

Untitled

me

7/26/2020

```
5+5
```

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

```
library(zoo)
```

```
##
```

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

```
## The following objects are masked from 'package:base':
```

```
##
```

```
##      as.Date, as.Date.numeric
```

```
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
```

```
library(FinTS)
```

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

```
library(rugarch)
```

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

```
## Loading required package: parallel
```

```
##
```

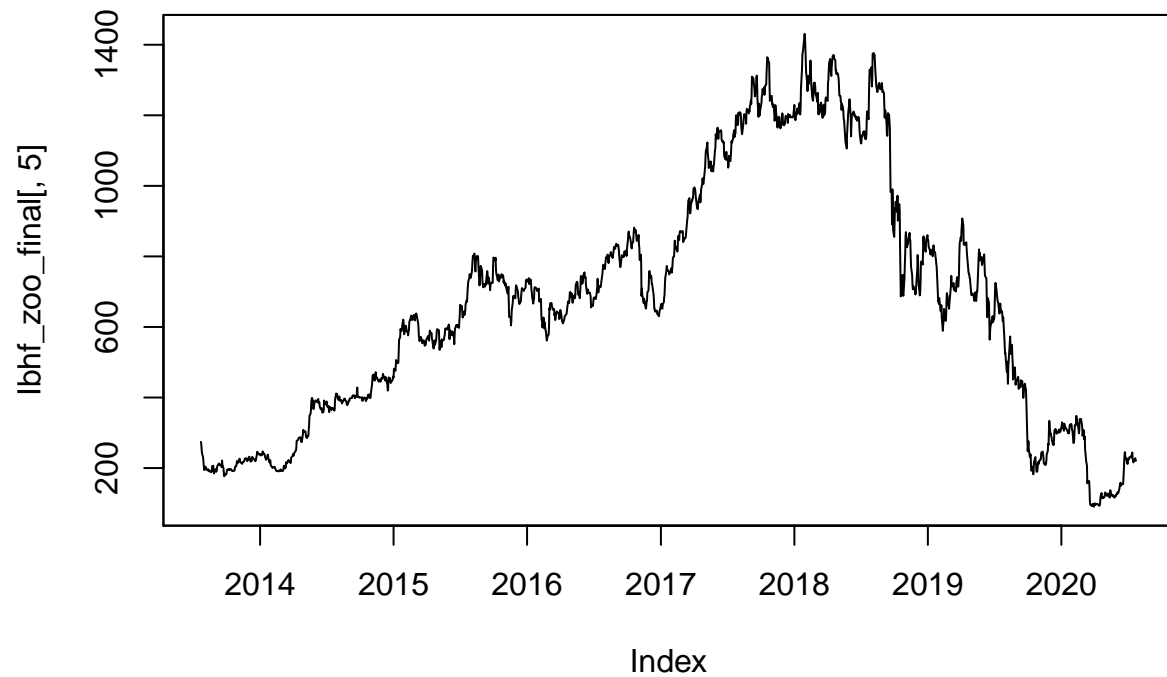
```
## Attaching package: 'rugarch'
```

```
## The following object is masked from 'package:stats':
```

```
##
```

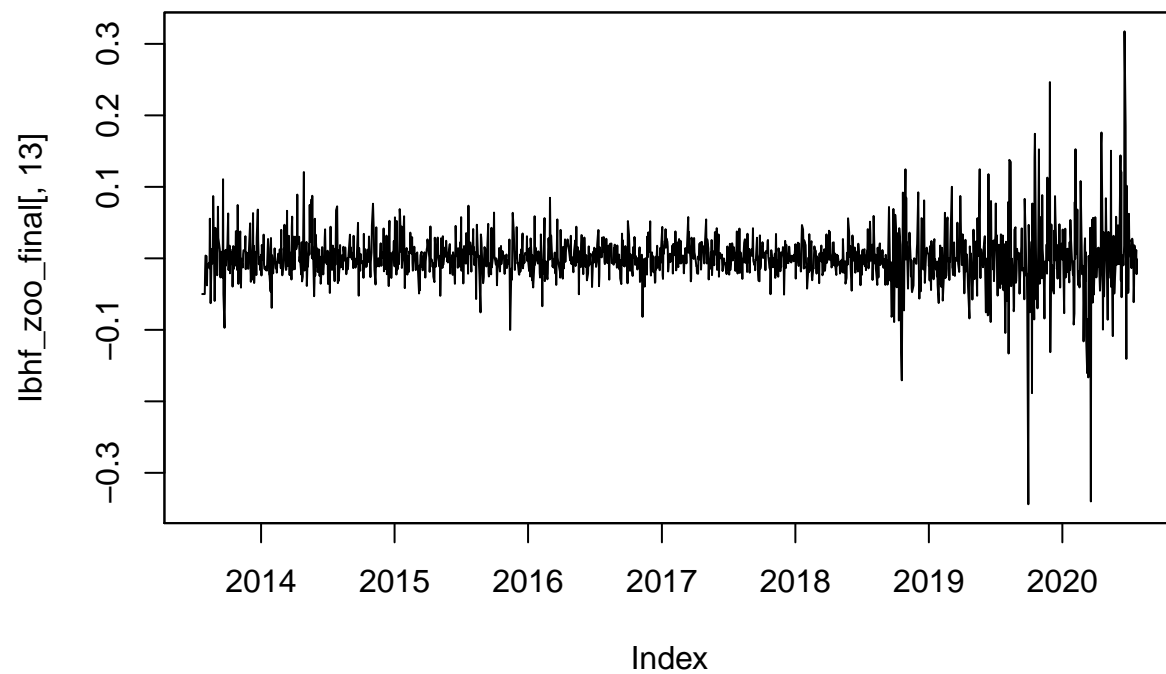
```
##      sigma
```

```
Ibhf_zoo_final<-read.zoo("India bulls housing finance.csv",header=TRUE,sep=",",format="%d-%b-%y",FUN = as.Date)
plot(Ibhf_zoo_final[,5])
```



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

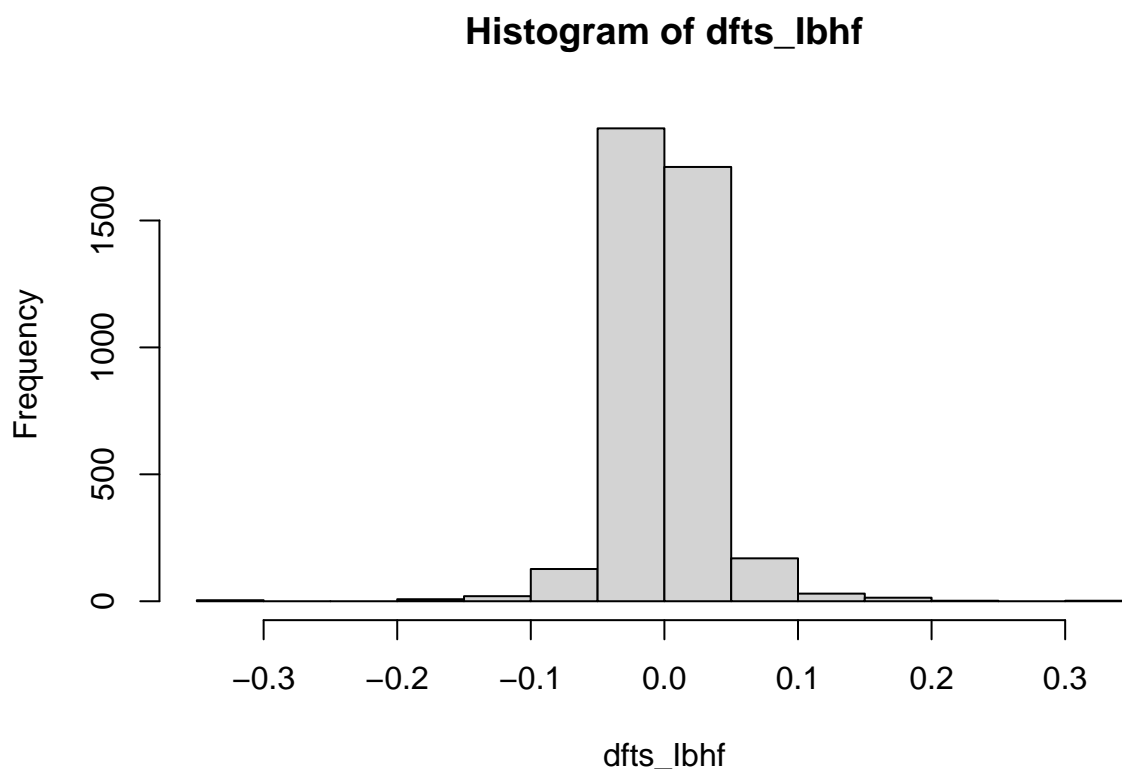
```
plot(Ibhf_zoo_final[,13])
```



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

```
ret_Ibhf<-Ibhf_zoo_final[-1,13]

dfts_Ibhf<- ts(ret_Ibhf,start=c(2010,1),end=c(2020,300),frequency = 365)
hist(dfts_Ibhf)
```



the return appears to be noormally distributed.

```
shapiro.test(dfts_Ibhf)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  dfts_Ibhf
## W = 0.85063, p-value < 2.2e-16
```

the series is staionary.

```
mean(dfts_Ibhf)
```

```
## [1] 0.000748546
```

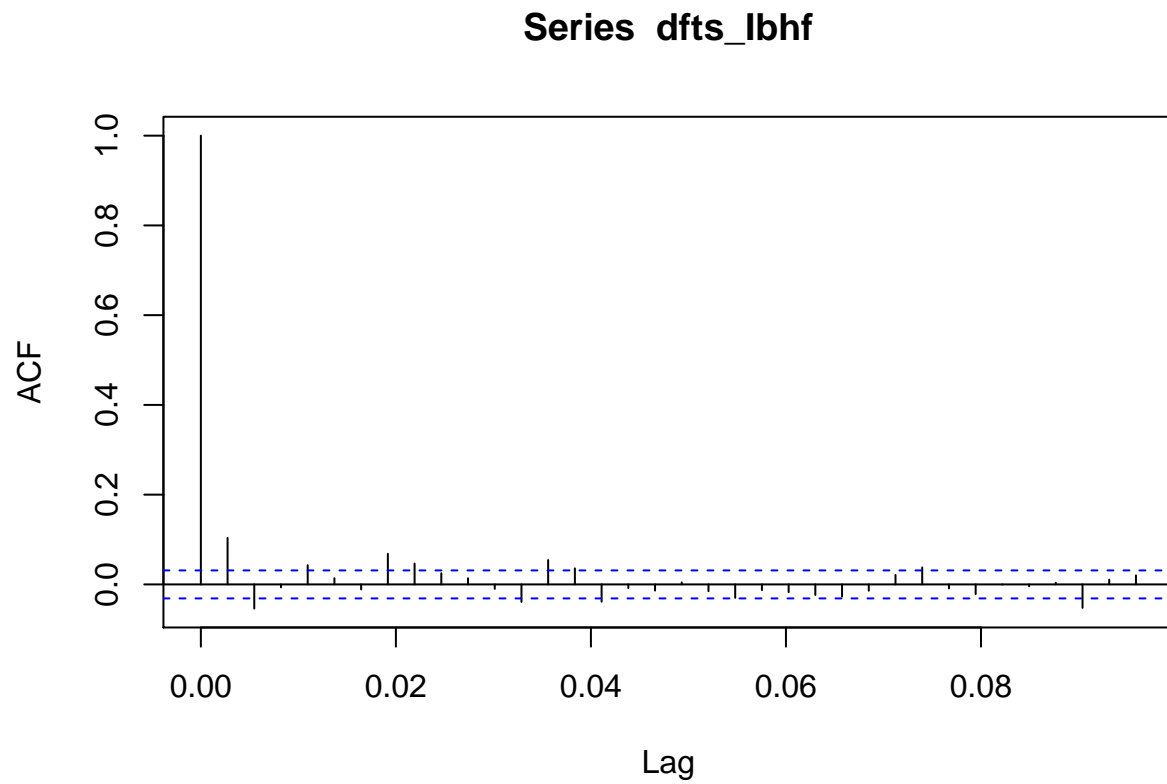
```
adf.test(ret_Ibhf)
```

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

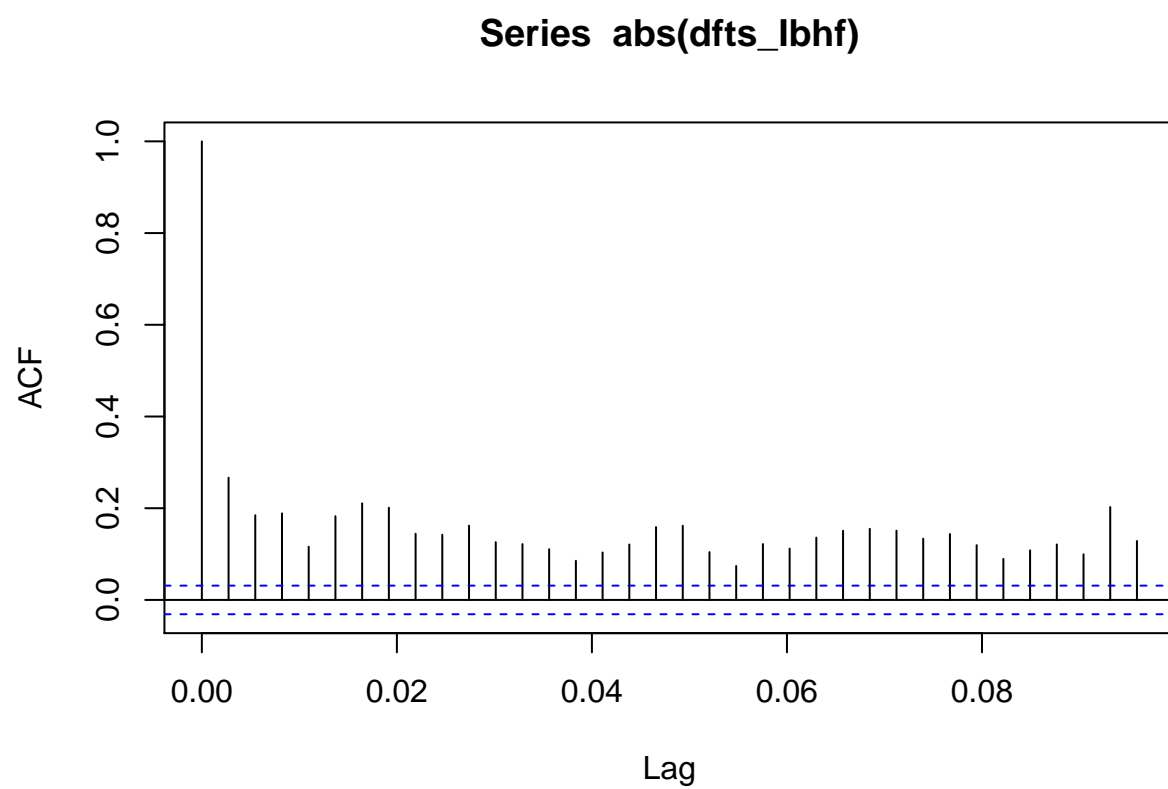
```
##
##  Augmented Dickey-Fuller Test
##
## data:  ret_Ibhf
## Dickey-Fuller = -11.61, Lag order = 11, p-value = 0.01
## alternative hypothesis: stationary
```

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

```
acf(dfts_Ibhf)
```

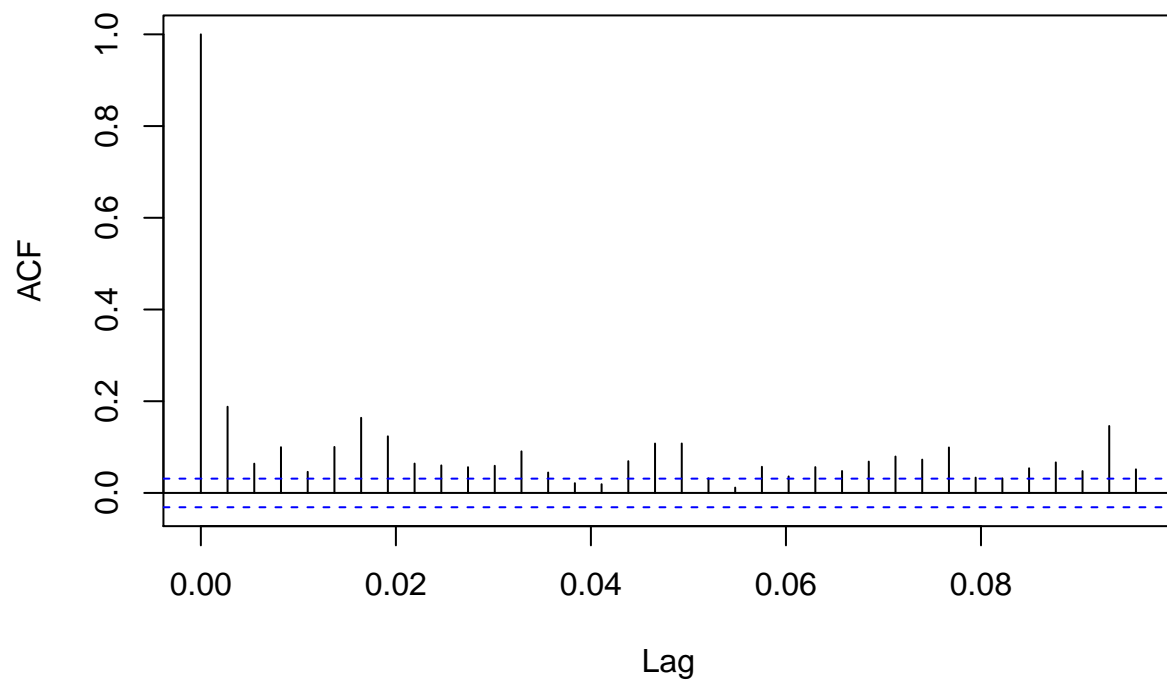


```
acf(abs(dfts_Ibhf))
```



```
acf(dfts_lbhf2)
```

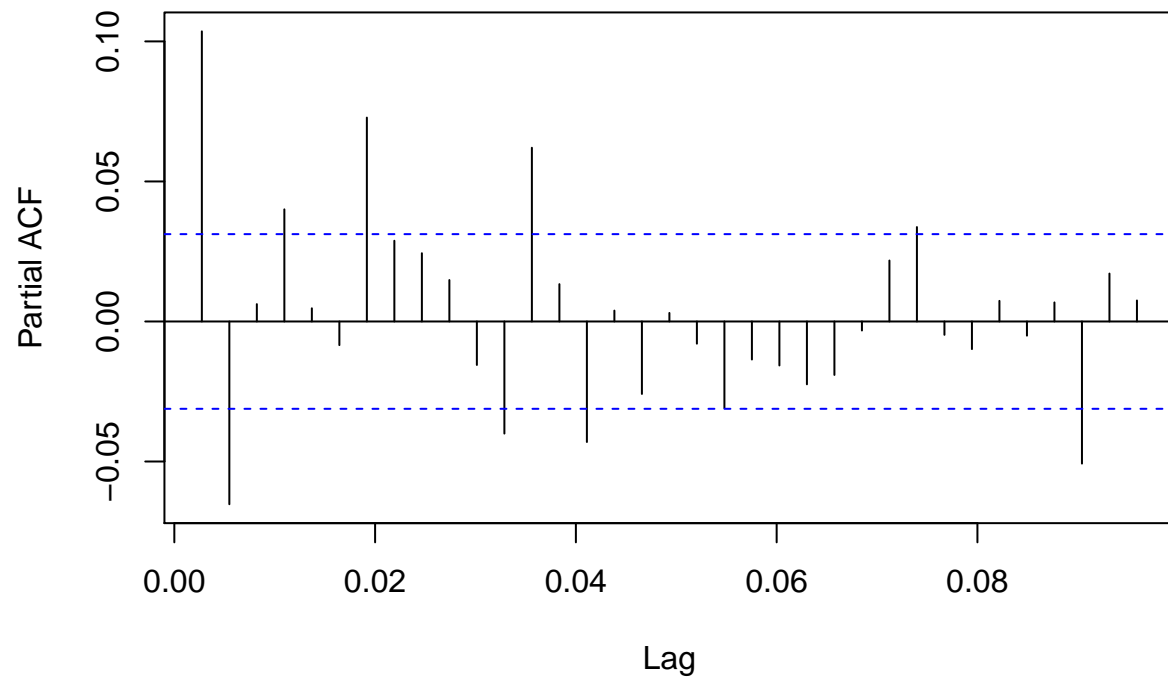
Series dfts_lbhf^2



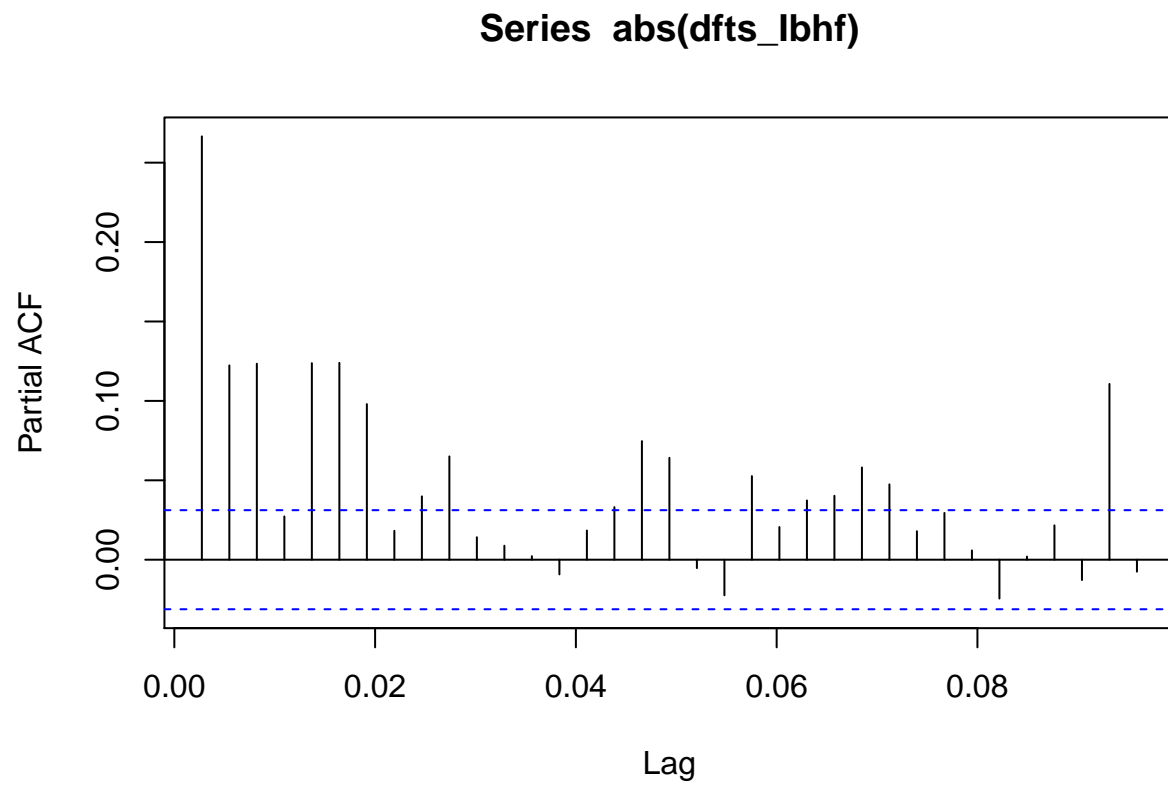
by acf function of return we can say there is no auto correlation and there will be no need of MA model
also by looking at the acf of absolute return we can say that the large return are followed by large returns
regardless of sign MA(2) may be

```
pacf(dfts_lbhf)
```

