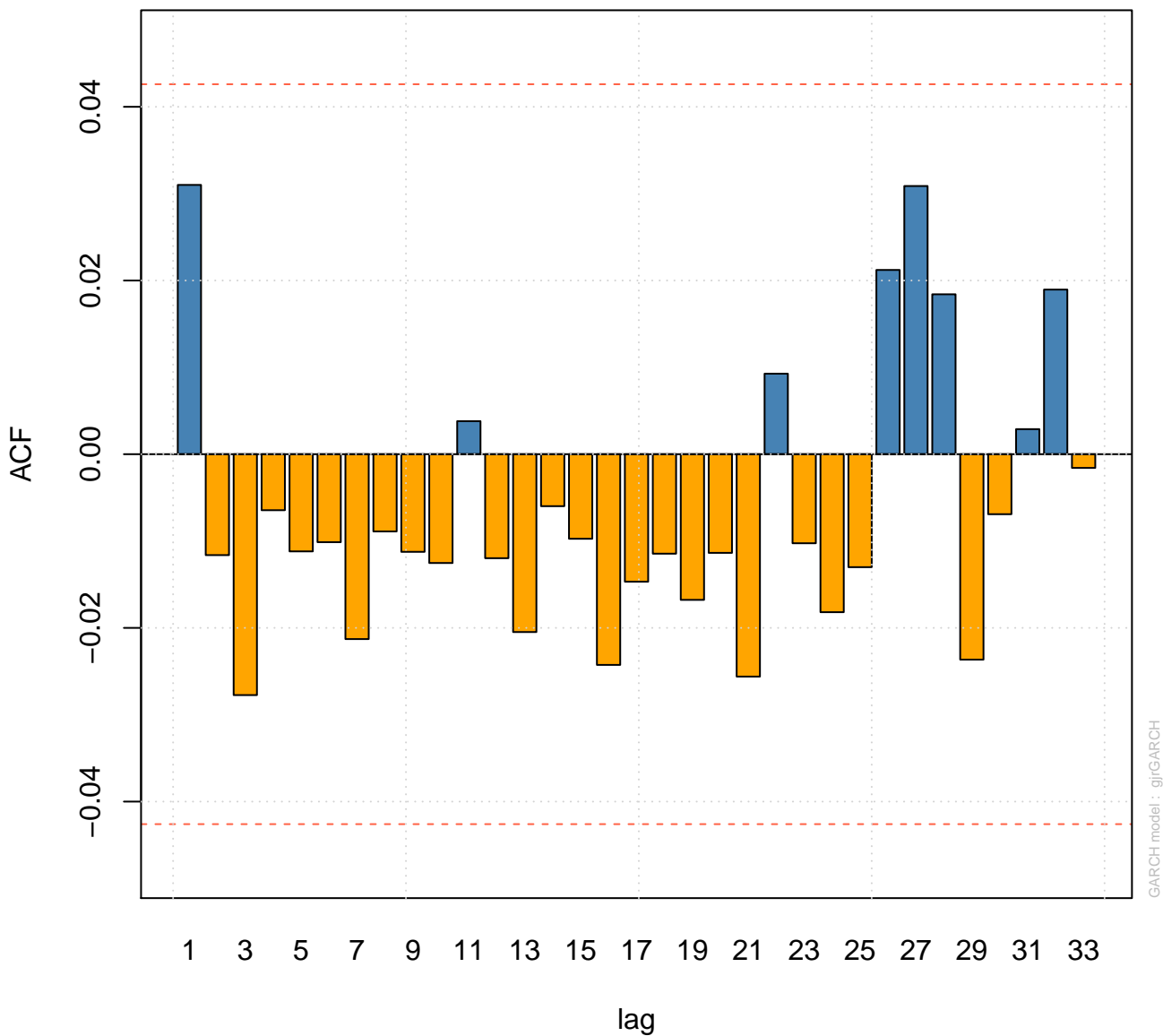
GARCH model : gjrGARCH
