Assignment5_6104641136.R

naravitch

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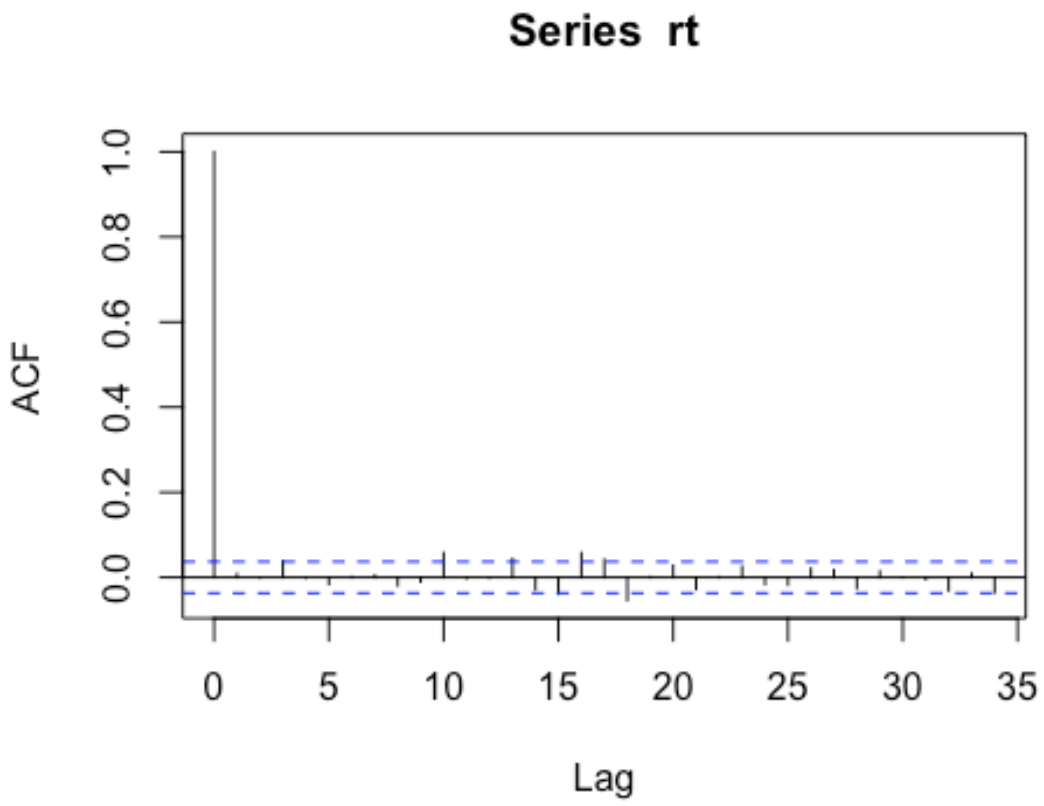
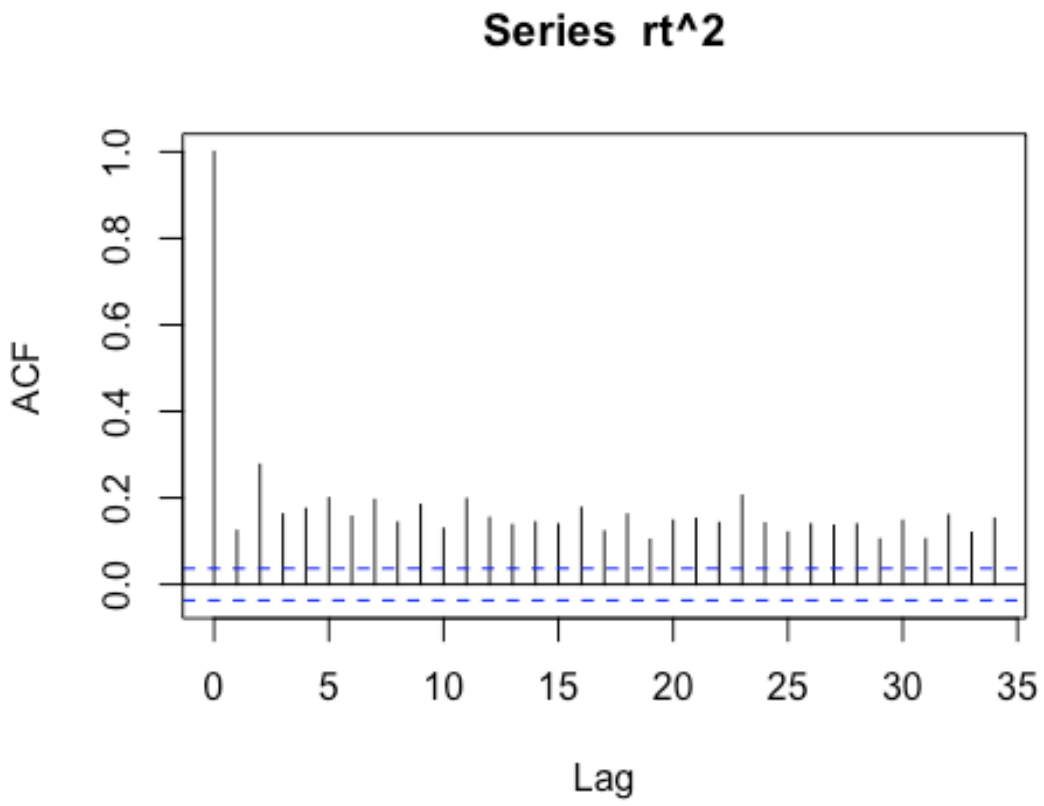
```
#EE 435 Naravitch Assignment 5
setwd("/Users/naravitch/Desktop/BE/EE435")
cat(rep("\n",50))  #clear R Console

#install.packages("quantmod")
#install.packages("fBasics")
#install.packages("sn")
#install.packages("PerformanceAnalytics")
#install.packages("car")
#install.packages("tseries")
#install.packages("forecast")
#install.packages("fGarch")
library(quantmod)

## Loading required package: xts

## Loading required package: zoo

##
## Attaching package: 'zoo'

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

## Loading required package: TTR

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

library(fBasics)

## Loading required package: timeDate

## Loading required package: timeSeries

##
## Attaching package: 'timeSeries'

## The following object is masked from 'package:zoo':
##
##     time<-
```

```
##
## Attaching package: 'fBasics'

## The following object is masked from 'package:TTR':
##
##     volatility

library(sn)

## Loading required package: stats4

##
## Attaching package: 'sn'

## The following object is masked from 'package:fBasics':
##
##     vech

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

library(PerformanceAnalytics)

##
## Attaching package: 'PerformanceAnalytics'

## The following objects are masked from 'package:timeDate':
##
##     kurtosis, skewness

## The following object is masked from 'package:graphics':
##
##     legend

library(car)

## Loading required package: carData

##
## Attaching package: 'car'

## The following object is masked from 'package:fBasics':
##
##     densityPlot

library(tseries)
library(forecast)
library(fGarch)
getSymbols("CAT",from="2006-01-03",to="2017-04-13")

## 'getSymbols' currently uses auto.assign=TRUE by default, but will
## use auto.assign=FALSE in 0.5-0. You will still be able to use
```