Series dfts_lbhf

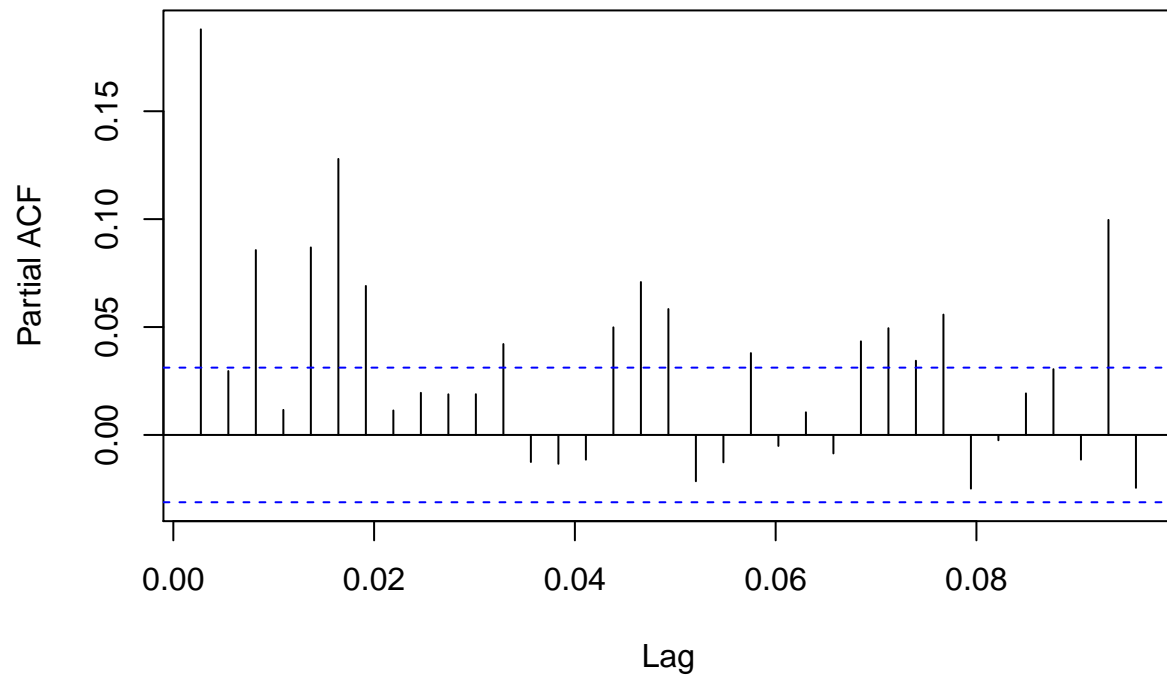


```
pacf(abs(dfts_lbhf))
```

```
pacf(dfts_lbhf2)
```

Series dfts_lbhf^2



there seems to be no need of any AR model to predict the log return series. AR(2)

```
Box.test(ret_Ibhf^2,lag=12,type="Ljung")
```

```
##
## Box-Ljung test
##
## data:  ret_Ibhf^2
## X-squared = 323.19, df = 12, p-value < 2.2e-16
```

```
ArchTest(ret_Ibhf)
```

```
##
## ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  ret_Ibhf
## Chi-squared = 125.67, 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.

```
arima001<-arima(ret_Ibhf,order = c(0,0,1))
AIC(arima001)
```

```
## [1] -6530.104
```

```
"arima001"
```

```
## [1] "arima001"
```

```
arima010<-arima(ret_Ibhf,order = c(0,1,0))  
AIC(arima010)
```

```
## [1] -5354.403
```

```
"arima010"
```

```
## [1] "arima010"
```

```
arima100<-arima(ret_Ibhf,order = c(1,0,0))  
AIC(arima100);"arima100"
```

```
## [1] -6530.003
```

```
## [1] "arima100"
```

```
arima101<-arima(ret_Ibhf,order = c(1,0,1))  
AIC(arima101);"arima101"
```

```
## [1] -6534.22
```

```
## [1] "arima101"
```

```
arima110<-arima(ret_Ibhf,order = c(1,1,0))  
AIC(arima110);"arima110"
```

```
## [1] -5819.849
```

```
## [1] "arima110"
```

```
arima011<-arima(ret_Ibhf,order = c(0,1,1))  
AIC(arima011);"arima011"
```

```
## [1] -6517.821
```

```
## [1] "arima011"
```

```
arima111<-arima(ret_Ibhf,order = c(1,1,1))  
AIC(arima111);"arima111"
```

```
## [1] -6517.973
```

```
## [1] "arima111"
```

```
arima200<-arima(ret_Ibhf,order = c(2,0,0))  
AIC(arima200);"arima200"
```

```
## [1] -6528.452
```

```
## [1] "arima200"
```

```
arima210<-arima(ret_Ibhf,order = c(2,1,0))  
AIC(arima210);"arima210"
```

```
## [1] -6069.564
```

```
## [1] "arima210"
```

```
arima201<-arima(ret_Ibhf,order = c(2,0,1))  
AIC(arima201);"arima201"
```

```
## [1] -6534.478
```

```
## [1] "arima201"
```

```
arima211<-arima(ret_Ibhf,order = c(2,1,1))  
AIC(arima211);"arima211"
```

```
## [1] -6516.427
```

```
## [1] "arima211"
```

```
arima020<-arima(ret_Ibhf,order = c(0,2,0))  
AIC(arima020);"arima020"
```

```
## [1] -3112.169
```

```
## [1] "arima020"
```

```
arima120<-arima(ret_Ibhf,order = c(1,2,0))  
AIC(arima120);"arima120"
```

```
## [1] -4170.702
```

```
## [1] "arima120"
```

```
arima021<-arima(ret_Ibhf,order = c(0,2,1))  
AIC(arima021);"arima021"
```

```
## [1] -5340.191
```

```
## [1] "arima021"
```

```
arima121<-arima(ret_Ibhf,order = c(1,2,1))  
AIC(arima121);"arima121"
```

```
## [1] -5804.567
```

```
## [1] "arima121"
```

```
arima002<-arima(ret_Ibhf,order = c(0,0,2))  
AIC(arima002);"arima002"
```

```
## [1] -6529.362
```

```
## [1] "arima002"
```

```
arima102<-arima(ret_Ibhf,order = c(1,0,2))  
AIC(arima102);"arima102"
```

```
## [1] -6533.848
```

```
## [1] "arima102"
```

```
arima012<-arima(ret_Ibhf,order = c(0,1,2))  
AIC(arima012);"arima012"
```

```
## [1] -6518.08
```

```
## [1] "arima012"
```

```
arima112<-arima(ret_Ibhf,order = c(1,1,2))  
AIC(arima112);"arima112"
```

```
## [1] -6522.213
```

```
## [1] "arima112"
```

```
arima222<-arima(ret_Ibhf,order = c(2,2,2))  
AIC(arima222);"arima222"
```

```
## [1] -6470.112
```

```
## [1] "arima222"
```

```
arima220<-arima(ret_Ibhf,order = c(2,2,0))  
AIC(arima220);"arima220"
```

```
## [1] -4739.029
```

```
## [1] "arima220"
```

```
arima202<-arima(ret_Ibhf,order = c(2,0,2))
```

```
## Warning in arima(ret_Ibhf, order = c(2, 0, 2)): possible convergence problem:
## optim gave code = 1
```

```
AIC(arima202);"arima202"
```

```
## [1] -6533.011
```

```
## [1] "arima202"
```

```
arima022<-arima(ret_Ibhf,order = c(0,2,2))
```

```
AIC(arima022);"arima022"
```

```
## [1] -6473.54
```

```
## [1] "arima022"
```

```
arima212<-arima(ret_Ibhf,order = c(2,1,2))
```

```
AIC(arima212);"arima212"
```

```
## [1] -6522.415
```

```
## [1] "arima212"
```

ARIMA201<-ARIMA101<-ARIMA102 is the best choice since there was not any recommendation from acf and pacf function we will ignore these model for now .

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(1,0)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(1,0)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : norm
##
## Optimal Parameters
## -----
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.051852   0.000013  4106.777    0
## ar1     -0.908190   0.000207 -4390.275    0
## ar2     -0.657896   0.000228 -2887.384    0
```

```

## omega    0.000003    0.000000    16.589    0
## alpha1   0.969902    0.000248   3918.735    0
##
## Robust Standard Errors:
##      Estimate   Std. Error   t value Pr(>|t|)
## mu          0.051852    1.113817   0.046553  0.96287
## ar1        -0.908190   13.234454  -0.068623  0.94529
## ar2        -0.657896   27.239340  -0.024152  0.98073
## omega       0.000003    0.003241   0.000866  0.99931
## alpha1      0.969902   26.597721   0.036466  0.97091
##
## LogLikelihood : 572.2388
##
## Information Criteria
## -----
##
## Akaike          -0.65729
## Bayes           -0.64149
## Shibata         -0.65730
## Hannan-Quinn   -0.65144
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                statistic p-value
## Lag[1]                0.3014 0.58299
## Lag[2*(p+q)+(p+q)-1] [5]  4.1406 0.04613
## Lag[4*(p+q)+(p+q)-1] [9]  5.3982 0.36750
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]                0.003434 0.9533
## Lag[2*(p+q)+(p+q)-1] [2]  0.008550 0.9910
## Lag[4*(p+q)+(p+q)-1] [5]  0.018127 0.9999
## d.o.f=1
##
## Weighted ARCH LM Tests
## -----
##
##      Statistic Shape Scale P-Value
## ARCH Lag[2]    0.01021 0.500 2.000 0.9195
## ARCH Lag[4]    0.01787 1.397 1.611 0.9985
## ARCH Lag[6]    0.01988 2.222 1.500 1.0000
##
## Nyblom stability test
## -----
## Joint Statistic: 1.6806
## Individual Statistics:
## mu          0.0336
## ar1          0.0336
## ar2          0.0336
## omega        0.0805
## alpha1       0.0336

```

```
##
## 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      0.3742 7.083e-01
## Negative Sign Bias 4.3736 1.295e-05 ***
## Positive Sign Bias 0.4795 6.317e-01
## Joint Effect      19.4867 2.168e-04 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      6003          0
## 2    30      6148          0
## 3    40      6309          0
## 4    50      6360          0
##
##
## Elapsed time : 0.9449871
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(0,1)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(0,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : norm
##
## Optimal Parameters
## -----
##      Estimate Std. Error   t value Pr(>|t|)
## mu      0.000586   0.000896    0.6539 0.513174
## ar1      0.110229   0.024026    4.5880 0.000004
## ar2     -0.067512   0.024014   -2.8114 0.004933
## omega    0.000002   0.000000   62.2454 0.000000
## beta1    0.999000   0.000012 81262.7707 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error   t value Pr(>|t|)
## mu      0.000586   0.000810    0.72389 0.469133
## ar1      0.110229   0.032580    3.38334 0.000716
## ar2     -0.067512   0.031253   -2.16015 0.030761
```



```

## omega  0.000002    0.000000    9.58574 0.000000
## beta1  0.999000    0.000129 7742.41689 0.000000
##
## LogLikelihood : 3295.311
##
## Information Criteria
## -----
##
## Akaike      -3.8126
## Bayes      -3.7968
## Shibata    -3.8127
## Hannan-Quinn -3.8068
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                statistic p-value
## Lag[1]                0.005183 0.9426
## Lag[2*(p+q)+(p+q)-1] [5] 1.228208 0.9998
## Lag[4*(p+q)+(p+q)-1] [9] 5.849434 0.2819
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]                69.02 1.11e-16
## Lag[2*(p+q)+(p+q)-1] [2] 72.94 0.00e+00
## Lag[4*(p+q)+(p+q)-1] [5] 93.46 0.00e+00
## d.o.f=1
##
## Weighted ARCH LM Tests
## -----
##
##      Statistic Shape Scale  P-Value
## ARCH Lag[2]      7.826 0.500 2.000 5.150e-03
## ARCH Lag[4]     25.109 1.397 1.611 5.846e-07
## ARCH Lag[6]     55.656 2.222 1.500 5.884e-15
##
## Nyblom stability test
## -----
## Joint Statistic: 91.011
## Individual Statistics:
## mu      0.23104
## ar1     0.01861
## ar2     0.05093
## omega   1.68055
## beta1   3.91347
##
## 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          1.309 1.906e-01
## Negative Sign Bias 8.936 1.015e-18 ***
## Positive Sign Bias 5.254 1.670e-07 ***
## Joint Effect      107.465 3.854e-23 ***
```

```
##
```

```
##
```

```
## Adjusted Pearson Goodness-of-Fit Test:
```

```
## -----
```

```
## group statistic p-value(g-1)
```

```
## 1 20 473.6 1.881e-88
```

```
## 2 30 504.1 4.104e-88
```

```
## 3 40 530.4 1.809e-87
```

```
## 4 50 530.8 4.290e-82
```

```
##
```

```
##
```

```
## Elapsed time : 0.5749929
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(1,1)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
```

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

```
## *          GARCH Model Fit          *
```

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

```
##
```

```
## Conditional Variance Dynamics
```

```
## -----
```

```
## GARCH Model : sGARCH(1,1)
```

```
## Mean Model : ARFIMA(2,0,0)
```

```
## Distribution : norm
```

```
##
```

```
## Optimal Parameters
```

```
## -----
```

```
## Estimate Std. Error t value Pr(>|t|)
```

```
## mu 0.001464 0.000638 2.2932 0.021835
```

```
## ar1 0.128655 0.024947 5.1571 0.000000
```

```
## ar2 -0.059922 0.025063 -2.3909 0.016808
```

```
## omega 0.000003 0.000002 1.3372 0.181154
```

```
## alpha1 0.038525 0.004036 9.5451 0.000000
```

```
## beta1 0.960475 0.003967 242.1159 0.000000
```

```
##
```

```
## Robust Standard Errors:
```

```
## Estimate Std. Error t value Pr(>|t|)
```

```
## mu 0.001464 0.000614 2.38389 0.017131
```

```
## ar1 0.128655 0.022901 5.61792 0.000000
```

```
## ar2 -0.059922 0.024237 -2.47237 0.013422
```

```
## omega 0.000003 0.000005 0.54413 0.586350
```

```
## alpha1 0.038525 0.006450 5.97315 0.000000
```

```
## beta1 0.960475 0.006617 145.14962 0.000000
```

```
##
```

```
## LogLikelihood : 3668.325
```

```
##
```

```
## Information Criteria
```

```

## -----
##
## Akaike          -4.2437
## Bayes           -4.2248
## Shibata         -4.2437
## Hannan-Quinn   -4.2367
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                statistic p-value
## Lag[1]          0.0003936 0.9842
## Lag[2*(p+q)+(p+q)-1] [5] 0.4976853 1.0000
## Lag[4*(p+q)+(p+q)-1] [9] 2.6103883 0.9407
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]          4.770 0.02895
## Lag[2*(p+q)+(p+q)-1] [5] 5.348 0.12755
## Lag[4*(p+q)+(p+q)-1] [9] 8.011 0.12825
## d.o.f=2
##
## Weighted ARCH LM Tests
## -----
##
##                Statistic Shape Scale P-Value
## ARCH Lag[3]     0.01699 0.500 2.000 0.8963
## ARCH Lag[5]     1.51686 1.440 1.667 0.5879
## ARCH Lag[7]     3.79340 2.315 1.543 0.3773
##
## Nyblom stability test
## -----
## Joint Statistic: 8.4195
## Individual Statistics:
## mu      0.09759
## ar1     0.07617
## ar2     0.03520
## omega   3.15249
## alpha1  0.31160
## beta1   0.21569
##
## 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          1.7253 8.465e-02  *
## Negative Sign Bias  4.2314 2.445e-05 ***
## Positive Sign Bias  0.5506 5.820e-01
## Joint Effect       18.2476 3.910e-04 ***
##

```

```
##
## Adjusted Pearson Goodness-of-Fit Test:
```

```
## -----
```

```
##   group statistic p-value(g-1)
## 1    20      132.5   4.962e-19
## 2    30      163.8   9.456e-21
## 3    40      154.1   1.313e-15
## 4    50      177.8   1.649e-16
```

```
##
```

```
##
```

```
## Elapsed time : 0.4490039
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(2,0)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
```

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

```
## *          GARCH Model Fit          *
```

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

```
##
```

```
## Conditional Variance Dynamics
```

```
## -----
```

```
## GARCH Model   : sGARCH(2,0)
```

```
## Mean Model    : ARFIMA(2,0,0)
```

```
## Distribution : norm
```

```
##
```

```
## Optimal Parameters
```

```
## -----
```

```
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.000099  0.000728  0.13621 0.891654
## ar1     0.132040  0.033024  3.99825 0.000064
## ar2    -0.077868  0.027470 -2.83465 0.004588
## omega   0.000587  0.000038 15.50221 0.000000
## alpha1  0.535597  0.076161  7.03247 0.000000
## alpha2  0.182075  0.034032  5.35003 0.000000
```

```
##
```

```
## Robust Standard Errors:
```

```
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.000099  0.001178  0.084194 0.932903
## ar1     0.132040  0.040042  3.297513 0.000975
## ar2    -0.077868  0.047532 -1.638218 0.101376
## omega   0.000587  0.000112  5.250831 0.000000
## alpha1  0.535597  0.222083  2.411701 0.015878
## alpha2  0.182075  0.058915  3.090464 0.001998
```

```
##
```

```
## LogLikelihood : 3485.264
```

```
##
```

```
## Information Criteria
```

```
## -----
```

```
##
```

```
## Akaike      -4.0316
```

```
## Bayes      -4.0126
```

```
## Shibata    -4.0316
```

```

## Hannan-Quinn -4.0246
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##               statistic p-value
## Lag[1]                0.1309 0.7175
## Lag[2*(p+q)+(p+q)-1] [5]    0.4526 1.0000
## Lag[4*(p+q)+(p+q)-1] [9]    3.2659 0.8463
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##               statistic p-value
## Lag[1]                0.2836 0.5944
## Lag[2*(p+q)+(p+q)-1] [5]    1.4943 0.7413
## Lag[4*(p+q)+(p+q)-1] [9]    8.1743 0.1191
## d.o.f=2
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale P-Value
## ARCH Lag[3]    0.8537 0.500 2.000 0.3555
## ARCH Lag[5]    1.9992 1.440 1.667 0.4714
## ARCH Lag[7]    6.2146 2.315 1.543 0.1274
##
## Nyblom stability test
## -----
## Joint Statistic: 4.4081
## Individual Statistics:
## mu      0.5044
## ar1     0.2630
## ar2     0.0955
## omega   2.3134
## alpha1  1.8973
## alpha2  2.1244
##
## 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      1.4180 0.1564
## Negative Sign Bias 0.4517 0.6516
## Positive Sign Bias 1.0782 0.2811
## Joint Effect    2.2465 0.5228
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      218.6    6.683e-36

```

```
## 2    30    231.2    2.202e-33
## 3    40    245.1    1.103e-31
## 4    50    264.3    2.773e-31
##
##
## Elapsed time : 0.9519989
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(0,2)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(0,2)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : norm
##
## Optimal Parameters
## -----
##      Estimate Std. Error   t value Pr(>|t|)
## mu      0.000587   0.000891  6.5898e-01 0.509909
## ar1      0.110027   0.024028  4.5791e+00 0.000005
## ar2     -0.067279   0.024016 -2.8014e+00 0.005089
## omega    0.000002   0.000000  1.0094e+02 0.000000
## beta1    0.000000   0.000098  1.1660e-03 0.999069
## beta2    0.999000   0.000009  1.1341e+05 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error   t value Pr(>|t|)
## mu      0.000587   0.000766  7.6606e-01 0.443641
## ar1      0.110027   0.031048  3.5437e+00 0.000394
## ar2     -0.067279   0.029921 -2.2486e+00 0.024541
## omega    0.000002   0.000000  2.2070e+01 0.000000
## beta1    0.000000   0.000390  2.9300e-04 0.999766
## beta2    0.999000   0.000041  2.4411e+04 0.000000
##
## LogLikelihood : 3302.52
##
## Information Criteria
## -----
##
## Akaike          -3.8198
## Bayes           -3.8009
## Shibata         -3.8199
## Hannan-Quinn   -3.8128
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                      statistic p-value
```

```

## Lag[1] 0.006226 0.9371
## Lag[2*(p+q)+(p+q)-1][5] 1.175991 0.9999
## Lag[4*(p+q)+(p+q)-1][9] 5.655275 0.3170
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
## statistic p-value
## Lag[1] 68.24 1.11e-16
## Lag[2*(p+q)+(p+q)-1][5] 92.18 0.00e+00
## Lag[4*(p+q)+(p+q)-1][9] 141.12 0.00e+00
## d.o.f=2
##
## Weighted ARCH LM Tests
## -----
## Statistic Shape Scale P-Value
## ARCH Lag[3] 18.12 0.500 2.000 2.073e-05
## ARCH Lag[5] 35.98 1.440 1.667 1.872e-09
## ARCH Lag[7] 81.28 2.315 1.543 0.000e+00
##
## Nyblom stability test
## -----
## Joint Statistic: 217.2647
## Individual Statistics:
## mu 0.24131
## ar1 0.01851
## ar2 0.05280
## omega 5.02034
## beta1 3.49068
## beta2 3.49036
##
## 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 1.318 1.878e-01
## Negative Sign Bias 8.933 1.043e-18 ***
## Positive Sign Bias 5.236 1.840e-07 ***
## Joint Effect 107.219 4.352e-23 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
## group statistic p-value(g-1)
## 1 20 488.6 1.405e-91
## 2 30 519.0 3.567e-91
## 3 40 540.2 1.865e-89
## 4 50 549.7 7.699e-86
##
##