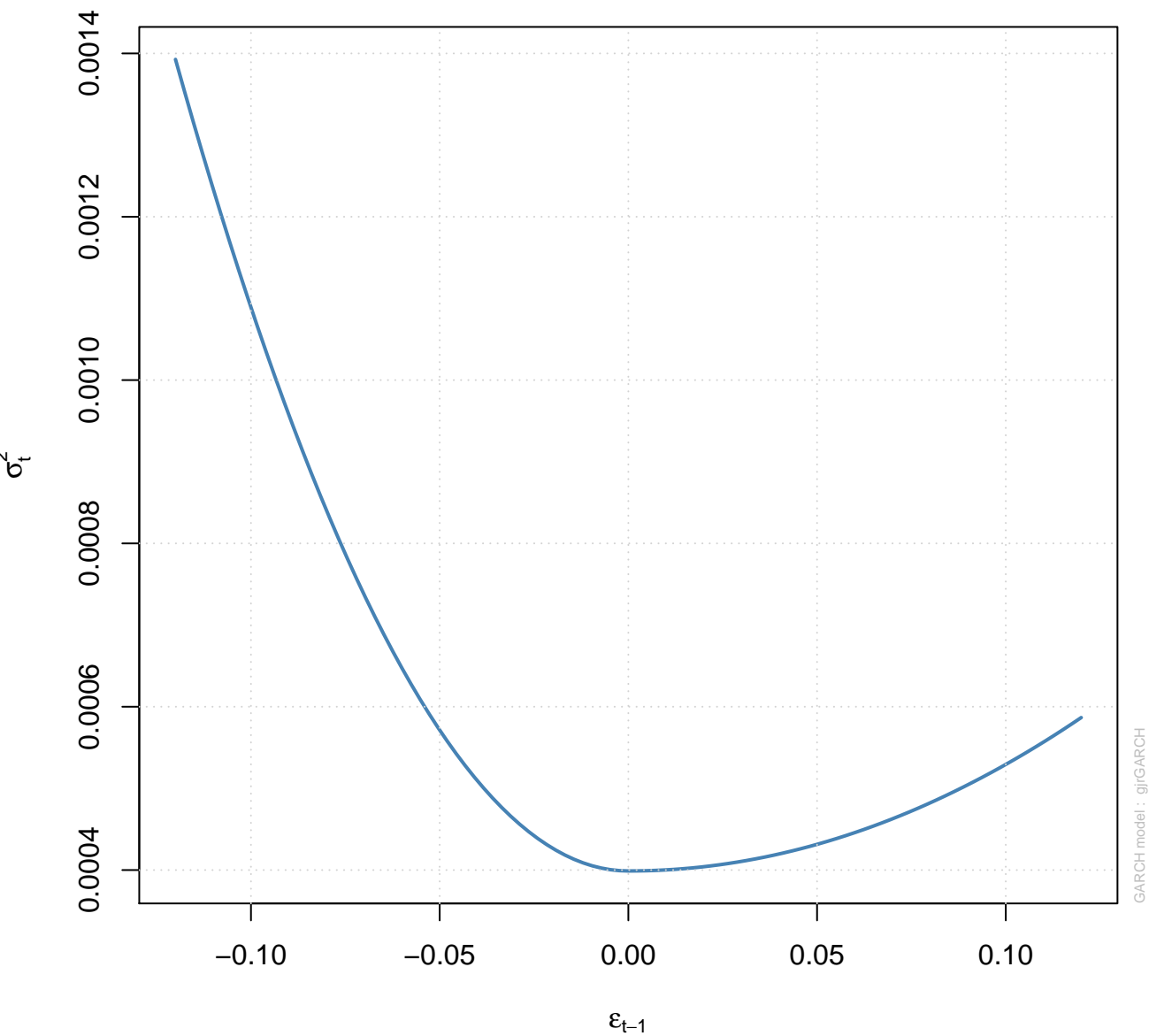
Forecast Series
w/th unconditional 1−Sigma bands