```
## 'loadSymbols' to automatically load data. getOption("getSymbols.env")
## and getOption("getSymbols.auto.assign") will still be checked for
## alternate defaults.
##
## This message is shown once per session and may be disabled by setting
## options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.

## [1] "CAT"

dim(CAT)

## [1] 2839    6

head(CAT)

##            CAT.Open CAT.High CAT.Low CAT.Close CAT.Volume CAT.Adjusted
## 2006-01-03    57.87    58.11   57.05     57.80    3697500     38.08682
## 2006-01-04    57.95    59.43   57.55     59.27    4577200     39.05544
## 2006-01-05    59.02    59.86   59.00     59.27    4590700     39.05544
## 2006-01-06    59.47    60.76   59.38     60.45    5692300     39.83300
## 2006-01-09    60.45    61.68   60.45     61.55    4408800     40.55783
## 2006-01-10    61.35    61.52   60.64     61.30    3188100     40.39312

tail(CAT)

##            CAT.Open CAT.High CAT.Low CAT.Close CAT.Volume CAT.Adjusted
## 2017-04-05    94.92    96.73   93.96     94.24    6061300     84.34099
## 2017-04-06    94.42    96.42   94.26     95.82    5421600     85.75500
## 2017-04-07    95.87    96.62   95.42     95.52    4463800     85.48653
## 2017-04-10    96.31    97.89   96.10     97.14    5168300     86.93636
## 2017-04-11    97.30    97.31   95.67     97.10    4250400     86.90057
## 2017-04-12    96.69    96.77   94.66     94.86    4773900     84.89585

da=CAT

par(mfrow=c(1,1))
rt<-diff(log(as.numeric(CAT[,6])))
acf(rt)
```




```
#Queation1
#1a
Box.test(rt,lag=10,type='Ljung')

##
##  Box-Ljung test
##
## data:  rt
## X-squared = 16.291, df = 10, p-value = 0.09159

#1b
acf(rt^2)
```



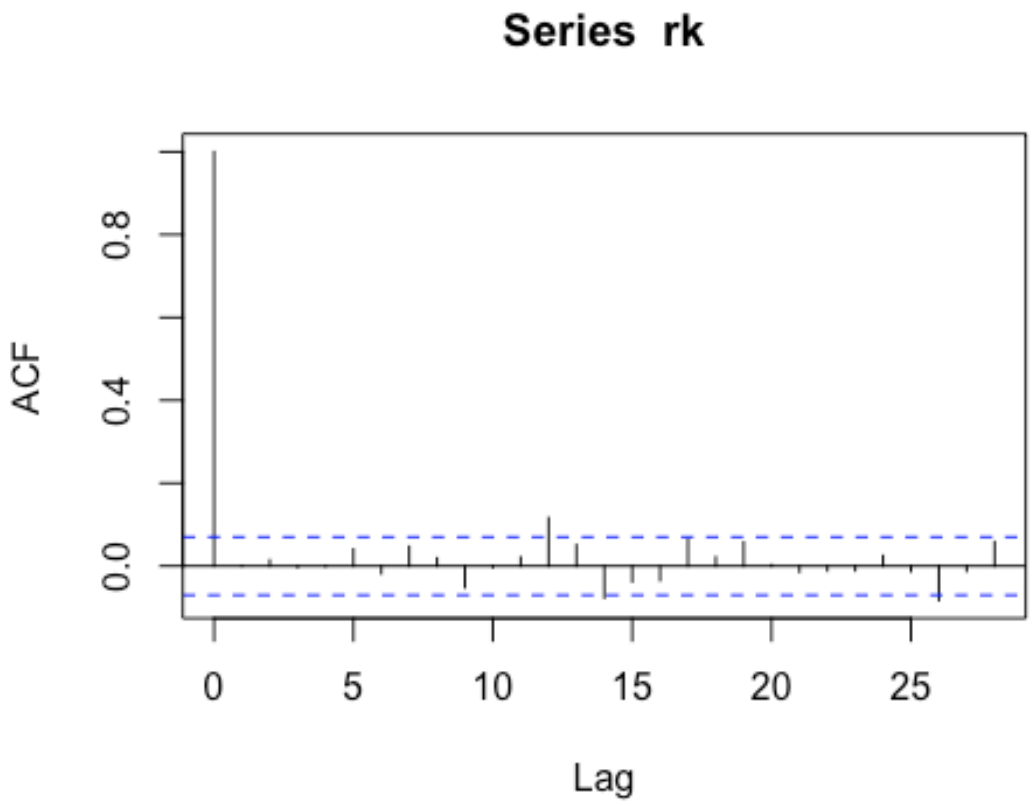

```
Box.test(rt^2,lag=10,type='Ljung')

##
##  Box-Ljung test
##
## data:  rt^2
## X-squared = 917.21, df = 10, p-value < 2.2e-16

#1c
m1=garchFit(~arma(1,0)+garch(1,1),data=rt,trace=F)
summary(m1)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 1), data = rt, trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x7f9b8abd9a10>
##  [data = rt]
##
```

```
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##         mu         ar1       omega      alpha1       beta1
## 4.8298e-04  1.6866e-02  4.4779e-06  4.9720e-02  9.3866e-01
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     4.830e-04   3.075e-04    1.571 0.116297
## ar1    1.687e-02   2.006e-02    0.841 0.400353
## omega  4.478e-06   1.278e-06    3.503 0.000461 ***
## alpha1 4.972e-02   8.191e-03    6.070 1.28e-09 ***
## beta1  9.387e-01   1.031e-02   91.048  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  7378.56    normalized:  2.599916
##
## Description:
##  Wed Apr 28 13:20:57 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  3298.441  0
##  Shapiro-Wilk Test  R    W      0.9663735 0
##  Ljung-Box Test     R    Q(10)  12.37554  0.2607088
##  Ljung-Box Test     R    Q(15)  14.79514  0.4662719
##  Ljung-Box Test     R    Q(20)  19.20107  0.5087928
##  Ljung-Box Test     R^2  Q(10)  0.980939  0.9998424
##  Ljung-Box Test     R^2  Q(15)  3.682825  0.9986048
##  Ljung-Box Test     R^2  Q(20)  6.9285    0.996913
##  LM Arch Test       R    TR^2   2.723165  0.9972029
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -5.196308 -5.185823 -5.196314 -5.192526