```

```
## Elapsed time : 0.7850039
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(2,2)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(2,2)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : norm
##
## Optimal Parameters
## -----
##      Estimate Std. Error  t value Pr(>|t|)
## mu      0.001529   0.000636   2.402620 0.016278
## ar1     0.130690   0.025658   5.093581 0.000000
## ar2    -0.057840   0.023850  -2.425148 0.015302
## omega   0.000005   0.000005   0.926337 0.354271
## alpha1  0.074790   0.015770   4.742433 0.000002
## alpha2  0.000000   0.014027   0.000004 0.999996
## beta1   0.064199   0.037909   1.693474 0.090365
## beta2   0.860012   0.035252  24.395836 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error  t value Pr(>|t|)
## mu      0.001529   0.000633   2.414582 0.015753
## ar1     0.130690   0.022405   5.833194 0.000000
## ar2    -0.057840   0.025054  -2.308627 0.020964
## omega   0.000005   0.000017   0.286172 0.774746
## alpha1  0.074790   0.033820   2.211418 0.027007
## alpha2  0.000000   0.023448   0.000003 0.999998
## beta1   0.064199   0.055488   1.156987 0.247278
## beta2   0.860012   0.036503  23.560014 0.000000
##
## LogLikelihood : 3676.309
##
## Information Criteria
## -----
##
## Akaike          -4.2506
## Bayes           -4.2254
## Shibata         -4.2507
## Hannan-Quinn   -4.2413
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                      statistic p-value
## Lag[1]              0.00147 0.9694
```



```

## Lag[2*(p+q)+(p+q)-1][5]    0.40511  1.0000
## Lag[4*(p+q)+(p+q)-1][9]    2.75905  0.9238
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##                statistic p-value
## Lag[1]                1.741  0.1870
## Lag[2*(p+q)+(p+q)-1][11]    7.842  0.2299
## Lag[4*(p+q)+(p+q)-1][19]   10.595  0.3894
## d.o.f=4
##
## Weighted ARCH LM Tests
## -----
##                Statistic Shape Scale P-Value
## ARCH Lag[5]          1.101 0.500 2.000 0.29402
## ARCH Lag[7]          8.474 1.473 1.746 0.02025
## ARCH Lag[9]          9.212 2.402 1.619 0.03927
##
## Nyblom stability test
## -----
## Joint Statistic:  1.9918
## Individual Statistics:
## mu      0.09025
## ar1     0.05767
## ar2     0.02572
## omega   0.59493
## alpha1  0.36050
## alpha2  0.45380
## beta1   0.29134
## beta2   0.25725
##
## 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          1.52911 0.126420
## Negative Sign Bias  3.40781 0.000670 ***
## Positive Sign Bias  0.05022 0.959955
## Joint Effect        11.62663 0.008778 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##    group statistic p-value(g-1)
## 1    20      125.7    9.437e-18
## 2    30      144.9    2.331e-17
## 3    40      160.3    1.208e-16
## 4    50      168.6    4.922e-15
##

```

```
##
```

```
## Elapsed time : 1.050993
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(1,2)),mean.model =list(armaOrder=c(2  
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)  
my_model_Ibhf
```

```
##
```

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

```
## *          GARCH Model Fit          *
```

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

```
##
```

```
## Conditional Variance Dynamics
```

```
## -----
```

```
## GARCH Model   : sGARCH(1,2)
```

```
## Mean Model    : ARFIMA(2,0,0)
```

```
## Distribution : norm
```

```
##
```

```
## Optimal Parameters
```

```
## -----
```

```
##      Estimate Std. Error t value Pr(>|t|)
```

```
## mu      0.001529   0.000636  2.40298 0.016262
```

```
## ar1     0.130689   0.025513  5.12247 0.000000
```

```
## ar2    -0.057841   0.023758 -2.43454 0.014911
```

```
## omega   0.000005   0.000005  0.98359 0.325315
```

```
## alpha1  0.074788   0.014741  5.07350 0.000000
```

```
## beta1   0.064183   0.028573  2.24626 0.024687
```

```
## beta2   0.860028   0.031560 27.25033 0.000000
```

```
##
```

```
## Robust Standard Errors:
```

```
##      Estimate Std. Error t value Pr(>|t|)
```

```
## mu      0.001529   0.000631  2.42338 0.015377
```

```
## ar1     0.130689   0.022372  5.84152 0.000000
```

```
## ar2    -0.057841   0.024025 -2.40758 0.016059
```

```
## omega   0.000005   0.000015  0.32937 0.741879
```

```
## alpha1  0.074788   0.040127  1.86380 0.062349
```

```
## beta1   0.064183   0.037406  1.71585 0.086190
```

```
## beta2   0.860028   0.050400 17.06403 0.000000
```

```
##
```

```
## LogLikelihood : 3676.309
```

```
##
```

```
## Information Criteria
```

```
## -----
```

```
##
```

```
## Akaike      -4.2518
```

```
## Bayes       -4.2297
```

```
## Shibata     -4.2518
```

```
## Hannan-Quinn -4.2436
```

```
##
```

```
## Weighted Ljung-Box Test on Standardized Residuals
```

```
## -----
```

```
##              statistic p-value
```

```
## Lag[1]              0.001467  0.9695
```

```
## Lag[2*(p+q)+(p+q)-1][5] 0.405103  1.0000
```

```

## Lag[4*(p+q)+(p+q)-1][9] 2.759070 0.9238
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]                1.741 0.1870
## Lag[2*(p+q)+(p+q)-1][8] 5.921 0.2431
## Lag[4*(p+q)+(p+q)-1][14] 9.079 0.2738
## d.o.f=3
##
## Weighted ARCH LM Tests
## -----
##
##      Statistic Shape Scale P-Value
## ARCH Lag[4] 0.05479 0.500 2.000 0.81494
## ARCH Lag[6] 6.60905 1.461 1.711 0.04898
## ARCH Lag[8] 7.81084 2.368 1.583 0.06813
##
## Nyblom stability test
## -----
## Joint Statistic: 1.941
## Individual Statistics:
## mu 0.09022
## ar1 0.05766
## ar2 0.02572
## omega 0.59496
## alpha1 0.36048
## beta1 0.29134
## beta2 0.25725
##
## 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      1.52910 0.1264239
## Negative Sign Bias 3.40783 0.0006699 ***
## Positive Sign Bias 0.05027 0.9599146
## Joint Effect    11.62681 0.0087773 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##      group statistic p-value(g-1)
## 1 20 125.7 9.437e-18
## 2 30 144.9 2.331e-17
## 3 40 160.3 1.208e-16
## 4 50 168.6 4.922e-15
##
##
## Elapsed time : 0.733999

```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(2,1)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(2,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : norm
##
## Optimal Parameters
## -----
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001464    0.000639   2.2921 0.021902
## ar1     0.128655    0.024964   5.1537 0.000000
## ar2    -0.059924    0.025063  -2.3909 0.016807
## omega   0.000003    0.000002   1.3335 0.182353
## alpha1  0.038525    0.017125   2.2497 0.024470
## alpha2  0.000000    0.018250   0.0000 1.000000
## beta1   0.960474    0.004143 231.8220 0.000000
##
## Robust Standard Errors:
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001464    0.000617   2.37139 0.017721
## ar1     0.128655    0.022872   5.62493 0.000000
## ar2    -0.059924    0.024235  -2.47265 0.013412
## omega   0.000003    0.000005   0.54047 0.588872
## alpha1  0.038525    0.019528   1.97283 0.048515
## alpha2  0.000000    0.019433   0.00000 1.000000
## beta1   0.960474    0.006722 142.89428 0.000000
##
## LogLikelihood : 3668.325
##
## Information Criteria
## -----
##
## Akaike          -4.2426
## Bayes           -4.2204
## Shibata         -4.2426
## Hannan-Quinn   -4.2344
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##              statistic p-value
## Lag[1]              0.0003934 0.9842
## Lag[2*(p+q)+(p+q)-1] [5] 0.4976742 1.0000
## Lag[4*(p+q)+(p+q)-1] [9] 2.6103753 0.9407
## d.o.f=2
```

```

## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]                4.770 0.02895
## Lag[2*(p+q)+(p+q)-1][8]    7.516 0.11917
## Lag[4*(p+q)+(p+q)-1][14]    9.771 0.21617
## d.o.f=3
##
## Weighted ARCH LM Tests
## -----
##
##          Statistic Shape Scale P-Value
## ARCH Lag[4]    0.05668 0.500 2.000 0.8118
## ARCH Lag[6]    4.13479 1.461 1.711 0.1760
## ARCH Lag[8]    5.29945 2.368 1.583 0.2186
##
## Nyblom stability test
## -----
## Joint Statistic: 10.5076
## Individual Statistics:
## mu      0.09760
## ar1     0.07617
## ar2     0.03520
## omega   3.15250
## alpha1  0.31160
## alpha2  0.36434
## beta1   0.21570
##
## 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          1.7253 8.465e-02  *
## Negative Sign Bias  4.2314 2.445e-05 ***
## Positive Sign Bias  0.5506 5.820e-01
## Joint Effect        18.2476 3.910e-04 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##
## group statistic p-value(g-1)
## 1      20      132.5      4.962e-19
## 2      30      163.8      9.456e-21
## 3      40      154.1      1.313e-15
## 4      50      177.8      1.649e-16
##
##
## Elapsed time : 0.707999

```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(0,1)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(0,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate  Std. Error    t value Pr(>|t|)
## mu      0.000760   0.000787     0.96572 0.334183
## ar1      0.037882   0.020875     1.81475 0.069563
## ar2     -0.061884   0.020616    -3.00168 0.002685
## omega    0.000003   0.000000    24.79209 0.000000
## beta1    0.999000   0.000023 43526.56745 0.000000
## skew     1.068887   0.032866    32.52297 0.000000
## shape    2.419737   0.032367    74.76004 0.000000
##
## Robust Standard Errors:
##      Estimate  Std. Error    t value Pr(>|t|)
## mu      0.000760   0.000881     0.86294 0.38817
## ar1      0.037882   0.025619     1.47867 0.13923
## ar2     -0.061884   0.027627    -2.24001 0.02509
## omega    0.000003   0.000000    16.83959 0.00000
## beta1    0.999000   0.000101 9881.14250 0.00000
## skew     1.068887   0.038390    27.84317 0.00000
## shape    2.419737   0.033012    73.29969 0.00000
##
## LogLikelihood : 3667.818
##
## Information Criteria
## -----
##
## Akaike          -4.2420
## Bayes           -4.2198
## Shibata         -4.2420
## Hannan-Quinn   -4.2338
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##              statistic  p-value
## Lag[1]              9.396 2.174e-03
## Lag[2*(p+q)+(p+q)-1][5] 10.530 1.799e-14
## Lag[4*(p+q)+(p+q)-1][9] 14.777 4.959e-05
## d.o.f=2
```

```

## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##               statistic  p-value
## Lag[1]                59.09 1.51e-14
## Lag[2*(p+q)+(p+q)-1][2]    62.48 0.00e+00
## Lag[4*(p+q)+(p+q)-1][5]    79.11 0.00e+00
## d.o.f=1
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale  P-Value
## ARCH Lag[2]      6.751 0.500 2.000 9.367e-03
## ARCH Lag[4]     20.431 1.397 1.611 9.882e-06
## ARCH Lag[6]     46.568 2.222 1.500 2.042e-12
##
## Nyblom stability test
## -----
## Joint Statistic: 36.3398
## Individual Statistics:
## mu      0.2432
## ar1     0.4119
## ar2     0.2960
## omega   7.0333
## beta1   6.9445
## skew    0.2794
## shape   4.5879
##
## 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          1.037 2.998e-01
## Negative Sign Bias  8.416 8.061e-17 ***
## Positive Sign Bias  5.190 2.357e-07 ***
## Joint Effect       97.780 4.664e-21 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      8.044      0.9862
## 2    30     16.294      0.9720
## 3    40     28.206      0.8997
## 4    50     43.409      0.6984
##
##
## Elapsed time : 1.697006

```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(1,0)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(1,0)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.000930    0.000703   1.3238 0.185583
## ar1     0.083488    0.026361   3.1671 0.001540
## ar2    -0.081537    0.021742  -3.7502 0.000177
## omega   0.000924    0.000145   6.3746 0.000000
## alpha1  0.558086    0.122056   4.5724 0.000005
## skew    1.092280    0.034497  31.6634 0.000000
## shape   2.825290    0.211006  13.3896 0.000000
##
## Robust Standard Errors:
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.000930    0.000788   1.1799 0.238035
## ar1     0.083488    0.027005   3.0916 0.001991
## ar2    -0.081537    0.027129  -3.0055 0.002652
## omega   0.000924    0.000176   5.2422 0.000000
## alpha1  0.558086    0.150909   3.6982 0.000217
## skew    1.092280    0.041804  26.1284 0.000000
## shape   2.825290    0.229188  12.3274 0.000000
##
## LogLikelihood : 3712.902
##
## Information Criteria
## -----
##
## Akaike          -4.2942
## Bayes           -4.2721
## Shibata         -4.2942
## Hannan-Quinn   -4.2860
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##                      statistic p-value
## Lag[1]                2.057  0.1516
## Lag[2*(p+q)+(p+q)-1] [5]  3.569  0.1794
## Lag[4*(p+q)+(p+q)-1] [9]  7.113  0.1176
## d.o.f=2
```



```

## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##               statistic    p-value
## Lag[1]                0.1422 7.061e-01
## Lag[2*(p+q)+(p+q)-1][2]    0.6993 6.070e-01
## Lag[4*(p+q)+(p+q)-1][5]    21.4706 7.625e-06
## d.o.f=1
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale   P-Value
## ARCH Lag[2]      1.112 0.500 2.000 2.917e-01
## ARCH Lag[4]     25.720 1.397 1.611 4.037e-07
## ARCH Lag[6]     34.571 2.222 1.500 4.279e-09
##
## Nyblom stability test
## -----
## Joint Statistic:  9.7862
## Individual Statistics:
## mu      0.3441
## ar1     0.1033
## ar2     0.3947
## omega   4.7227
## alpha1  2.9823
## skew    0.4918
## shape   3.1054
##
## 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      1.869 0.06186  *
## Negative Sign Bias  1.042 0.29746
## Positive Sign Bias  1.098 0.27231
## Joint Effect     3.683 0.29777
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      16.27      0.6391
## 2    30      24.74      0.6916
## 3    40      47.63      0.1618
## 4    50      42.83      0.7202
##
##
## Elapsed time : 1.550998

```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(1,1)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(1,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001478    0.000622   2.3774 0.017433
## ar1      0.078582    0.023730   3.3115 0.000928
## ar2     -0.058648    0.022725  -2.5808 0.009858
## omega    0.000038    0.000015   2.4526 0.014184
## alpha1   0.112180    0.032114   3.4931 0.000477
## beta1    0.863133    0.036793  23.4594 0.000000
## skew     1.146596    0.036483  31.4286 0.000000
## shape    3.711351    0.361108  10.2777 0.000000
##
## Robust Standard Errors:
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001478    0.000642   2.3035 0.021253
## ar1      0.078582    0.023942   3.2821 0.001030
## ar2     -0.058648    0.022224  -2.6390 0.008315
## omega    0.000038    0.000024   1.5958 0.110542
## alpha1   0.112180    0.049732   2.2557 0.024092
## beta1    0.863133    0.060847  14.1852 0.000000
## skew     1.146596    0.037415  30.6450 0.000000
## shape    3.711351    0.365498  10.1542 0.000000
##
## LogLikelihood : 3780.194
##
## Information Criteria
## -----
##
## Akaike          -4.3710
## Bayes           -4.3457
## Shibata         -4.3711
## Hannan-Quinn   -4.3617
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##              statistic p-value
## Lag[1]              3.630 0.05676
## Lag[2*(p+q)+(p+q)-1] [5] 3.839 0.09873
```

```

## Lag[4*(p+q)+(p+q)-1][9]      5.845 0.28261
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##               statistic p-value
## Lag[1]                0.7135 0.3983
## Lag[2*(p+q)+(p+q)-1][5]      1.7019 0.6903
## Lag[4*(p+q)+(p+q)-1][9]      3.8694 0.6110
## d.o.f=2
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale P-Value
## ARCH Lag[3]      0.287 0.500 2.000 0.5921
## ARCH Lag[5]      1.037 1.440 1.667 0.7219
## ARCH Lag[7]      2.827 2.315 1.543 0.5468
##
## Nyblom stability test
## -----
## Joint Statistic: 2.9855
## Individual Statistics:
## mu      0.09051
## ar1     0.09553
## ar2     0.13339
## omega   0.20357
## alpha1  0.59979
## beta1   0.34604
## skew    0.53950
## shape   0.08304
##
## 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      1.47004 0.141734
## Negative Sign Bias 2.89728 0.003812 ***
## Positive Sign Bias 0.08144 0.935103
## Joint Effect    8.47115 0.037215 **
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      14.90      0.72869
## 2    30      27.11      0.56602
## 3    40      38.08      0.51173
## 4    50      62.30      0.09613
##
##

```

```
## Elapsed time : 1.229993
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(2,0)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(2,0)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.000875  0.000683   1.2821 0.199810
## ar1      0.080844  0.025279   3.1981 0.001384
## ar2     -0.056839  0.025182  -2.2571 0.024001
## omega    0.000678  0.000094   7.2239 0.000000
## alpha1   0.407239  0.088810   4.5855 0.000005
## alpha2   0.270127  0.069837   3.8680 0.000110
## skew     1.096863  0.034959  31.3754 0.000000
## shape    3.045918  0.244396  12.4630 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.000875  0.000740   1.1826 0.236960
## ar1      0.080844  0.024169   3.3449 0.000823
## ar2     -0.056839  0.027250  -2.0858 0.036997
## omega    0.000678  0.000104   6.5374 0.000000
## alpha1   0.407239  0.098584   4.1309 0.000036
## alpha2   0.270127  0.070770   3.8169 0.000135
## skew     1.096863  0.040383  27.1614 0.000000
## shape    3.045918  0.249834  12.1918 0.000000
##
## LogLikelihood : 3734.563
##
## Information Criteria
## -----
##
## Akaike          -4.3181
## Bayes           -4.2929
## Shibata         -4.3182
## Hannan-Quinn   -4.3088
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                      statistic p-value
## Lag[1]                2.990 0.08377
```

```

## Lag[2*(p+q)+(p+q)-1][5]      3.354 0.27119
## Lag[4*(p+q)+(p+q)-1][9]      6.255 0.21723
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##               statistic p-value
## Lag[1]                0.02933 0.8640
## Lag[2*(p+q)+(p+q)-1][5]    1.23632 0.8043
## Lag[4*(p+q)+(p+q)-1][9]    8.49526 0.1029
## d.o.f=2
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale P-Value
## ARCH Lag[3]    0.5651 0.500 2.000 0.45223
## ARCH Lag[5]    1.8779 1.440 1.667 0.49886
## ARCH Lag[7]    6.8677 2.315 1.543 0.09272
##
## Nyblom stability test
## -----
## Joint Statistic: 7.4833
## Individual Statistics:
## mu      0.27124
## ar1     0.06662
## ar2     0.15560
## omega   3.02916
## alpha1  2.61515
## alpha2  1.56947
## skew    0.54649
## shape   1.85533
##
## 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      1.6124 0.1071
## Negative Sign Bias 1.0484 0.2946
## Positive Sign Bias 0.7389 0.4601
## Joint Effect    2.7688 0.4287
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      10.01      0.9526
## 2    30      17.58      0.9524
## 3    40      33.86      0.7030
## 4    50      37.96      0.8735
##

```

```
##
```

```
## Elapsed time : 1.710991
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(0,2)),mean.model =list(armaOrder=c(2  
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)  
my_model_Ibhf
```

```
##
```

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

```
## *          GARCH Model Fit          *
```