Horizon: 100

- ○ Actual
- ○ Forecast

Series

Time/Horizon

GARCH model : gjrGARCH
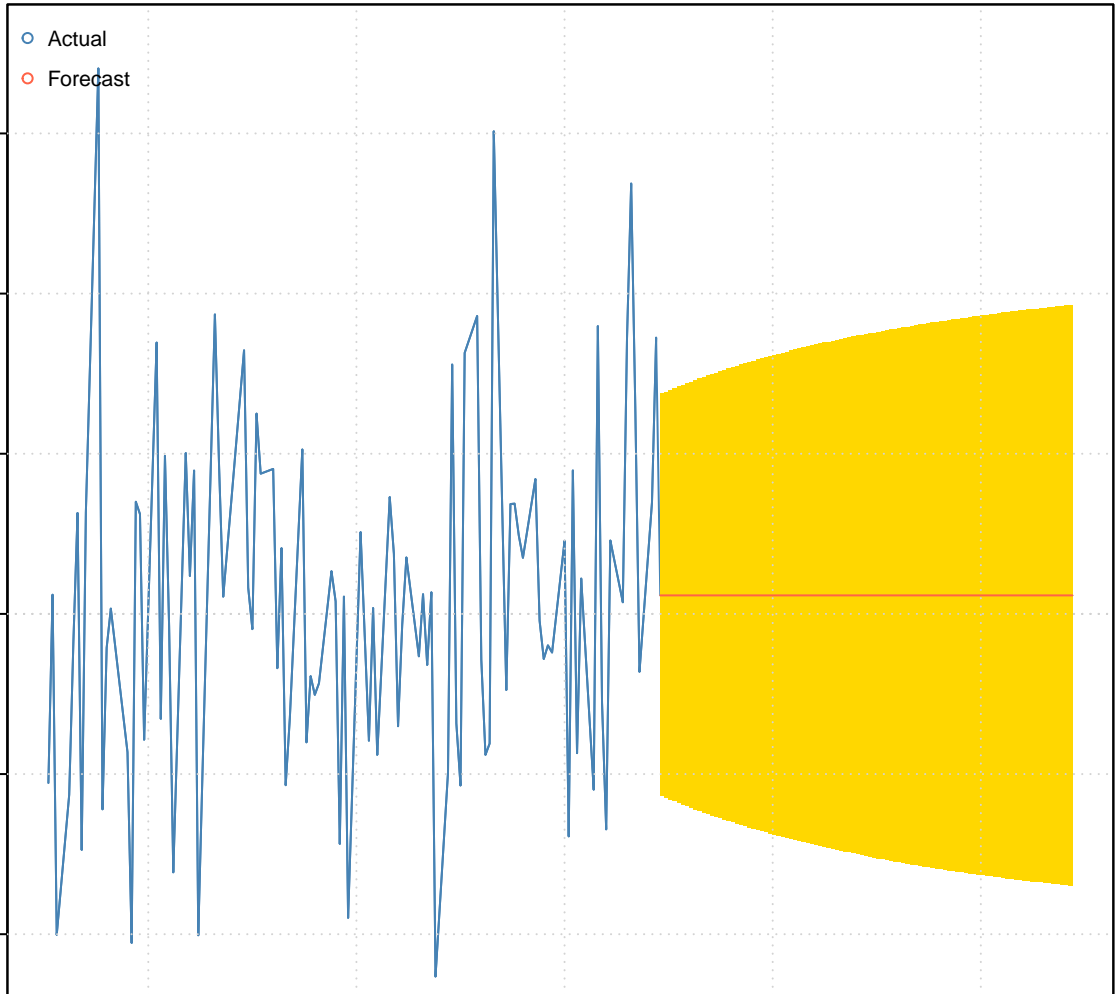
Rolling Forecast vs Actual Series
w/th conditional 2−Sigma bands