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

```
##
```

```
## Conditional Variance Dynamics
```

```
## -----
```

```
## GARCH Model   : sGARCH(0,2)
```

```
## Mean Model    : ARFIMA(2,0,0)
```

```
## Distribution   : sstd
```

```
##
```

```
## Optimal Parameters
```

```
## -----
```

```
##      Estimate Std. Error   t value Pr(>|t|)
```

```
## mu      0.000810  0.000793   1.020563 0.307462
```

```
## ar1     0.038674  0.020978   1.843567 0.065246
```

```
## ar2    -0.060987  0.020699  -2.946360 0.003215
```

```
## omega   0.000004  0.000000  20.836023 0.000000
```

```
## beta1   0.000033  0.000446   0.074037 0.940981
```

```
## beta2   0.998967  0.000117 8552.019111 0.000000
```

```
## skew    1.071637  0.033210  32.268263 0.000000
```

```
## shape   2.399407  0.062867  38.166111 0.000000
```

```
##
```

```
## Robust Standard Errors:
```

```
##      Estimate Std. Error   t value Pr(>|t|)
```

```
## mu      0.000810  0.000877   0.92312 0.355946
```

```
## ar1     0.038674  0.025687   1.50557 0.132177
```

```
## ar2    -0.060987  0.027316  -2.23265 0.025572
```

```
## omega   0.000004  0.000000  11.72830 0.000000
```

```
## beta1   0.000033  0.000816   0.04053 0.967671
```

```
## beta2   0.998967  0.000142 7049.41290 0.000000
```

```
## skew    1.071637  0.038105  28.12360 0.000000
```

```
## shape   2.399407  0.113344  21.16931 0.000000
```

```
##
```

```
## LogLikelihood : 3672.526
```

```
##
```

```
## Information Criteria
```

```
## -----
```

```
##
```

```
## Akaike      -4.2463
```

```
## Bayes      -4.2210
```

```
## Shibata    -4.2463
```

```
## Hannan-Quinn -4.2369
```

```
##
```

```
## Weighted Ljung-Box Test on Standardized Residuals
```

```
## -----
```

```
##              statistic    p-value
```

```

## Lag[1] 9.164 2.468e-03
## Lag[2*(p+q)+(p+q)-1][5] 10.181 1.213e-13
## Lag[4*(p+q)+(p+q)-1][9] 14.113 1.081e-04
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
## statistic p-value
## Lag[1] 57.49 3.397e-14
## Lag[2*(p+q)+(p+q)-1][5] 76.80 0.000e+00
## Lag[4*(p+q)+(p+q)-1][9] 117.21 0.000e+00
## d.o.f=2
##
## Weighted ARCH LM Tests
## -----
## Statistic Shape Scale P-Value
## ARCH Lag[3] 14.94 0.500 2.000 1.113e-04
## ARCH Lag[5] 28.22 1.440 1.667 1.781e-07
## ARCH Lag[7] 66.22 2.315 1.543 0.000e+00
##
## Nyblom stability test
## -----
## Joint Statistic: 36.4137
## Individual Statistics:
## mu 0.2257
## ar1 0.4085
## ar2 0.2991
## omega 7.1976
## beta1 6.1269
## beta2 6.1251
## skew 0.2639
## shape 4.0902
##
## 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 1.055 2.918e-01
## Negative Sign Bias 8.393 9.725e-17 ***
## Positive Sign Bias 5.133 3.181e-07 ***
## Joint Effect 96.805 7.556e-21 ***
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
## group statistic p-value(g-1)
## 1 20 8.322 0.9831
## 2 30 14.139 0.9907
## 3 40 28.809 0.8841
## 4 50 40.570 0.7989

```

```
##
##
## Elapsed time : 1.49299
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(2,2)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(2,2)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001527    0.000622   2.45424 0.014118
## ar1     0.084888    0.024305   3.49264 0.000478
## ar2    -0.059482    0.021516  -2.76455 0.005700
## omega   0.000052    0.000024   2.16371 0.030487
## alpha1  0.153469    0.040707   3.77006 0.000163
## alpha2  0.009711    0.046847   0.20729 0.835780
## beta1   0.102440    0.155474   0.65889 0.509966
## beta2   0.698308    0.129679   5.38491 0.000000
## skew    1.150844    0.036863  31.21990 0.000000
## shape   3.796226    0.377508  10.05602 0.000000
##
## Robust Standard Errors:
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001527    0.000642   2.37809 0.017402
## ar1     0.084888    0.024803   3.42246 0.000621
## ar2    -0.059482    0.022234  -2.67524 0.007467
## omega   0.000052    0.000040   1.30621 0.191479
## alpha1  0.153469    0.056251   2.72829 0.006366
## alpha2  0.009711    0.063464   0.15302 0.878385
## beta1   0.102440    0.211230   0.48497 0.627696
## beta2   0.698308    0.169758   4.11356 0.000039
## skew    1.150844    0.038191  30.13419 0.000000
## shape   3.796226    0.383279   9.90460 0.000000
##
## LogLikelihood : 3783.868
##
## Information Criteria
## -----
##
## Akaike          -4.3730
## Bayes           -4.3414
## Shibata         -4.3730
```



```

## Hannan-Quinn -4.3613
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##               statistic p-value
## Lag[1]                2.745 0.09757
## Lag[2*(p+q)+(p+q)-1][5] 3.040 0.44696
## Lag[4*(p+q)+(p+q)-1][9] 5.434 0.36028
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##               statistic p-value
## Lag[1]                0.1455 0.7029
## Lag[2*(p+q)+(p+q)-1][11] 4.2611 0.6936
## Lag[4*(p+q)+(p+q)-1][19] 6.7017 0.8124
## d.o.f=4
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale P-Value
## ARCH Lag[5] 0.08302 0.500 2.000 0.7732
## ARCH Lag[7] 4.60559 1.473 1.746 0.1475
## ARCH Lag[9] 5.99632 2.402 1.619 0.1757
##
## Nyblom stability test
## -----
## Joint Statistic: 4.4199
## Individual Statistics:
## mu      0.10056
## ar1     0.09808
## ar2     0.11824
## omega   0.16804
## alpha1  0.55518
## alpha2  0.29977
## beta1   0.29620
## beta2   0.24209
## skew    0.48054
## shape   0.08948
##
## 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      1.4793 0.139230
## Negative Sign Bias 2.6517 0.008082 ***
## Positive Sign Bias 0.5126 0.608267
## Joint Effect    7.3167 0.062459  *
##
##

```

```
## Adjusted Pearson Goodness-of-Fit Test:
```

```
## -----
```

```
##   group statistic p-value(g-1)
```

```
## 1    20      15.07      0.7184
```

```
## 2    30      23.84      0.7369
```

```
## 3    40      34.00      0.6970
```

```
## 4    50      42.31      0.7393
```

```
##
```

```
##
```

```
## Elapsed time : 1.626997
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(1,2)),mean.model =list(armaOrder=c(2
```

```
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
```

```
my_model_Ibhf
```

```
##
```

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

```
## *          GARCH Model Fit          *
```

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

```
##
```

```
## Conditional Variance Dynamics
```

```
## -----
```

```
## GARCH Model   : sGARCH(1,2)
```

```
## Mean Model    : ARFIMA(2,0,0)
```

```
## Distribution   : sstd
```

```
##
```

```
## Optimal Parameters
```

```
## -----
```

```
##      Estimate  Std. Error  t value Pr(>|t|)
```

```
## mu      0.001525   0.000622   2.4492 0.014316
```

```
## ar1     0.084687   0.024316   3.4828 0.000496
```

```
## ar2    -0.059388   0.021413  -2.7734 0.005547
```

```
## omega   0.000049   0.000019   2.5439 0.010963
```

```
## alpha1  0.155235   0.039975   3.8833 0.000103
```

```
## beta1   0.132330   0.096293   1.3742 0.169365
```

```
## beta2   0.678010   0.107461   6.3093 0.000000
```

```
## skew    1.150933   0.036846  31.2363 0.000000
```

```
## shape   3.799033   0.377991  10.0506 0.000000
```

```
##
```

```
## Robust Standard Errors:
```

```
##      Estimate  Std. Error  t value Pr(>|t|)
```

```
## mu      0.001525   0.000643   2.3723 0.017677
```

```
## ar1     0.084687   0.024573   3.4464 0.000568
```

```
## ar2    -0.059388   0.022222  -2.6724 0.007530
```

```
## omega   0.000049   0.000029   1.7200 0.085435
```

```
## alpha1  0.155235   0.060550   2.5637 0.010356
```

```
## beta1   0.132330   0.117707   1.1242 0.260917
```

```
## beta2   0.678010   0.159830   4.2421 0.000022
```

```
## skew    1.150933   0.038088  30.2175 0.000000
```

```
## shape   3.799033   0.386256   9.8355 0.000000
```

```
##
```

```
## LogLikelihood : 3783.848
```

```
##
```

```
## Information Criteria
```

```

## -----
##
## Akaike          -4.3741
## Bayes           -4.3457
## Shibata         -4.3742
## Hannan-Quinn   -4.3636
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##                statistic p-value
## Lag[1]          2.782 0.09533
## Lag[2*(p+q)+(p+q)-1] [5] 3.077 0.42409
## Lag[4*(p+q)+(p+q)-1] [9] 5.482 0.35049
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##                statistic p-value
## Lag[1]          0.1275 0.7210
## Lag[2*(p+q)+(p+q)-1] [8] 2.5216 0.7721
## Lag[4*(p+q)+(p+q)-1] [14] 5.2201 0.7418
## d.o.f=3
##
## Weighted ARCH LM Tests
## -----
##          Statistic Shape Scale P-Value
## ARCH Lag[4] 0.09077 0.500 2.000 0.7632
## ARCH Lag[6] 2.66116 1.461 1.711 0.3618
## ARCH Lag[8] 4.44764 2.368 1.583 0.3136
##
## Nyblom stability test
## -----
## Joint Statistic: 3.1329
## Individual Statistics:
## mu      0.09982
## ar1     0.10035
## ar2     0.11962
## omega   0.16232
## alpha1  0.53027
## beta1   0.26809
## beta2   0.23248
## skew    0.47471
## shape   0.09024
##
## 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        1.4977 0.134404
## Negative Sign Bias 2.6562 0.007975 ***

```

```
## Positive Sign Bias 0.5418 0.588008
## Joint Effect      7.3726 0.060924  *
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      15.55      0.6869
## 2    30      21.72      0.8317
## 3    40      33.95      0.6990
## 4    50      39.01      0.8459
##
##
## Elapsed time : 1.369995
```

```
spec_of_garch_Ibhf<- ugarchspec(variance.model = list(garchOrder=c(2,1)),mean.model =list(armaOrder=c(2
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : sGARCH(2,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate Std. Error  t value Pr(>|t|)
## mu      0.001479  0.000630  2.347516 0.018899
## ar1      0.078593  0.023772  3.306047 0.000946
## ar2     -0.058649  0.022726 -2.580718 0.009859
## omega    0.000038  0.000024  1.556688 0.119545
## alpha1   0.112187  0.034638  3.238871 0.001200
## alpha2   0.000000  0.060685  0.000001 1.000000
## beta1    0.863136  0.063723 13.545195 0.000000
## skew     1.146631  0.036558 31.364614 0.000000
## shape    3.710569  0.411244  9.022781 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error  t value Pr(>|t|)
## mu      0.001479  0.000666  2.22161 0.026310
## ar1      0.078593  0.023813  3.30042 0.000965
## ar2     -0.058649  0.022183 -2.64382 0.008198
## omega    0.000038  0.000055  0.68562 0.492954
## alpha1   0.112187  0.035410  3.16826 0.001534
## alpha2   0.000000  0.114209  0.00000 1.000000
## beta1    0.863136  0.149943  5.75644 0.000000
## skew     1.146631  0.037314 30.72912 0.000000
## shape    3.710569  0.568399  6.52810 0.000000
```

```

##
## LogLikelihood : 3780.194
##
## Information Criteria
## -----
##
## Akaike      -4.3699
## Bayes      -4.3414
## Shibata    -4.3699
## Hannan-Quinn -4.3593
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                statistic p-value
## Lag[1]                3.628 0.05680
## Lag[2*(p+q)+(p+q)-1] [5] 3.838 0.09903
## Lag[4*(p+q)+(p+q)-1] [9] 5.844 0.28282
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]                0.7139 0.3982
## Lag[2*(p+q)+(p+q)-1] [8] 3.2430 0.6409
## Lag[4*(p+q)+(p+q)-1] [14] 5.9339 0.6477
## d.o.f=3
##
## Weighted ARCH LM Tests
## -----
##
##                Statistic Shape Scale P-Value
## ARCH Lag[4]      0.7843 0.500 2.000 0.3758
## ARCH Lag[6]      2.4251 1.461 1.711 0.4041
## ARCH Lag[8]      3.7462 2.368 1.583 0.4142
##
## Nyblom stability test
## -----
## Joint Statistic: 4.414
## Individual Statistics:
## mu      0.09039
## ar1     0.09541
## ar2     0.13339
## omega   0.20395
## alpha1  0.59992
## alpha2  0.74035
## beta1   0.34637
## skew    0.53917
## shape   0.08312
##
## 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      1.47003 0.141737
## Negative Sign Bias 2.89759 0.003808 ***
## Positive Sign Bias 0.08116 0.935323
## Joint Effect    8.47286 0.037186 **
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      14.90      0.72869
## 2    30      27.11      0.56602
## 3    40      38.08      0.51173
## 4    50      63.05      0.08558
##
##
## Elapsed time : 1.307997
```

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="eGARCH",garchOrder=c(1,1)),mean.model = list
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : eGARCH(1,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001113   0.000691   1.6104 0.107312
## ar1      0.071473   0.025020   2.8567 0.004281
## ar2     -0.064705   0.022594  -2.8638 0.004185
## omega   -0.114240   0.013041  -8.7598 0.000000
## alpha1  -0.058238   0.016184  -3.5984 0.000320
## beta1    0.983717   0.001829 537.9391 0.000000
## gamma1   0.154018   0.030718   5.0139 0.000001
## skew     1.136959   0.036898  30.8136 0.000000
## shape    3.813267   0.379349  10.0521 0.000000
##
## Robust Standard Errors:
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001113   0.000845   1.3179 0.187527
## ar1      0.071473   0.028885   2.4744 0.013347
## ar2     -0.064705   0.023418  -2.7631 0.005726
## omega   -0.114240   0.005671 -20.1434 0.000000
## alpha1  -0.058238   0.020330  -2.8646 0.004175
```

```

## beta1    0.983717    0.000702 1400.6722 0.000000
## gamma1   0.154018    0.038399   4.0110 0.000060
## skew     1.136959    0.039907  28.4904 0.000000
## shape    3.813267    0.382342   9.9734 0.000000
##
## LogLikelihood : 3782.215
##
## Information Criteria
## -----
##
## Akaike          -4.3722
## Bayes           -4.3438
## Shibata         -4.3723
## Hannan-Quinn   -4.3617
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                statistic  p-value
## Lag[1]                5.090 0.0240635
## Lag[2*(p+q)+(p+q)-1][5] 5.351 0.0009535
## Lag[4*(p+q)+(p+q)-1][9] 7.426 0.0922214
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]                5.763 0.01637
## Lag[2*(p+q)+(p+q)-1][5] 6.291 0.07678
## Lag[4*(p+q)+(p+q)-1][9] 8.035 0.12686
## d.o.f=2
##
## Weighted ARCH LM Tests
## -----
##
##      Statistic Shape Scale P-Value
## ARCH Lag[3]    0.2783 0.500 2.000 0.5978
## ARCH Lag[5]    0.9309 1.440 1.667 0.7536
## ARCH Lag[7]    2.2952 2.315 1.543 0.6550
##
## Nyblom stability test
## -----
## Joint Statistic: 3.1446
## Individual Statistics:
## mu      0.03751
## ar1     0.12979
## ar2     0.15495
## omega   0.21612
## alpha1  0.63860
## beta1   0.19054
## gamma1  0.16817
## skew    0.39736
## shape   0.21785
##
## 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          1.277 0.20185
## Negative Sign Bias  2.662 0.00783 ***
## Positive Sign Bias  1.514 0.13019
## Joint Effect       10.599 0.01410 **
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      21.14      0.3292
## 2    30      34.65      0.2163
## 3    40      38.54      0.4906
## 4    50      58.70      0.1614
##
##
## Elapsed time : 2.056005
```

this model is rejected since there is no leverage effect.

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(1,1)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : gjrGARCH(1,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001128    0.000615   1.8344 0.066591
## ar1      0.072700    0.023257   3.1260 0.001772
## ar2     -0.063966    0.022349  -2.8622 0.004207
## omega    0.000031    0.000013   2.3563 0.018459
## alpha1   0.055090    0.025378   2.1708 0.029949
## beta1    0.881337    0.035789  24.6257 0.000000
## gamma1   0.088309    0.032357   2.7292 0.006349
## skew     1.139250    0.035895  31.7381 0.000000
## shape    3.802084    0.378112  10.0554 0.000000
##
```



```

## Robust Standard Errors:
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.001128  0.000664   1.6997 0.089193
## ar1      0.072700  0.023696   3.0681 0.002154
## ar2     -0.063966  0.022397  -2.8561 0.004289
## omega    0.000031  0.000020   1.5732 0.115675
## alpha1   0.055090  0.035473   1.5530 0.120425
## beta1    0.881337  0.057729  15.2668 0.000000
## gamma1   0.088309  0.045111   1.9576 0.050281
## skew     1.139250  0.036522  31.1938 0.000000
## shape    3.802084  0.377641  10.0680 0.000000
##
## LogLikelihood : 3785.318
##
## Information Criteria
## -----
##
## Akaike          -4.3758
## Bayes           -4.3474
## Shibata         -4.3759
## Hannan-Quinn   -4.3653
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##              statistic p-value
## Lag[1]              4.434 0.035223
## Lag[2*(p+q)+(p+q)-1] [5] 4.771 0.007087
## Lag[4*(p+q)+(p+q)-1] [9] 6.774 0.151230
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##              statistic p-value
## Lag[1]              1.155 0.2826
## Lag[2*(p+q)+(p+q)-1] [5] 1.922 0.6369
## Lag[4*(p+q)+(p+q)-1] [9] 3.549 0.6659
## d.o.f=2
##
## Weighted ARCH LM Tests
## -----
##
##      Statistic Shape Scale P-Value
## ARCH Lag[3]    0.06199 0.500 2.000 0.8034
## ARCH Lag[5]    0.88827 1.440 1.667 0.7664
## ARCH Lag[7]    1.83488 2.315 1.543 0.7522
##
## Nyblom stability test
## -----
## Joint Statistic: 2.999
## Individual Statistics:
## mu      0.06350
## ar1     0.10567
## ar2     0.14288
## omega   0.14136

```

```
## alpha1 0.24330
## beta1 0.20776
## gamma1 0.59706
## skew 0.42940
## shape 0.08892
##
## 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      1.2075 0.22739
## Negative Sign Bias 2.1272 0.03355 **
## Positive Sign Bias 0.5657 0.57168
## Joint Effect      5.3906 0.14533
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      19.79      0.4071
## 2    30      38.23      0.1173
## 3    40      35.71      0.6205
## 4    50      45.49      0.6160
##
##
## Elapsed time : 2.941003
```

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(1,2)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : gjrGARCH(1,2)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.001176  0.000614   1.9140 0.055619
## ar1      0.074666  0.023715   3.1484 0.001642
## ar2     -0.062259  0.021289  -2.9245 0.003450
## omega    0.000046  0.000016   2.7952 0.005186
## alpha1   0.081039  0.030579   2.6502 0.008045
## beta1    0.132748  0.089503   1.4832 0.138028
```

```

## beta2    0.688527    0.095885    7.1808 0.000000
## gamma1   0.135229    0.046149    2.9303 0.003386
## skew     1.145098    0.036294   31.5507 0.000000
## shape    3.886072    0.393244    9.8821 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.001176   0.000667   1.7630 0.077899
## ar1     0.074666   0.023527   3.1737 0.001505
## ar2    -0.062259   0.021840  -2.8506 0.004363
## omega   0.000046   0.000020   2.2558 0.024083
## alpha1  0.081039   0.033495   2.4194 0.015546
## beta1   0.132748   0.096597   1.3742 0.169364
## beta2   0.688527   0.117267   5.8715 0.000000
## gamma1  0.135229   0.062732   2.1557 0.031110
## skew    1.145098   0.037356  30.6539 0.000000
## shape   3.886072   0.388444  10.0042 0.000000
##
## LogLikelihood : 3789.341
##
## Information Criteria
## -----
##
## Akaike          -4.3793
## Bayes           -4.3477
## Shibata         -4.3794
## Hannan-Quinn   -4.3676
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                statistic p-value
## Lag[1]                3.967 0.04639
## Lag[2*(p+q)+(p+q)-1] [5]    4.305 0.02934
## Lag[4*(p+q)+(p+q)-1] [9]    6.643 0.16620
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]                0.240 0.6242
## Lag[2*(p+q)+(p+q)-1] [8]    1.677 0.9052
## Lag[4*(p+q)+(p+q)-1] [14]   5.167 0.7485
## d.o.f=3
##
## Weighted ARCH LM Tests
## -----
##
##      Statistic Shape Scale P-Value
## ARCH Lag[4]    0.3792 0.500 2.000 0.5381
## ARCH Lag[6]    0.9852 1.461 1.711 0.7520
## ARCH Lag[8]    3.0087 2.368 1.583 0.5418
##
## Nyblom stability test
## -----

```