Horizon: 100

○ Actual
○ Forecast

Series

Time/Horizon

Jun   Jul   Aug   Sep   Oct   Nov   Dec

0.10   0.05   0.00   −0.05

GARCH model : gjrGARCH
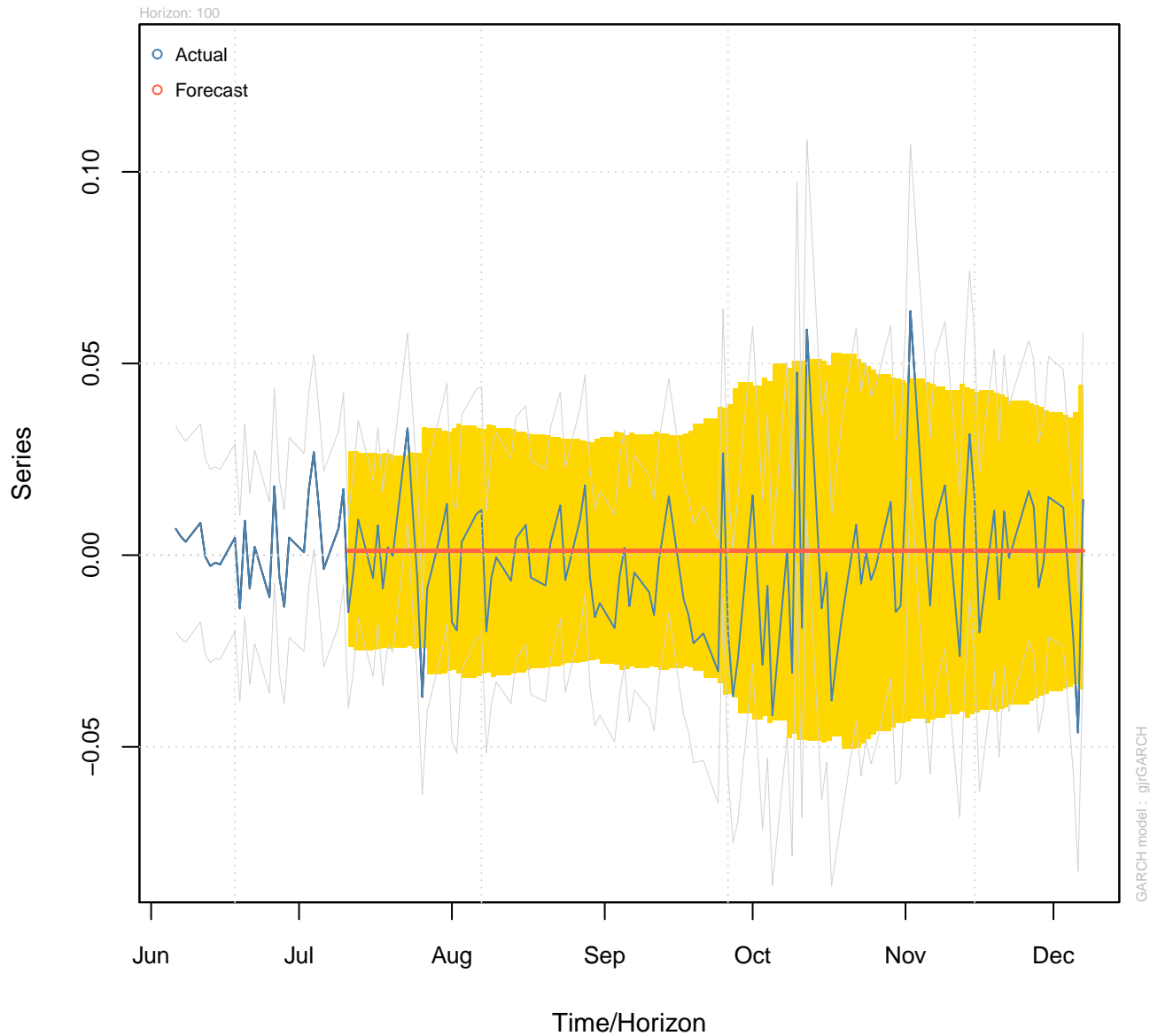