```
## Joint Statistic: 3.2005
## Individual Statistics:
## mu      0.07537
## ar1     0.11418
## ar2     0.14029
## omega   0.13357
## alpha1  0.22450
## beta1   0.18048
## beta2   0.15467
## gamma1  0.56775
## skew    0.41779
## shape   0.09810
##
## 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      1.2852 0.1989
## Negative Sign Bias 1.6418 0.1008
## Positive Sign Bias 0.1031 0.9179
## Joint Effect    3.3820 0.3364
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      19.82      0.4057
## 2    30      31.90      0.3242
## 3    40      36.64      0.5779
## 4    50      48.91      0.4766
##
##
## Elapsed time : 2.927001
```

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(2,1)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : gjrGARCH(2,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
```

```

##      Estimate Std. Error  t value Pr(>|t|)
## mu      0.001068   0.000613   1.742203 0.081473
## ar1      0.063206   0.023614   2.676567 0.007438
## ar2     -0.064073   0.021659  -2.958298 0.003093
## omega    0.000017   0.000004   3.862489 0.000112
## alpha1   0.028375   0.023074   1.229725 0.218800
## alpha2   0.000000   0.024914   0.000002 0.999999
## beta1    0.930930   0.012259  75.939441 0.000000
## gamma1   0.247948   0.082573   3.002765 0.002675
## gamma2  -0.189105   0.079559  -2.376913 0.017458
## skew     1.142575   0.036207  31.556739 0.000000
## shape    3.896390   0.383587  10.157776 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error  t value Pr(>|t|)
## mu      0.001068   0.000695   1.535811 0.124585
## ar1      0.063206   0.023126   2.733056 0.006275
## ar2     -0.064073   0.021846  -2.932958 0.003357
## omega    0.000017   0.000006   2.638972 0.008316
## alpha1   0.028375   0.021355   1.328736 0.183935
## alpha2   0.000000   0.028990   0.000001 0.999999
## beta1    0.930930   0.011512  80.867362 0.000000
## gamma1   0.247948   0.090199   2.748889 0.005980
## gamma2  -0.189105   0.084132  -2.247702 0.024595
## skew     1.142575   0.036935  30.934405 0.000000
## shape    3.896390   0.401058   9.715279 0.000000
##
## LogLikelihood : 3788.295
##
## Information Criteria
## -----
##
## Akaike          -4.3769
## Bayes           -4.3422
## Shibata         -4.3770
## Hannan-Quinn   -4.3641
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##              statistic  p-value
## Lag[1]                6.348 1.175e-02
## Lag[2*(p+q)+(p+q)-1] [5] 6.734 3.473e-06
## Lag[4*(p+q)+(p+q)-1] [9] 8.635 3.326e-02
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##              statistic  p-value
## Lag[1]                1.909 0.1670
## Lag[2*(p+q)+(p+q)-1] [8] 3.395 0.6131
## Lag[4*(p+q)+(p+q)-1] [14] 6.036 0.6339
## d.o.f=3
##

```

```

## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale P-Value
## ARCH Lag[4]    0.6678 0.500 2.000  0.4138
## ARCH Lag[6]    1.2966 1.461 1.711  0.6646
## ARCH Lag[8]    2.5757 2.368 1.583  0.6254
##
## Nyblom stability test
## -----
## Joint Statistic:  6.285
## Individual Statistics:
## mu      0.07951
## ar1     0.11005
## ar2     0.18933
## omega   0.61938
## alpha1  0.12178
## alpha2  0.14502
## beta1   0.11808
## gamma1  0.31942
## gamma2  0.27047
## skew    0.38894
## shape   0.11086
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:      2.49 2.75 3.27
## Individual Statistic:  0.35 0.47 0.75
##
## Sign Bias Test
## -----
##           t-value   prob sig
## Sign Bias      1.458 0.14513
## Negative Sign Bias  1.398 0.16216
## Positive Sign Bias  1.174 0.24047
## Joint Effect      6.647 0.08404  *
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      20.91      0.3420
## 2    30      32.11      0.3150
## 3    40      40.12      0.4204
## 4    50      56.21      0.2229
##
##
## Elapsed time : 4.289004

spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(2,2)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf

##
## *-----*
## *           GARCH Model Fit           *

```

```

## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model : gjrGARCH(2,2)
## Mean Model : ARFIMA(2,0,0)
## Distribution : sstd
##
## Optimal Parameters
## -----
##      Estimate Std. Error  t value Pr(>|t|)
## mu      0.001198   0.000615   1.947896 0.051427
## ar1      0.080032   0.023894   3.349518 0.000810
## ar2     -0.064973   0.021383  -3.038545 0.002377
## omega    0.000050   0.000022   2.289569 0.022046
## alpha1   0.086544   0.031143   2.778957 0.005453
## alpha2   0.000000   0.033103   0.000001 0.999999
## beta1    0.023486   0.076991   0.305043 0.760333
## beta2    0.779441   0.069364  11.236920 0.000000
## gamma1   0.093383   0.046147   2.023621 0.043009
## gamma2   0.061723   0.041724   1.479310 0.139057
## skew     1.144768   0.036412  31.438966 0.000000
## shape    3.906202   0.405303   9.637741 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error  t value Pr(>|t|)
## mu      0.001198   0.000668   1.794561 0.072724
## ar1      0.080032   0.024471   3.270554 0.001073
## ar2     -0.064973   0.021941  -2.961306 0.003063
## omega    0.000050   0.000034   1.479695 0.138955
## alpha1   0.086544   0.038282   2.260673 0.023780
## alpha2   0.000000   0.045678   0.000001 0.999999
## beta1    0.023486   0.094216   0.249274 0.803149
## beta2    0.779441   0.077534  10.052887 0.000000
## gamma1   0.093383   0.058930   1.584656 0.113045
## gamma2   0.061723   0.051062   1.208780 0.226747
## skew     1.144768   0.037602  30.444167 0.000000
## shape    3.906202   0.406742   9.603639 0.000000
##
## LogLikelihood : 3790.081
##
## Information Criteria
## -----
##
## Akaike      -4.3778
## Bayes       -4.3399
## Shibata     -4.3779
## Hannan-Quinn -4.3638
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##                                statistic p-value
## Lag[1]                                3.203 0.07352
## Lag[2*(p+q)+(p+q)-1] [5]          3.662 0.14734

```

```

## Lag[4*(p+q)+(p+q)-1][9]      6.113 0.23846
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##               statistic p-value
## Lag[1]                0.2491 0.6177
## Lag[2*(p+q)+(p+q)-1][11]    3.3787 0.8211
## Lag[4*(p+q)+(p+q)-1][19]    5.8503 0.8853
## d.o.f=4
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale P-Value
## ARCH Lag[5]    0.01706 0.500 2.000 0.8961
## ARCH Lag[7]    2.70624 1.473 1.746 0.3673
## ARCH Lag[9]    4.62861 2.402 1.619 0.3115
##
## Nyblom stability test
## -----
## Joint Statistic: 4.4235
## Individual Statistics:
## mu      0.07253
## ar1      0.09682
## ar2      0.13138
## omega    0.13805
## alpha1   0.21120
## alpha2   0.20130
## beta1    0.24254
## beta2    0.15807
## gamma1   0.44652
## gamma2   0.59091
## skew     0.40483
## shape    0.10190
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:      2.69 2.96 3.51
## Individual Statistic: 0.35 0.47 0.75
##
## Sign Bias Test
## -----
##               t-value   prob sig
## Sign Bias      1.21520 0.22445
## Negative Sign Bias 1.98547 0.04725 **
## Positive Sign Bias 0.06256 0.95013
## Joint Effect    4.20879 0.23978
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      18.33      0.5003
## 2    30      29.54      0.4373

```



```
## 3      40      38.73      0.4822
## 4      50      43.76      0.6850
##
##
## Elapsed time : 5.736991
```

sGARCH(0,2) Akaike -4.5795 sstd sGARCH(2,0) Akaike -4.6343 sstd sGARCH(2,1) Akaike -4.6599 sstd
sGARCH(2,2) Akaike -4.6650 sstd sGARCH(1,1) Akaike -4.6611 sstd sGARCH(1,2) Akaike -4.6657 sstd
gjrGARCH(2,1) Akaike -4.6685 sstd gjrGARCH(1,1) Akaike -4.6703 sstd gjrGARCH(1,2) Akaike -4.6730
sstd gjrGARCH(2,2) Akaike -4.6742 sstd

so we are taking (1,2) instead of (2,2) because many terme in it are not significant

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(1,3)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : gjrGARCH(1,3)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.001159  0.000614  1.88807 0.059016
## ar1     0.074602  0.023815  3.13264 0.001732
## ar2    -0.061624  0.021287 -2.89498 0.003792
## omega   0.000046  0.000017  2.75637 0.005845
## alpha1  0.080863  0.030367  2.66290 0.007747
## beta1   0.102887  0.139850  0.73570 0.461914
## beta2   0.678787  0.114138  5.94708 0.000000
## beta3   0.037753  0.150791  0.25037 0.802305
## gamma1  0.136979  0.048811  2.80630 0.005011
## skew    1.144234  0.036187 31.61988 0.000000
## shape   3.904269  0.394161  9.90527 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.001159  0.000671  1.72762 0.084055
## ar1     0.074602  0.024063  3.10025 0.001934
## ar2    -0.061624  0.022186 -2.77764 0.005475
## omega   0.000046  0.000020  2.29470 0.021750
## alpha1  0.080863  0.032649  2.47677 0.013258
## beta1   0.102887  0.115176  0.89331 0.371694
## beta2   0.678787  0.145501  4.66519 0.000003
## beta3   0.037753  0.150416  0.25099 0.801822
## gamma1  0.136979  0.065939  2.07736 0.037768
```

```

## skew      1.144234      0.037312 30.66685 0.000000
## shape     3.904269      0.393285  9.92732 0.000000
##
## LogLikelihood : 3789.087
##
## Information Criteria
## -----
##
## Akaike      -4.3779
## Bayes      -4.3431
## Shibata    -4.3779
## Hannan-Quinn -4.3650
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##                statistic p-value
## Lag[1]                4.028 0.04475
## Lag[2*(p+q)+(p+q)-1][5] 4.356 0.02534
## Lag[4*(p+q)+(p+q)-1][9] 6.702 0.15933
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##                statistic p-value
## Lag[1]                0.2255 0.6349
## Lag[2*(p+q)+(p+q)-1][11] 3.6837 0.7790
## Lag[4*(p+q)+(p+q)-1][19] 6.7316 0.8096
## d.o.f=4
##
## Weighted ARCH LM Tests
## -----
##
##                Statistic Shape Scale P-Value
## ARCH Lag[5]      0.06196 0.500 2.000 0.8034
## ARCH Lag[7]      2.36803 1.473 1.746 0.4283
## ARCH Lag[9]      5.38132 2.402 1.619 0.2287
##
## Nyblom stability test
## -----
## Joint Statistic: 4.3258
## Individual Statistics:
## mu      0.07563
## ar1     0.11648
## ar2     0.14344
## omega   0.13431
## alpha1  0.22036
## beta1   0.16966
## beta2   0.14923
## beta3   0.17200
## gamma1  0.57598
## skew    0.40381
## shape   0.10360
##
## Asymptotic Critical Values (10% 5% 1%)

```

```
## Joint Statistic:          2.49 2.75 3.27
## Individual Statistic:    0.35 0.47 0.75
##
## Sign Bias Test
## -----
##              t-value    prob sig
## Sign Bias      1.29583 0.19521
## Negative Sign Bias 1.65051 0.09902 *
## Positive Sign Bias 0.08869 0.92934
## Joint Effect      3.40964 0.33267
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      18.47      0.4911
## 2    30      29.50      0.4391
## 3    40      36.97      0.5630
## 4    50      51.23      0.3862
##
##
## Elapsed time : 3.334995
```

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(3,1)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : gjrGARCH(3,1)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.001046  0.000691  1.51348 0.130159
## ar1      0.063812  0.023893  2.67068 0.007570
## ar2     -0.065384  0.022169 -2.94936 0.003184
## omega    0.000015  0.000011  1.39766 0.162216
## alpha1   0.026395  0.023150  1.14013 0.254232
## alpha2   0.000000  0.043886  0.00000 1.000000
## alpha3   0.000000  0.050487  0.00000 1.000000
## beta1    0.935615  0.012027 77.79049 0.000000
## gamma1   0.239626  0.081890  2.92618 0.003432
## gamma2  -0.154367  0.119950 -1.28692 0.198121
## gamma3  -0.030364  0.091030 -0.33356 0.738710
## skew     1.141148  0.037868 30.13527 0.000000
## shape    3.923325  0.445494  8.80668 0.000000
```

```

##
## Robust Standard Errors:
##      Estimate   Std. Error   t value Pr(>|t|)
## mu      0.001046    0.002239   0.467084 0.640440
## ar1     0.063812    0.028813   2.214686 0.026782
## ar2    -0.065384    0.023088  -2.831986 0.004626
## omega   0.000015    0.000068   0.225717 0.821421
## alpha1  0.026395    0.039604   0.666467 0.505113
## alpha2  0.000000    0.053154   0.000000 1.000000
## alpha3  0.000000    0.217890   0.000000 1.000000
## beta1   0.935615    0.040410  23.153051 0.000000
## gamma1  0.239626    0.113748   2.106648 0.035148
## gamma2 -0.154367    0.310395  -0.497323 0.618961
## gamma3 -0.030364    0.380587  -0.079782 0.936411
## skew    1.141148    0.082483  13.834942 0.000000
## shape   3.923325    1.549805   2.531496 0.011358
##
## LogLikelihood : 3788.104
##
## Information Criteria
## -----
##
## Akaike      -4.3744
## Bayes       -4.3333
## Shibata     -4.3745
## Hannan-Quinn -4.3592
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##              statistic   p-value
## Lag[1]                6.365 1.164e-02
## Lag[2*(p+q)+(p+q)-1] [5]    6.808 2.508e-06
## Lag[4*(p+q)+(p+q)-1] [9]    8.690 3.165e-02
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##              statistic   p-value
## Lag[1]                2.103 0.1470
## Lag[2*(p+q)+(p+q)-1] [11]    5.176 0.5540
## Lag[4*(p+q)+(p+q)-1] [19]    7.533 0.7274
## d.o.f=4
##
## Weighted ARCH LM Tests
## -----
##
##      Statistic Shape Scale P-Value
## ARCH Lag[5]    0.5109 0.500 2.000 0.4748
## ARCH Lag[7]    1.7354 1.473 1.746 0.5647
## ARCH Lag[9]    3.8659 2.402 1.619 0.4177
##
## Nyblom stability test
## -----
## Joint Statistic: 10.294

```

```
## Individual Statistics:
## mu      0.08077
## ar1     0.10491
## ar2     0.19377
## omega   1.12666
## alpha1  0.11537
## alpha2  0.13699
## alpha3  0.17216
## beta1   0.11160
## gamma1  0.30548
## gamma2  0.25790
## gamma3  0.26878
## skew    0.38307
## shape   0.12168
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:      2.89 3.15 3.69
## Individual Statistic: 0.35 0.47 0.75
##
## Sign Bias Test
## -----
##              t-value   prob sig
## Sign Bias      1.405 0.16025
## Negative Sign Bias 1.450 0.14719
## Positive Sign Bias 1.264 0.20657
## Joint Effect      6.857 0.07659  *
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      22.34      0.2675
## 2    30      30.51      0.3888
## 3    40      43.64      0.2807
## 4    50      58.59      0.1640
##
##
## Elapsed time : 5.733994
```

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(2,3)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : gjrGARCH(2,3)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
```

```

## Optimal Parameters
## -----
##      Estimate   Std. Error   t value Pr(>|t|)
## mu      0.001054    0.000609   1.730468 0.083547
## ar1     0.067906    0.024023   2.826724 0.004703
## ar2    -0.062652    0.021994  -2.848549 0.004392
## omega   0.000033    0.000019   1.714037 0.086522
## alpha1  0.059523    0.031811   1.871111 0.061330
## alpha2  0.000000    0.039124   0.000000 1.000000
## beta1   0.646480    0.260381   2.482827 0.013034
## beta2   0.020015    0.629590   0.031791 0.974639
## beta3   0.201100    0.134967   1.489994 0.136226
## gamma1  0.190469    0.078855   2.415441 0.015716
## gamma2 -0.088559    0.034382  -2.575757 0.010002
## skew    1.140811    0.036142  31.565090 0.000000
## shape   3.884155    0.379058  10.246871 0.000000
##
## Robust Standard Errors:
##      Estimate   Std. Error   t value Pr(>|t|)
## mu      0.001054    0.000676   1.558484 0.119119
## ar1     0.067906    0.023628   2.874001 0.004053
## ar2    -0.062652    0.022474  -2.787814 0.005306
## omega   0.000033    0.000034   0.961252 0.336425
## alpha1  0.059523    0.029175   2.040181 0.041332
## alpha2  0.000000    0.067032   0.000000 1.000000
## beta1   0.646480    1.212700   0.533091 0.593970
## beta2   0.020015    1.457941   0.013728 0.989047
## beta3   0.201100    0.529722   0.379633 0.704218
## gamma1  0.190469    0.131200   1.451742 0.146573
## gamma2 -0.088559    0.139867  -0.633165 0.526626
## skew    1.140811    0.036937  30.885610 0.000000
## shape   3.884155    0.433811   8.953565 0.000000
##
## LogLikelihood : 3788.483
##
## Information Criteria
## -----
##
## Akaike      -4.3748
## Bayes       -4.3338
## Shibata     -4.3749
## Hannan-Quinn -4.3596
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##              statistic   p-value
## Lag[1]              5.180 0.0228521
## Lag[2*(p+q)+(p+q)-1] [5] 5.525 0.0005007
## Lag[4*(p+q)+(p+q)-1] [9] 7.442 0.0910641
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----

```

```

##                                statistic p-value
## Lag[1]                        0.4493  0.5027
## Lag[2*(p+q)+(p+q)-1][14]    4.9965  0.7699
## Lag[4*(p+q)+(p+q)-1][24]    7.8556  0.8835
## d.o.f=5
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale P-Value
## ARCH Lag[6]      0.3099 0.500 2.000  0.5777
## ARCH Lag[8]      2.2315 1.480 1.774  0.4650
## ARCH Lag[10]     4.9553 2.424 1.650  0.2885
##
## Nyblom stability test
## -----
## Joint Statistic:  4.2696
## Individual Statistics:
## mu      0.07754
## ar1     0.10780
## ar2     0.18422
## omega   0.11819
## alpha1  0.16731
## alpha2  0.16467
## beta1   0.15399
## beta2   0.15665
## beta3   0.14496
## gamma1  0.46409
## gamma2  0.34330
## skew    0.38176
## shape   0.09801
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:      2.89 3.15 3.69
## Individual Statistic:  0.35 0.47 0.75
##
## Sign Bias Test
## -----
##           t-value  prob sig
## Sign Bias      1.4753 0.1403
## Negative Sign Bias 1.4532 0.1464
## Positive Sign Bias 0.4157 0.6777
## Joint Effect    4.1384 0.2469
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20     16.22     0.6422
## 2    30     27.04     0.5698
## 3    40     33.95     0.6990
## 4    50     58.24     0.1718
##
##
## Elapsed time : 5.343994

```

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(3,2)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : gjrGARCH(3,2)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001128    0.000615   1.8347 0.066549
## ar1      0.072365    0.024140   2.9978 0.002720
## ar2     -0.065047    0.021383  -3.0420 0.002350
## omega    0.000037    0.000021   1.7309 0.083463
## alpha1   0.065068    0.032236   2.0185 0.043540
## alpha2   0.000000    0.034374   0.0000 1.000000
## alpha3   0.000000    0.040866   0.0000 1.000000
## beta1    0.009208    0.076606   0.1202 0.904327
## beta2    0.840739    0.085386   9.8463 0.000000
## gamma1   0.224510    0.086102   2.6075 0.009121
## gamma2   0.057248    0.031493   1.8178 0.069095
## gamma3  -0.162727    0.082800  -1.9653 0.049380
## skew     1.146201    0.036578  31.3362 0.000000
## shape    3.968853    0.434757   9.1289 0.000000
##
## Robust Standard Errors:
##      Estimate  Std. Error  t value Pr(>|t|)
## mu      0.001128    0.000697   1.616980 0.105883
## ar1      0.072365    0.024010   3.013906 0.002579
## ar2     -0.065047    0.021620  -3.008660 0.002624
## omega    0.000037    0.000038   0.958047 0.338039
## alpha1   0.065068    0.031524   2.064079 0.039010
## alpha2   0.000000    0.053673   0.000000 1.000000
## alpha3   0.000000    0.054717   0.000000 1.000000
## beta1    0.009208    0.092308   0.099751 0.920542
## beta2    0.840739    0.118692   7.083374 0.000000
## gamma1   0.224510    0.098281   2.284360 0.022350
## gamma2   0.057248    0.039464   1.450654 0.146876
## gamma3  -0.162727    0.102073  -1.594216 0.110888
## skew     1.146201    0.038277  29.944745 0.000000
## shape    3.968853    0.495295   8.013109 0.000000
##
## LogLikelihood : 3792.226
##
## Information Criteria
```



```

## -----
##
## Akaike      -4.3780
## Bayes      -4.3338
## Shibata    -4.3781
## Hannan-Quinn -4.3617
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##                statistic  p-value
## Lag[1]                4.445 0.034997
## Lag[2*(p+q)+(p+q)-1] [5]    4.918 0.004366
## Lag[4*(p+q)+(p+q)-1] [9]    7.053 0.122989
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##                statistic  p-value
## Lag[1]                0.2083 0.6481
## Lag[2*(p+q)+(p+q)-1] [14]    3.3350 0.9349
## Lag[4*(p+q)+(p+q)-1] [24]    5.7123 0.9764
## d.o.f=5
##
## Weighted ARCH LM Tests
## -----
##                Statistic Shape Scale P-Value
## ARCH Lag[6]          0.6952 0.500 2.000 0.4044
## ARCH Lag[8]          2.6183 1.480 1.774 0.3921
## ARCH Lag[10]         3.7404 2.424 1.650 0.4548
##
## Nyblom stability test
## -----
## Joint Statistic: 4.7519
## Individual Statistics:
## mu      0.08286
## ar1     0.09231
## ar2     0.15823
## omega   0.12329
## alpha1  0.12605
## alpha2  0.25059
## alpha3  0.13050
## beta1   0.20013
## beta2   0.12400
## gamma1  0.27244
## gamma2  0.52551
## gamma3  0.18678
## skew    0.38310
## shape   0.11013
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:      3.08 3.34 3.9
## Individual Statistic: 0.35 0.47 0.75
##

```

```
## Sign Bias Test
## -----
##          t-value   prob sig
## Sign Bias      1.3639 0.1728
## Negative Sign Bias 1.3069 0.1914
## Positive Sign Bias 0.4086 0.6829
## Joint Effect      3.5346 0.3163
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1     20      20.42      0.3697
## 2     30      29.54      0.4373
## 3     40      39.19      0.4613
## 4     50      52.39      0.3439
##
##
## Elapsed time : 7.984991
```

```
spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(3,3)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf)
my_model_Ibhf
```

```
##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model   : gjrGARCH(3,3)
## Mean Model    : ARFIMA(2,0,0)
## Distribution   : sstd
##
## Optimal Parameters
## -----
##      Estimate  Std. Error   t value Pr(>|t|)
## mu      0.001129   0.000600   1.880848 0.059993
## ar1     0.072422   0.024171   2.996234 0.002733
## ar2    -0.065078   0.021308  -3.054144 0.002257
## omega   0.000037   0.000022   1.724661 0.084589
## alpha1  0.067015   0.032471   2.063865 0.039030
## alpha2  0.000000   0.013698   0.000000 1.000000
## alpha3  0.000000   0.024725   0.000001 1.000000
## beta1   0.000000   0.220539   0.000002 0.999999
## beta2   0.830322   0.055624  14.927350 0.000000
## beta3   0.016518   0.178791   0.092389 0.926389
## gamma1  0.223160   0.085007   2.625197 0.008660
## gamma2  0.056567   0.016273   3.476099 0.000509
## gamma3 -0.159757   0.073495  -2.173693 0.029728
## skew    1.146385   0.036316  31.567346 0.000000
## shape   3.967165   0.382898  10.360899 0.000000
##
```

```

## Robust Standard Errors:
##      Estimate   Std. Error   t value Pr(>|t|)
## mu      0.001129    0.000671   1.683727 0.092234
## ar1     0.072422    0.024133   3.000897 0.002692
## ar2    -0.065078    0.021730  -2.994840 0.002746
## omega   0.000037    0.000037   1.012822 0.311145
## alpha1  0.067015    0.029701   2.256282 0.024053
## alpha2  0.000000    0.052267   0.000000 1.000000
## alpha3  0.000000    0.042346   0.000000 1.000000
## beta1   0.000000    0.479493   0.000001 0.999999
## beta2   0.830322    0.069474  11.951608 0.000000
## beta3   0.016518    0.392987   0.042033 0.966473
## gamma1  0.223160    0.098615   2.262929 0.023640
## gamma2  0.056567    0.051172   1.105433 0.268972
## gamma3 -0.159757    0.105406  -1.515624 0.129615
## skew    1.146385    0.037583  30.502972 0.000000
## shape   3.967165    0.406492   9.759518 0.000000
##
## LogLikelihood : 3792.271
##
## Information Criteria
## -----
##
## Akaike          -4.3769
## Bayes           -4.3295
## Shibata         -4.3771
## Hannan-Quinn   -4.3594
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##              statistic  p-value
## Lag[1]              4.422 0.035478
## Lag[2*(p+q)+(p+q)-1] [5]    4.894 0.004739
## Lag[4*(p+q)+(p+q)-1] [9]    7.041 0.124115
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##
##              statistic  p-value
## Lag[1]              0.1797 0.6717
## Lag[2*(p+q)+(p+q)-1] [17]    4.1031 0.9497
## Lag[4*(p+q)+(p+q)-1] [29]    6.9471 0.9848
## d.o.f=6
##
## Weighted ARCH LM Tests
## -----
##
##      Statistic Shape Scale P-Value
## ARCH Lag[7]      1.374 0.500 2.000 0.2411
## ARCH Lag[9]      3.485 1.485 1.796 0.2703
## ARCH Lag[11]     3.735 2.440 1.677 0.4694
##
## Nyblom stability test
## -----

```

```

## Joint Statistic:  5.5108
## Individual Statistics:
## mu      0.08405
## ar1     0.09504
## ar2     0.15991
## omega   0.12216
## alpha1  0.13096
## alpha2  0.23145
## alpha3  0.13153
## beta1   0.19178
## beta2   0.12219
## beta3   0.19311
## gamma1  0.27985
## gamma2  0.50096
## gamma3  0.18707
## skew    0.37978
## shape   0.11024
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:      3.26 3.54 4.07
## Individual Statistic:  0.35 0.47 0.75
##
## Sign Bias Test
## -----
##              t-value   prob sig
## Sign Bias      1.3850 0.1662
## Negative Sign Bias 1.3116 0.1898
## Positive Sign Bias 0.3619 0.7174
## Joint Effect    3.5021 0.3205
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      20.67      0.3551
## 2    30      29.68      0.4302
## 3    40      39.98      0.4265
## 4    50      52.91      0.3256
##
##
## Elapsed time : 8.577

```

going further is not leading any good results

```

spec_of_garch_Ibhf<-ugarchspec(variance.model =list(model="gjrGARCH",garchOrder=c(1,3)),mean.model = li
my_model_Ibhf<-ugarchfit(spec=spec_of_garch_Ibhf,data=ret_Ibhf,out.sample = 500)
my_model_Ibhf

```

```

##
## *-----*
## *          GARCH Model Fit          *
## *-----*
##

```

```

## Conditional Variance Dynamics
## -----
## GARCH Model : gjrGARCH(1,3)
## Mean Model : ARFIMA(2,0,0)
## Distribution : sstd
##
## Optimal Parameters
## -----
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.001560  0.000666  2.34266 0.019147
## ar1      0.094774  0.029021  3.26572 0.001092
## ar2     -0.031310  0.027686 -1.13091 0.258095
## omega    0.000063  0.000045  1.39592 0.162738
## alpha1   0.100172  0.045661  2.19380 0.028250
## beta1    0.542046  0.116956  4.63462 0.000004
## beta2    0.000000  0.323474  0.00000 1.000000
## beta3    0.242930  0.110726  2.19397 0.028237
## gamma1  -0.007170  0.048022 -0.14931 0.881309
## skew     1.189087  0.047416 25.07765 0.000000
## shape    5.199244  0.772588  6.72964 0.000000
##
## Robust Standard Errors:
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.001560  0.000698  2.23697 0.025288
## ar1      0.094774  0.027715  3.41960 0.000627
## ar2     -0.031310  0.027768 -1.12755 0.259509
## omega    0.000063  0.000066  0.95419 0.339986
## alpha1   0.100172  0.056322  1.77856 0.075312
## beta1    0.542046  0.182118  2.97634 0.002917
## beta2    0.000000  0.300917  0.00000 1.000000
## beta3    0.242930  0.236647  1.02655 0.304632
## gamma1  -0.007170  0.045679 -0.15697 0.875270
## skew     1.189087  0.049133 24.20158 0.000000
## shape    5.199244  0.692375  7.50929 0.000000
##
## LogLikelihood : 2963.23
##
## Information Criteria
## -----
##
## Akaike      -4.8160
## Bayes       -4.7702
## Shibata     -4.8162
## Hannan-Quinn -4.7988
##
## Weighted Ljung-Box Test on Standardized Residuals
## -----
##
##              statistic p-value
## Lag[1]              0.3346  0.5630
## Lag[2*(p+q)+(p+q)-1] [5]  2.5356  0.7595
## Lag[4*(p+q)+(p+q)-1] [9]  4.2306  0.6362
## d.o.f=2
## H0 : No serial correlation
##

```

```

## Weighted Ljung-Box Test on Standardized Squared Residuals
## -----
##               statistic p-value
## Lag[1]          2.133e-05  0.9963
## Lag[2*(p+q)+(p+q)-1][11] 9.231e+00  0.1317
## Lag[4*(p+q)+(p+q)-1][19] 1.692e+01  0.0468
## d.o.f=4
##
## Weighted ARCH LM Tests
## -----
##           Statistic Shape Scale P-Value
## ARCH Lag[5]      2.429 0.500 2.000 0.11915
## ARCH Lag[7]      3.652 1.473 1.746 0.23521
## ARCH Lag[9]     11.574 2.402 1.619 0.01202
##
## Nyblom stability test
## -----
## Joint Statistic:  5.5856
## Individual Statistics:
## mu      0.12297
## ar1     0.11597
## ar2     0.02438
## omega   0.53029
## alpha1  0.77417
## beta1   0.57518
## beta2   0.50637
## beta3   0.53744
## gamma1  0.48248
## skew    0.10816
## shape   0.10687
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:      2.49 2.75 3.27
## Individual Statistic:  0.35 0.47 0.75
##
## Sign Bias Test
## -----
##               t-value  prob sig
## Sign Bias      1.1275 0.2597
## Negative Sign Bias 1.1449 0.2525
## Positive Sign Bias 0.5204 0.6029
## Joint Effect    1.7125 0.6342
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## -----
##   group statistic p-value(g-1)
## 1    20      13.90      0.7894
## 2    30      28.57      0.4877
## 3    40      33.77      0.7069
## 4    50      53.93      0.2913
##
##
## Elapsed time : 3.696997

```

```
back_testing<-ugarchroll(spec_of_garch_Ibhf,ret_Ibhf,n.ahead=1,n.start = 1500,refit.every =30,refit.wi
```

```
##
## Iter: 1 fn: -3469.3672 Pars: 0.00105627 0.09311132 -0.05976516 0.00002873 0.07005112 0.4656
## Iter: 2 fn: -3469.3672 Pars: 0.00105628 0.09311103 -0.05976585 0.00002873 0.07004858 0.4656
## Iter: 3 fn: -3469.3672 Pars: 0.00105628 0.09311103 -0.05976585 0.00002873 0.07004858 0.4656
## solnp--> Completed in 3 iterations
##
## Iter: 1 fn: -3464.5520 Pars: 0.00117941598 0.08548745723 -0.06809542504 0.00003013904 0.0678
## Iter: 2 fn: -3464.5520 Pars: 0.00117941598 0.08548745728 -0.06809542509 0.00003013904 0.0678
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -3442.2912 Pars: 0.001207506 0.085185506 -0.070550940 0.000034297 0.057424288 0
## Iter: 2 fn: -3442.2912 Pars: 0.001207506 0.085185506 -0.070550940 0.000034297 0.057424288 0
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -3417.8987 Pars: 0.00131826 0.07967348 -0.05633088 0.00003327 0.06309338 0.1400
## Iter: 2 fn: -3417.8987 Pars: 0.00131806 0.07967815 -0.05632539 0.00003327 0.06308101 0.1401
## Iter: 3 fn: -3417.8987 Pars: 0.00131806 0.07967815 -0.05632539 0.00003327 0.06308101 0.1401
## solnp--> Completed in 3 iterations
##
## Iter: 1 fn: -3402.6756 Pars: 0.00136706 0.07881005 -0.05862140 0.00003753 0.06509809 0.1362
## Iter: 2 fn: -3402.6756 Pars: 0.00136717 0.07880849 -0.05862144 0.00003753 0.06510156 0.1362
## Iter: 3 fn: -3402.6756 Pars: 0.00136717 0.07880849 -0.05862144 0.00003753 0.06510156 0.1362
## solnp--> Completed in 3 iterations
##
## Iter: 1 fn: -3359.8920 Pars: 0.00123969 0.07869656 -0.05790131 0.00003522 0.06329162 0.1415
## Iter: 2 fn: -3359.8920 Pars: 0.00123969 0.07869656 -0.05790131 0.00003522 0.06329162 0.1415
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -3337.5695 Pars: 0.00104078 0.07357411 -0.06306549 0.00003614 0.06159288 0.1127
## Iter: 2 fn: -3337.5695 Pars: 0.00104078 0.07357411 -0.06306549 0.00003614 0.06159288 0.1127
## solnp--> Completed in 2 iterations
##
## Iter: 1 fn: -3322.9101 Pars: 0.00107483 0.07048172 -0.06831731 0.00004256 0.08153163 0.0742
## Iter: 2 fn: -3322.9101 Pars: 0.00107483 0.07048172 -0.06831731 0.00004256 0.08153163 0.0742
## solnp--> Completed in 2 iterations
```

```
report(back_testing)
```

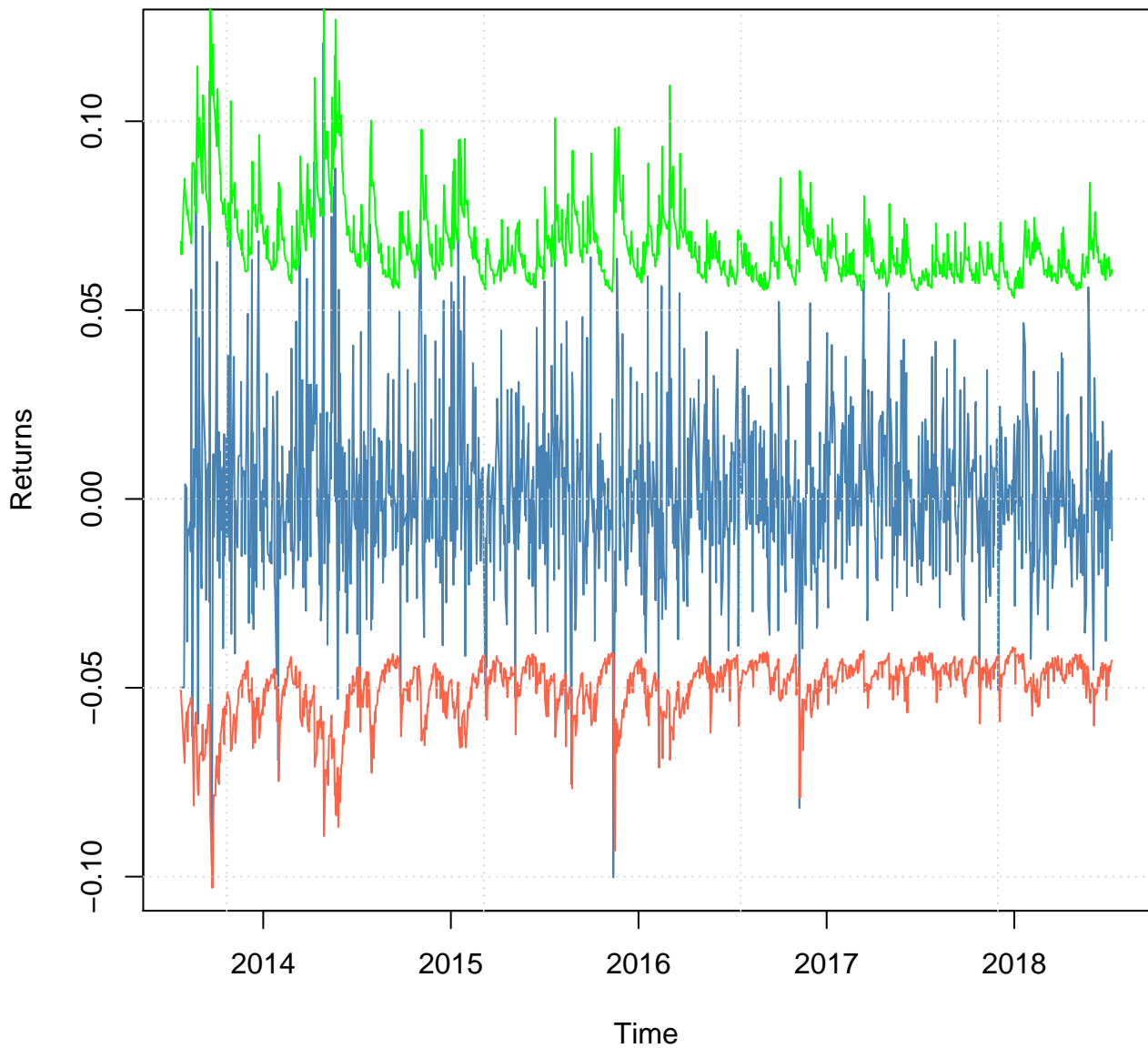
```
## VaR Backtest Report
## =====
## Model: gjrGARCH-sstd
## Backtest Length: 226
## Data:
##
## =====
## alpha: 1%
## Expected Exceed: 2.3
## Actual VaR Exceed: 6
## Actual %: 2.7%
##
```

```
## Unconditional Coverage (Kupiec)
## Null-Hypothesis: Correct Exceedances
## LR.uc Statistic: 4.3
## LR.uc Critical:      3.841
## LR.uc p-value:      0.038
## Reject Null:      YES
##
## Conditional Coverage (Christoffersen)
## Null-Hypothesis: Correct Exceedances and
##                      Independence of Failures
## LR.cc Statistic: 4.628
## LR.cc Critical:      5.991
## LR.cc p-value:      0.099
## Reject Null:      NO
```

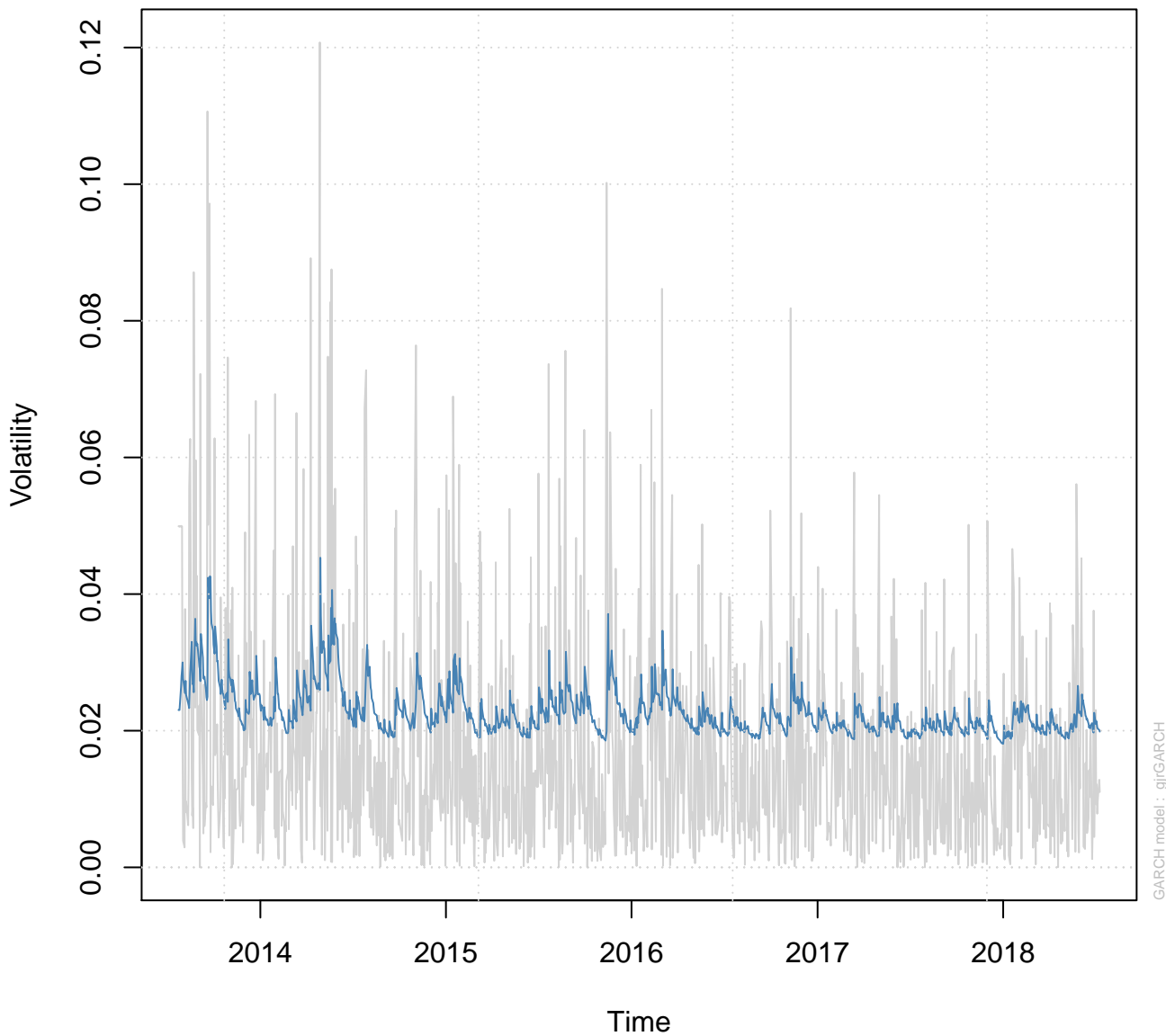
```
forecast<- ugarchforecast(my_model_Ibhf,data=ret_Ibhf,n.ahead =100,n.roll = 100)
```