Forecast Unconditional Sigma
(n.roll = 0)
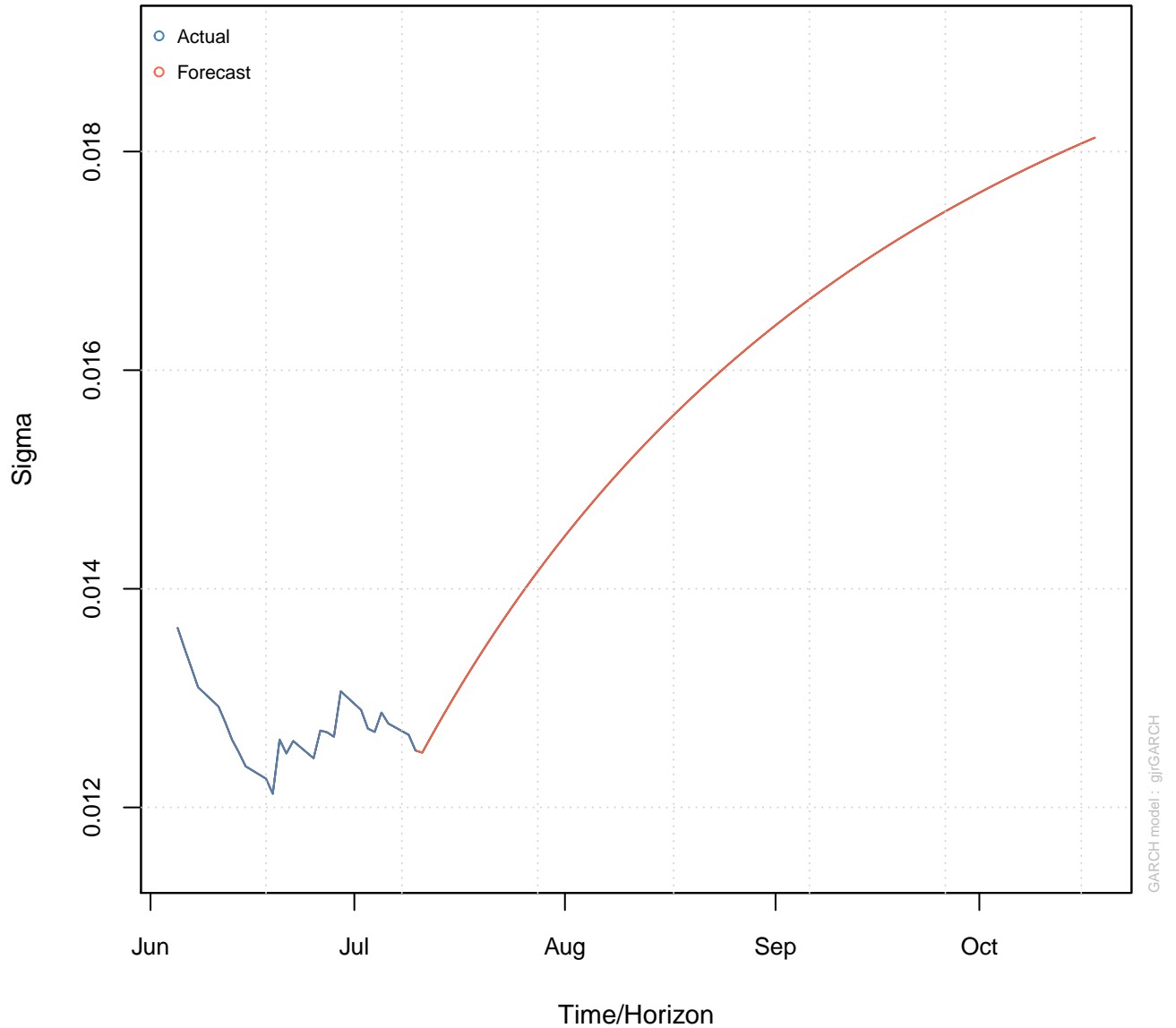
Forecast Rolling Sigma vs |Series|

Horizon: 100

- ○ Actual
- ○ Forecast
- ○ |Series|

Sigma

Time/Horizon

GARCH model : gjrGARCH