GARCH model : gjrGARCH

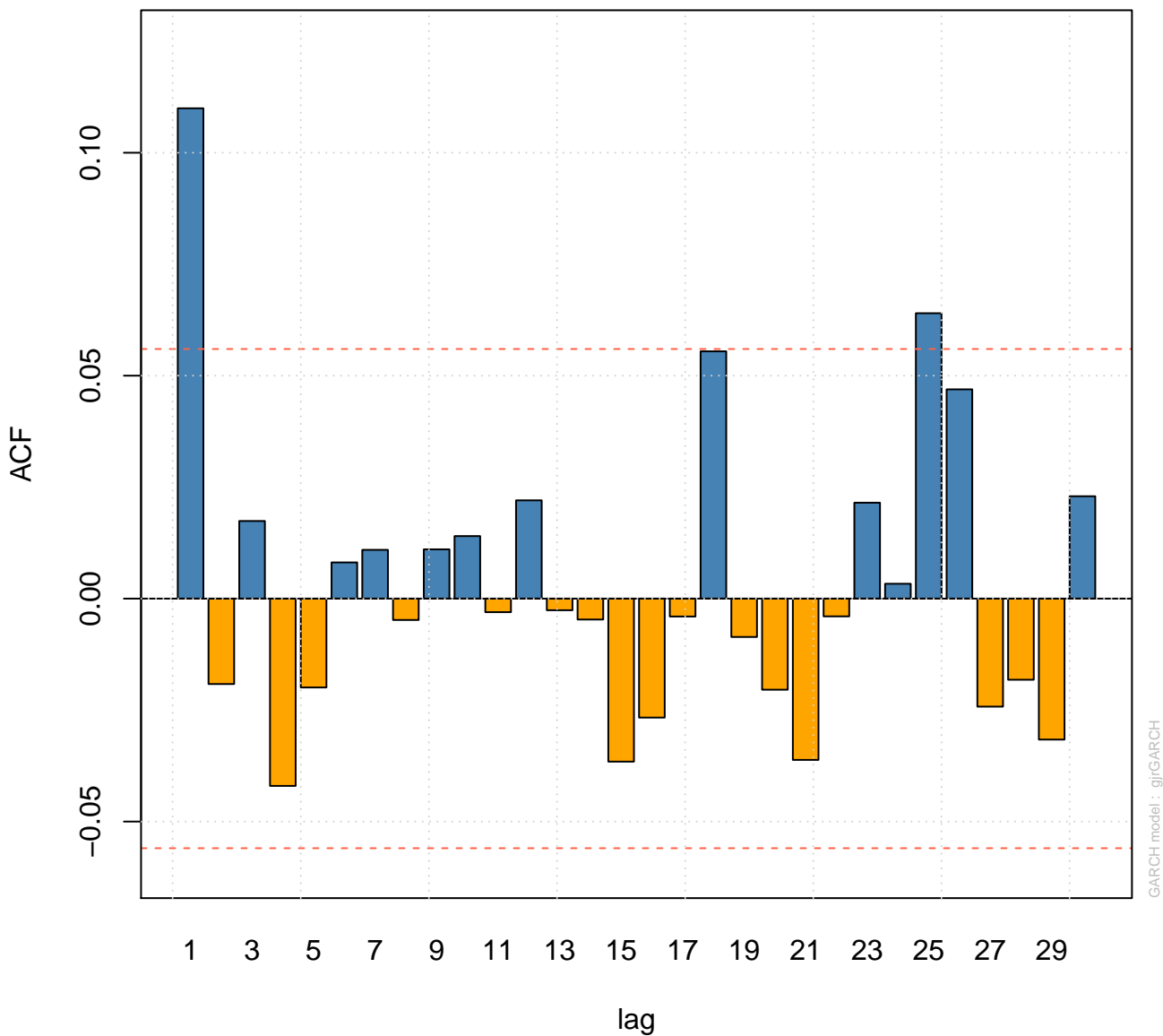
GARCH model : gjrGARCH



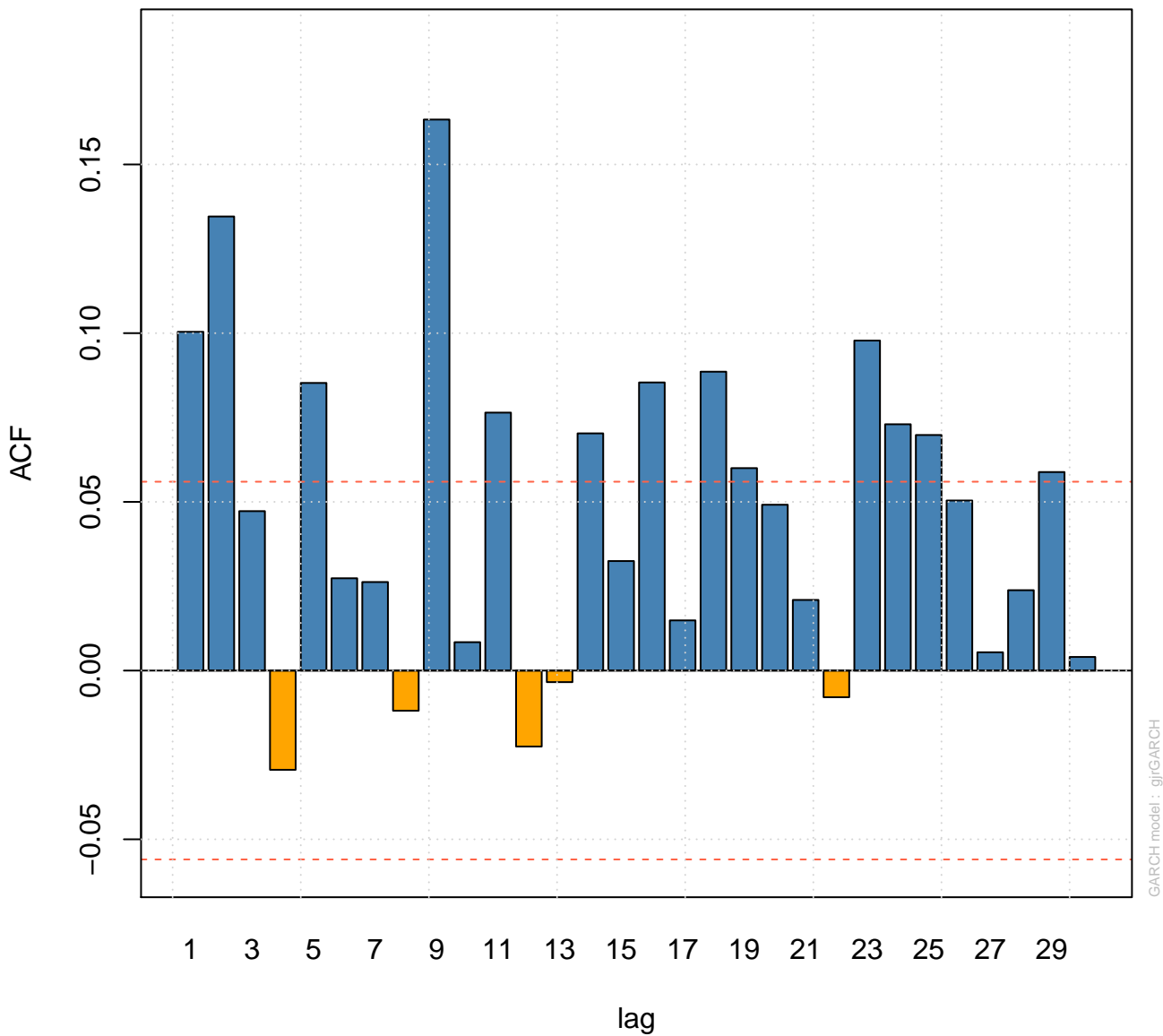
Conditional SD (vs |returns|)



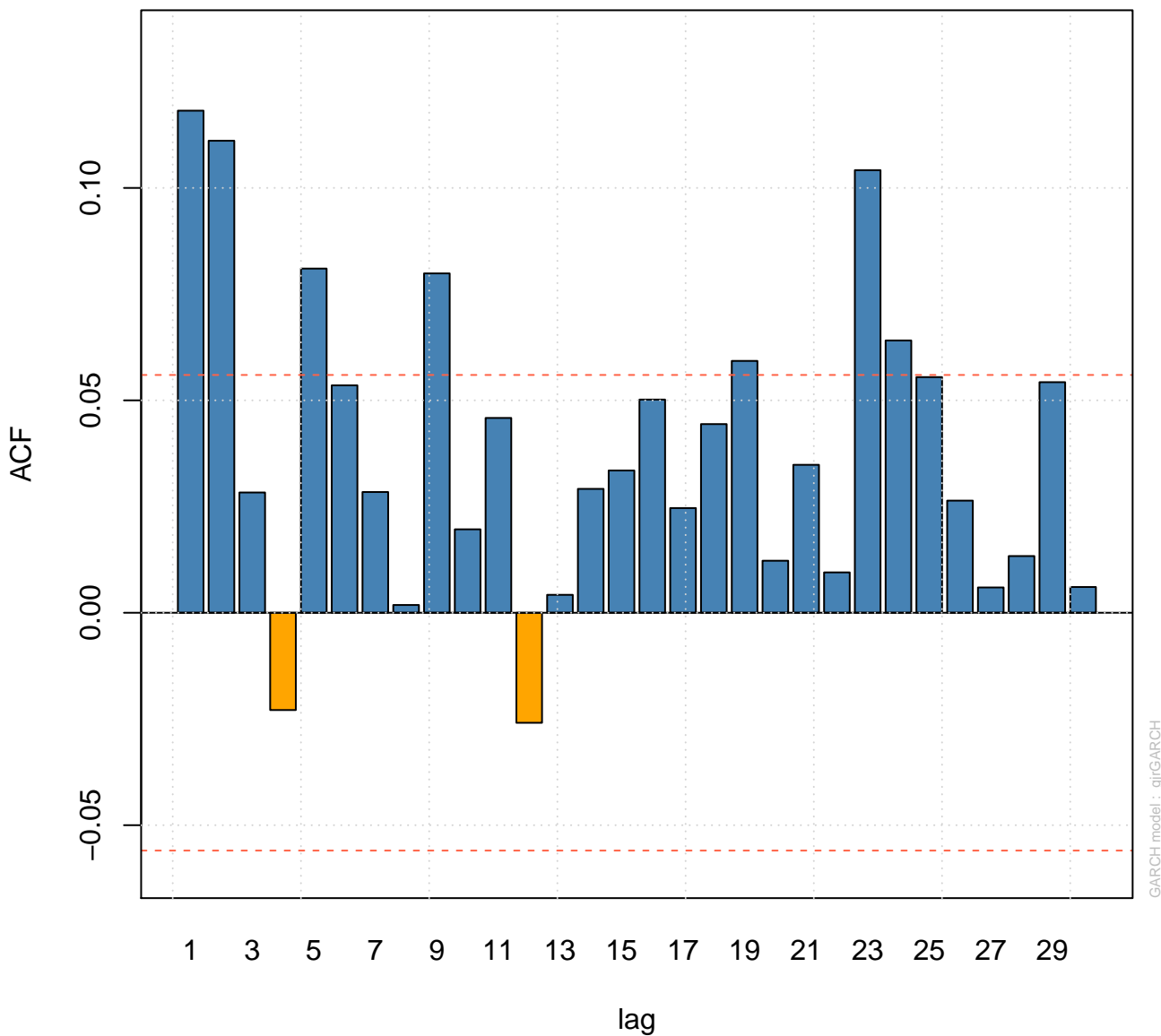
ACF of Observations



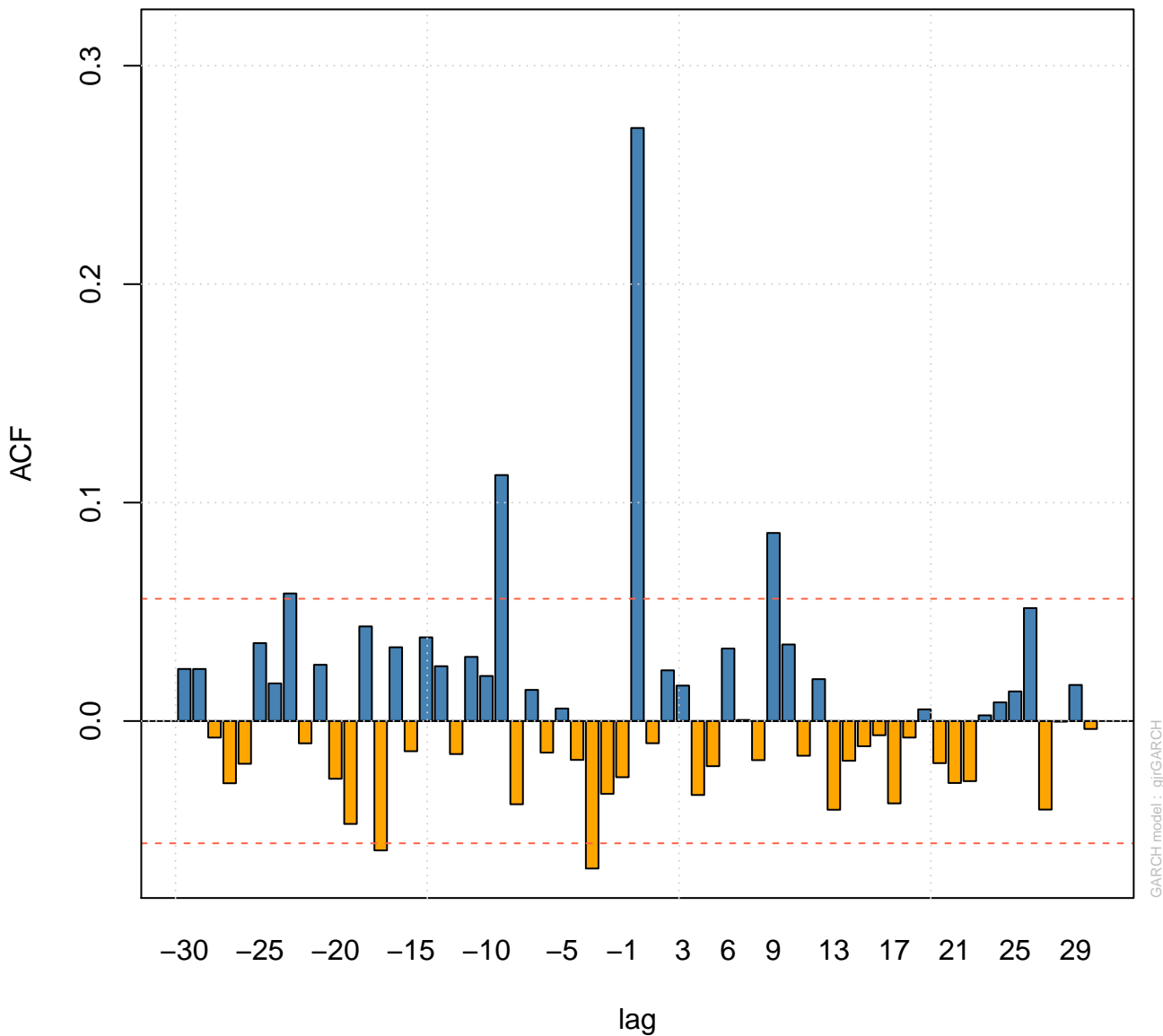
ACF of Squared Observations



ACF of Absolute Observations

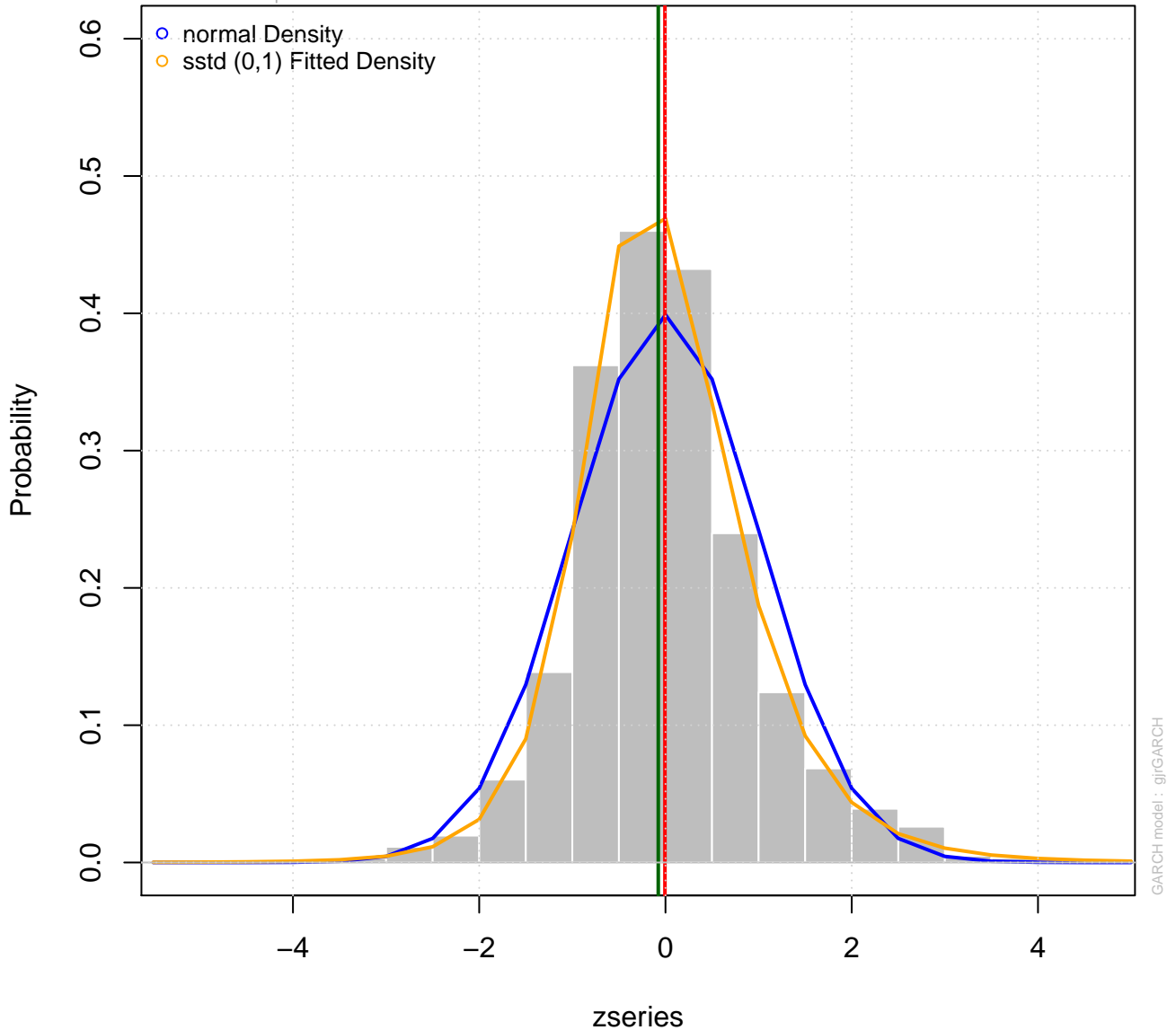


Cross-Correlations of Squared vs Actual Observations

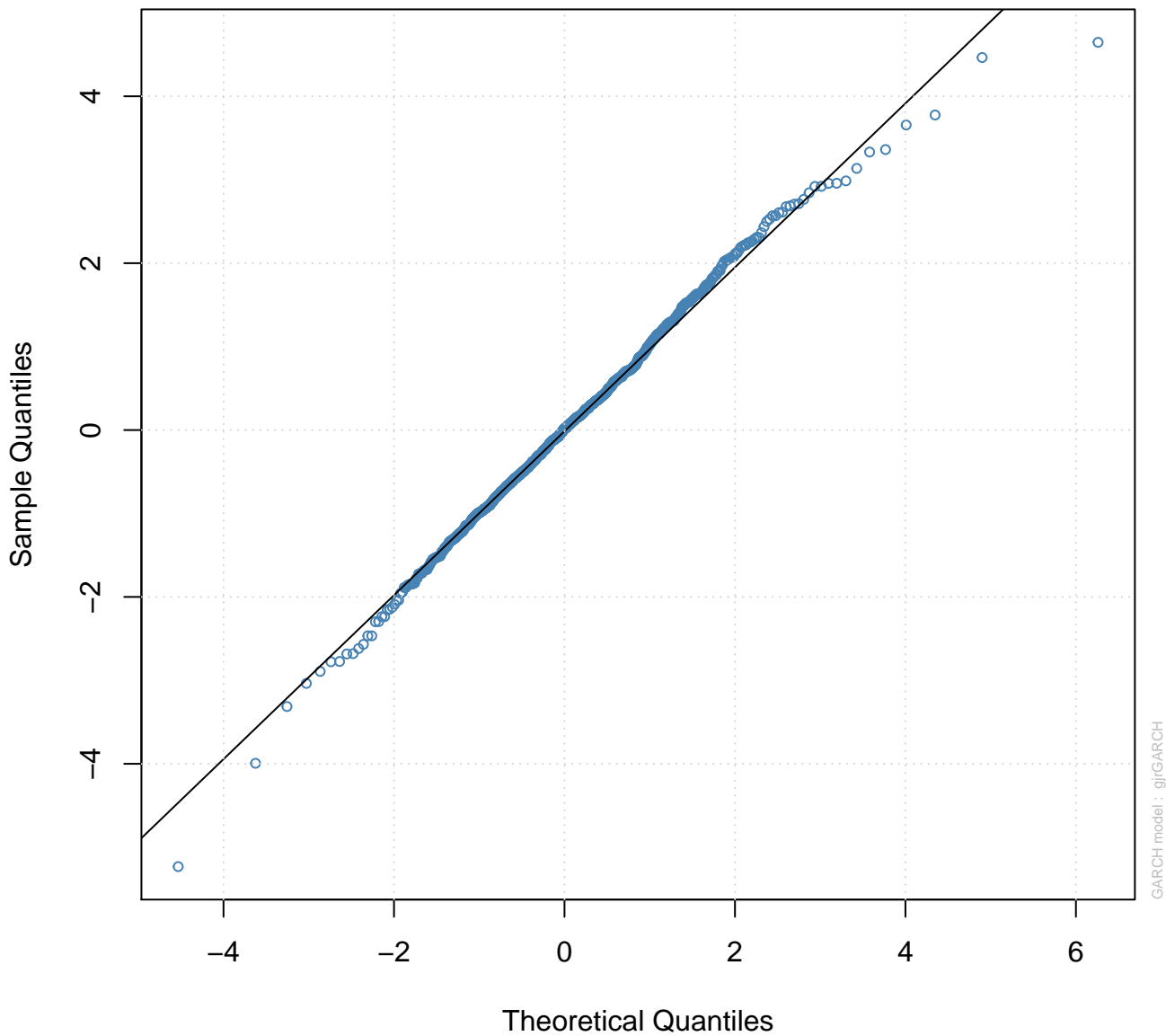


Empirical Density of Standardized Residuals

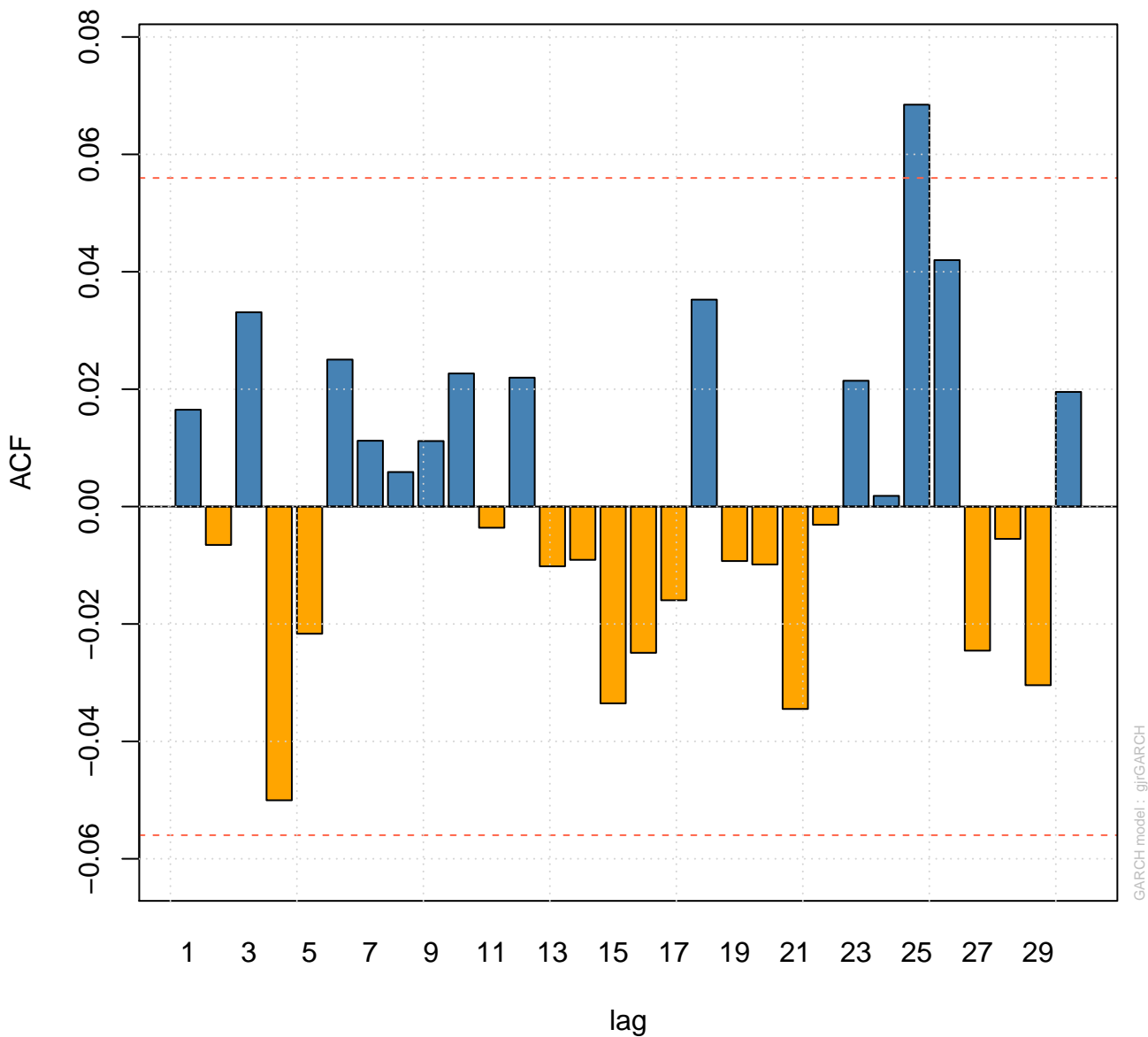
Median: -0.08 | Mean: -0.00589



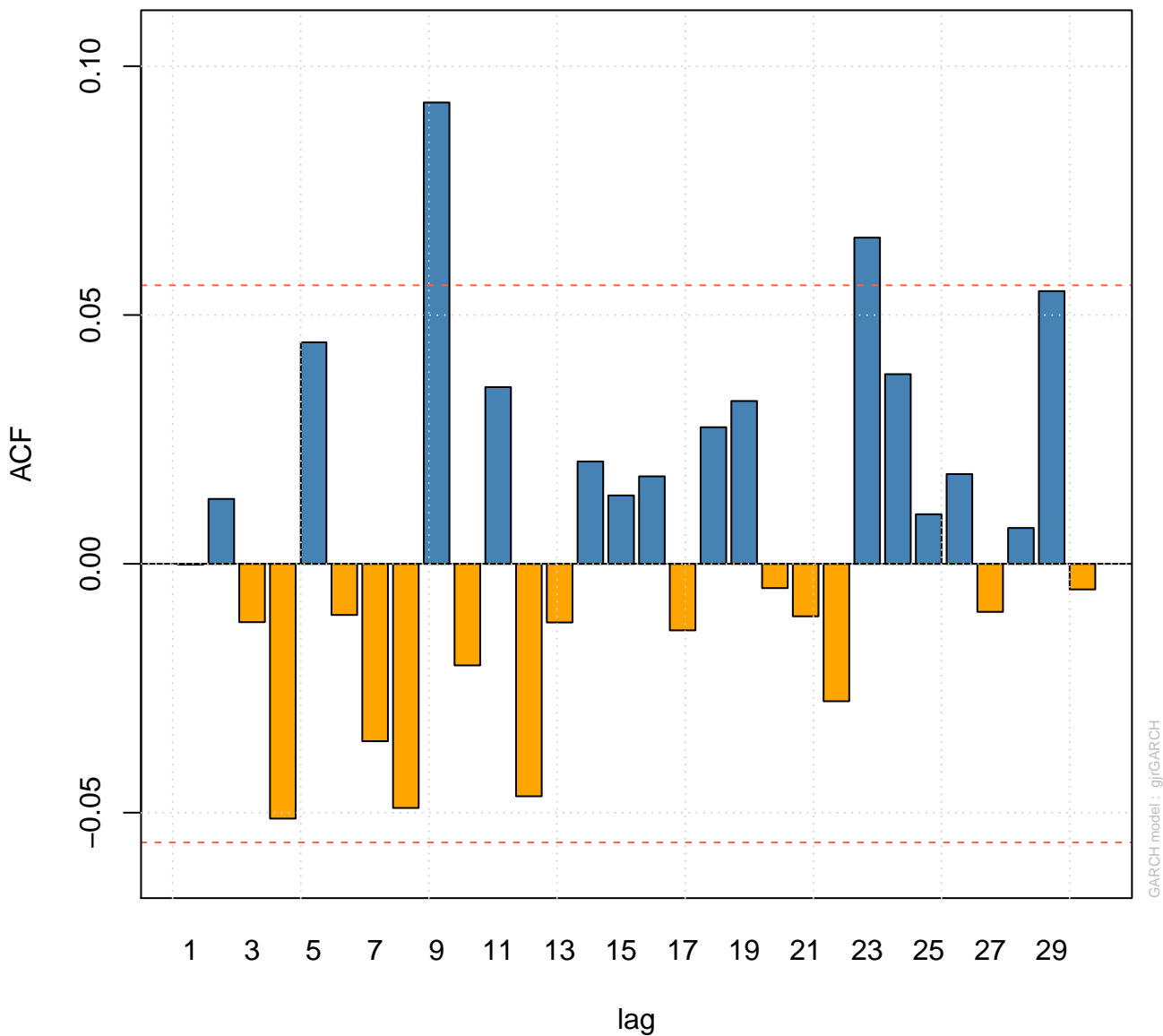
sstd – QQ Plot



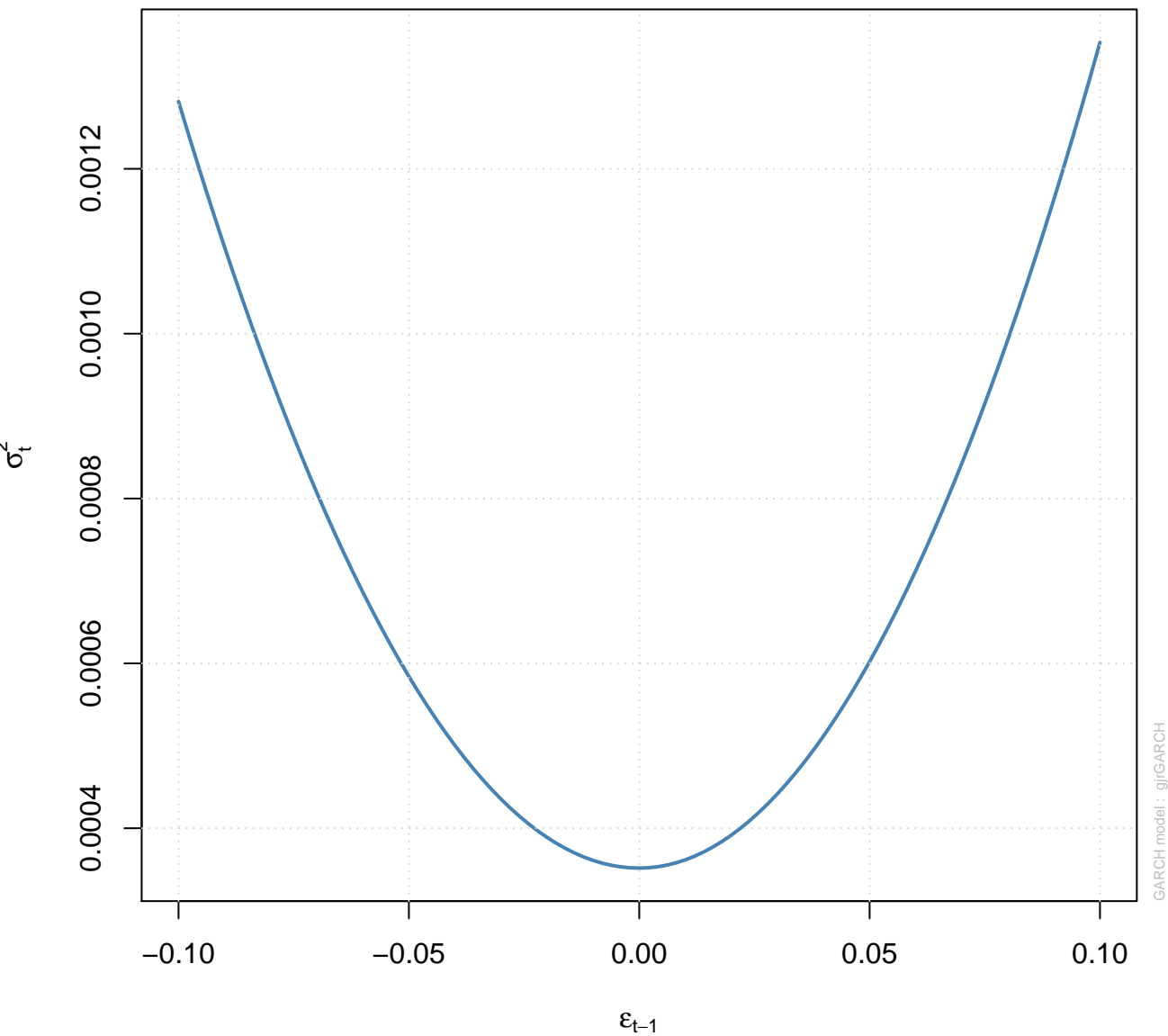
ACF of Standardized Residuals



ACF of Squared Standardized Residuals



News Impact Curve

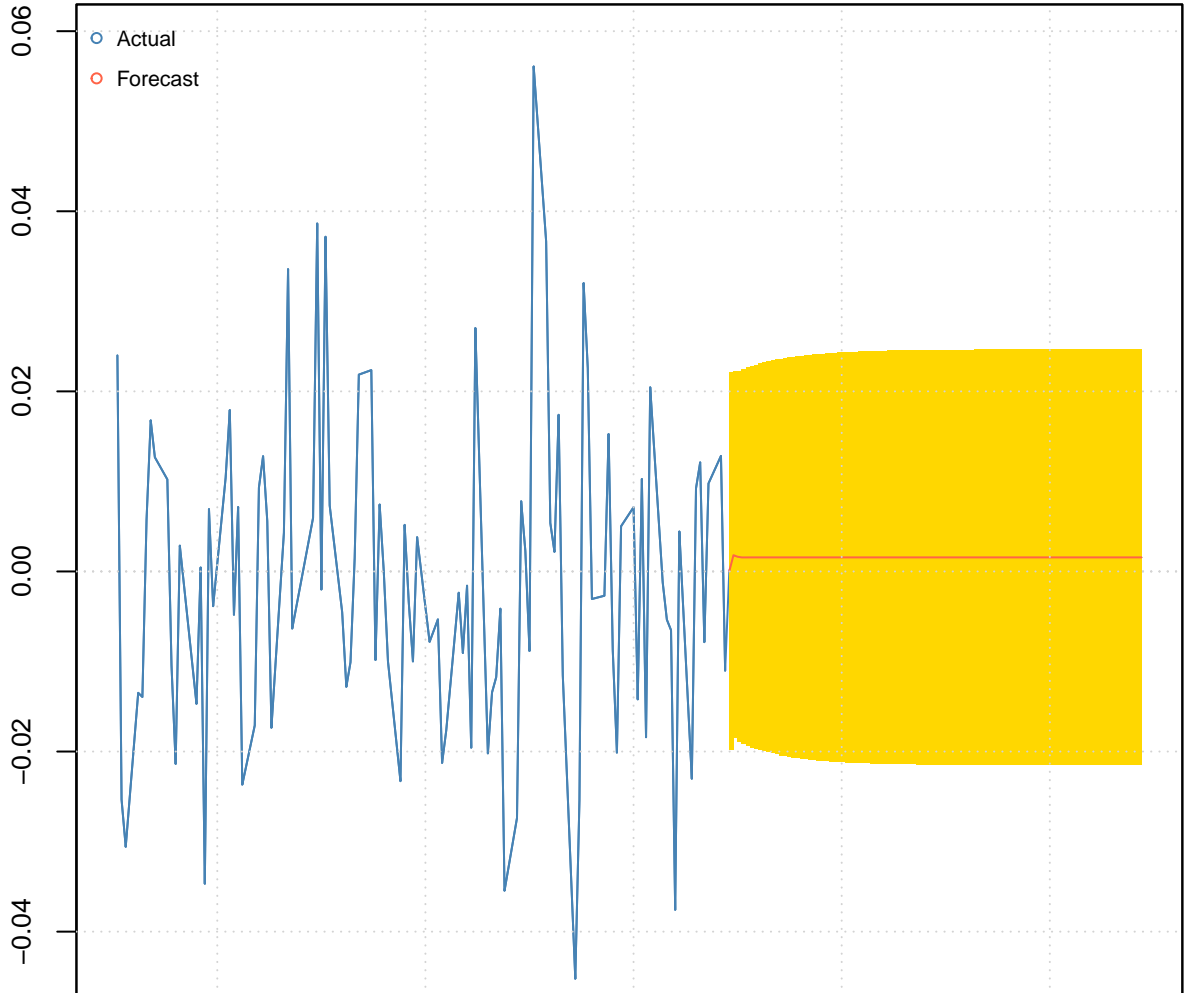


Forecast Series
w/th unconditional 1-Sigma bands

Horizon: 100

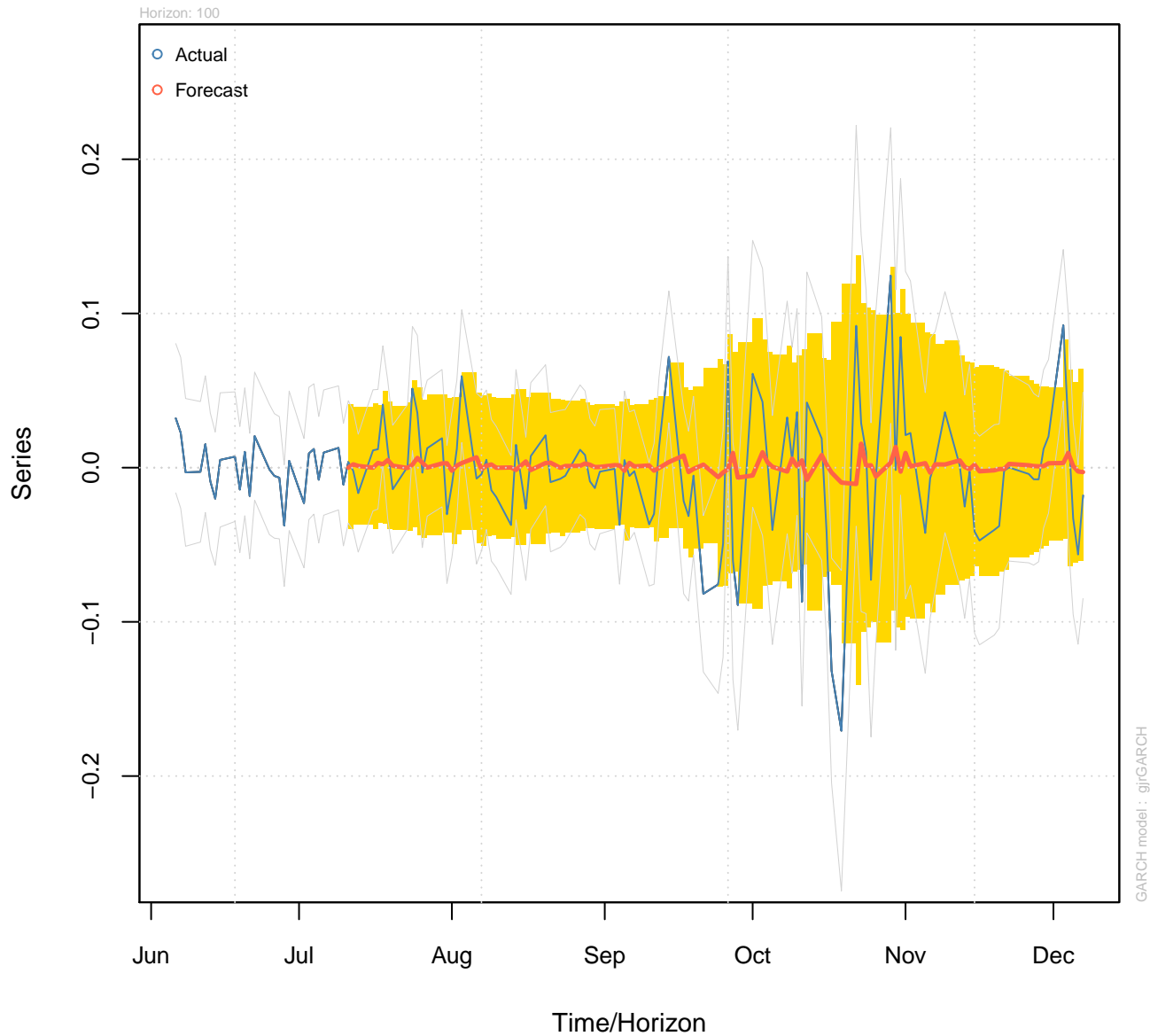
- Actual
- Forecast

Series



GARCH model : gjrGARCH

Rolling Forecast vs Actual Series w/th conditional 2-Sigma bands



Forecast Unconditional Sigma
(n.roll = 0)

Horizon: 100

- Actual
- Forecast

Sigma

0.026
0.024
0.022
0.020

Jun

Jul

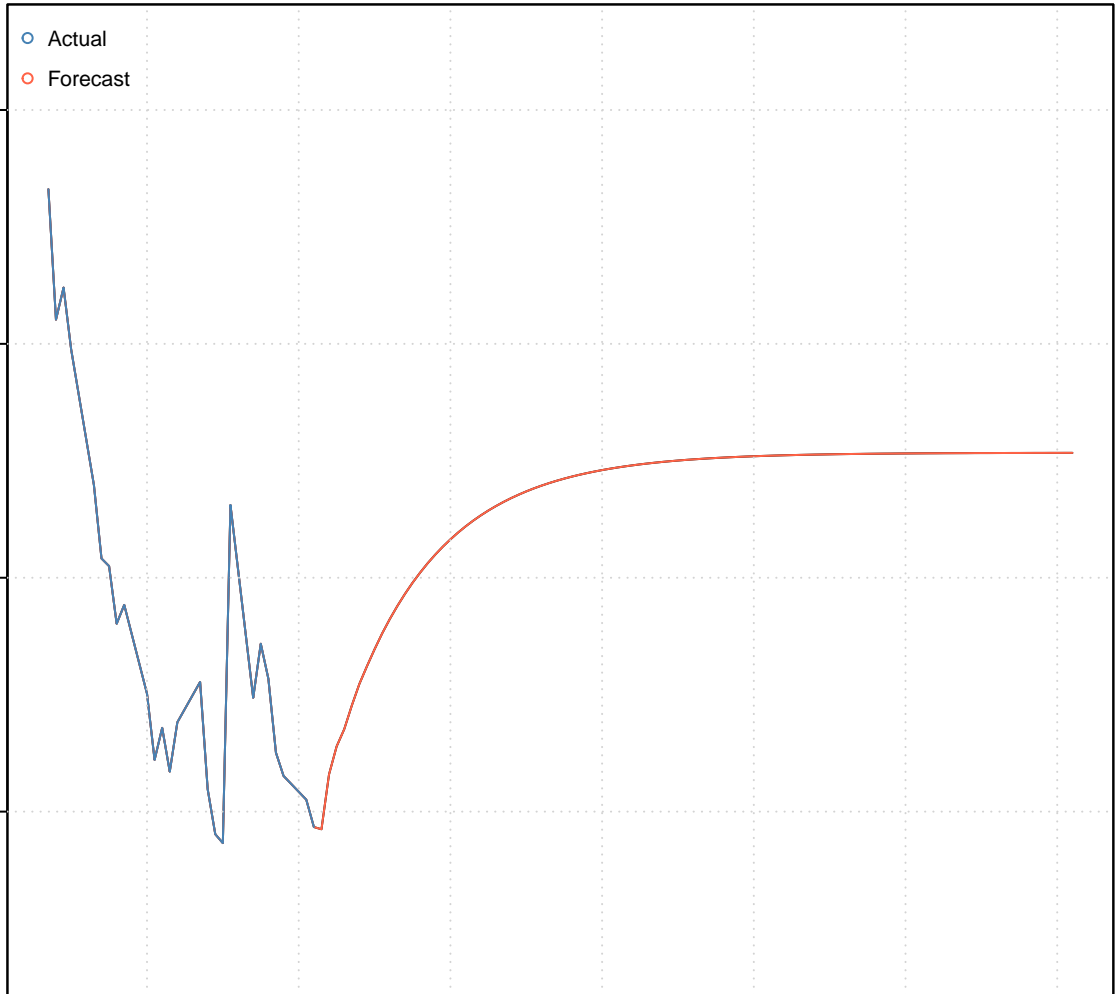
Aug

Sep

Oct

Time/Horizon

GARCH model : gjrGARCH



Forecast Rolling Sigma vs |Series|