#since Ljung-Box test for both R and R^2 we cannot reject H0 then we can say
that the model is adequate in mean equation and volatility model is adequate
#plot(m1)
#selection:13

#1d
```

```
m2=garchFit(~garch(1,1),data=rt,cond.dist="std",trace=F)
summary(m2)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = rt, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x7f9b88440440>
##  [data = rt]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##         mu       omega      alpha1       beta1       shape
## 5.9780e-04  4.2035e-06  7.2376e-02  9.2033e-01  5.0958e+00
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     5.978e-04   2.702e-04    2.212  0.02695 *
## omega  4.203e-06   1.571e-06    2.675  0.00747 **
## alpha1 7.238e-02   1.374e-02    5.267 1.39e-07 ***
## beta1  9.203e-01   1.472e-02   62.503  < 2e-16 ***
## shape  5.096e+00   4.825e-01   10.561  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  7507.106    normalized:  2.64521
##
## Description:
##  Wed Apr 28 13:20:57 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  4056.502  0
##  Shapiro-Wilk Test  R    W      0.9639091 0
##  Ljung-Box Test     R    Q(10)  14.77968  0.140303
##  Ljung-Box Test     R    Q(15)  16.74279  0.3344718
##  Ljung-Box Test     R    Q(20)  20.39783  0.433304
```

```
##  Ljung-Box Test     R^2  Q(10)  2.953085  0.9825066
##  Ljung-Box Test     R^2  Q(15)  5.482428  0.9871938
##  Ljung-Box Test     R^2  Q(20)  9.458146  0.9769677
##  LM Arch Test       R    TR^2   4.273688  0.977976
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -5.286897 -5.276412 -5.286903 -5.283115

#since Ljung-Box test for both R and R^2 we cannot reject H0 then we can say
that the model is adequate in mean equation and volatility model is adequate
#plot(m2)
#selection:13
#1e


#1f
predict(m2,5)

##   meanForecast  meanError standardDeviation
## 1 0.0005977987 0.01515760        0.01515760
## 2 0.0005977987 0.01524072        0.01524072
## 3 0.0005977987 0.01532280        0.01532280
## 4 0.0005977987 0.01540384        0.01540384
## 5 0.0005977987 0.01548387        0.01548387

#1g
predict(m2,5)

##   meanForecast  meanError standardDeviation
## 1 0.0005977987 0.01515760        0.01515760
## 2 0.0005977987 0.01524072        0.01524072
## 3 0.0005977987 0.01532280        0.01532280
## 4 0.0005977987 0.01540384        0.01540384
## 5 0.0005977987 0.01548387        0.01548387

#Question2
#1b
k=read.table("m-kovw-5116.txt",header=T)
head(k)

##   PERMNO     date        ko    vwretd
## 1  11308 19520131  0.024390  0.017002
## 2  11308 19520229  0.009524 -0.025141
## 3  11308 19520331  0.016509  0.045870
## 4  11308 19520430 -0.016393 -0.049148
## 5  11308 19520529  0.028571  0.032847
## 6  11308 19520630  0.046296  0.039575

rk=log(k$ko+1)
acf(rk)
```

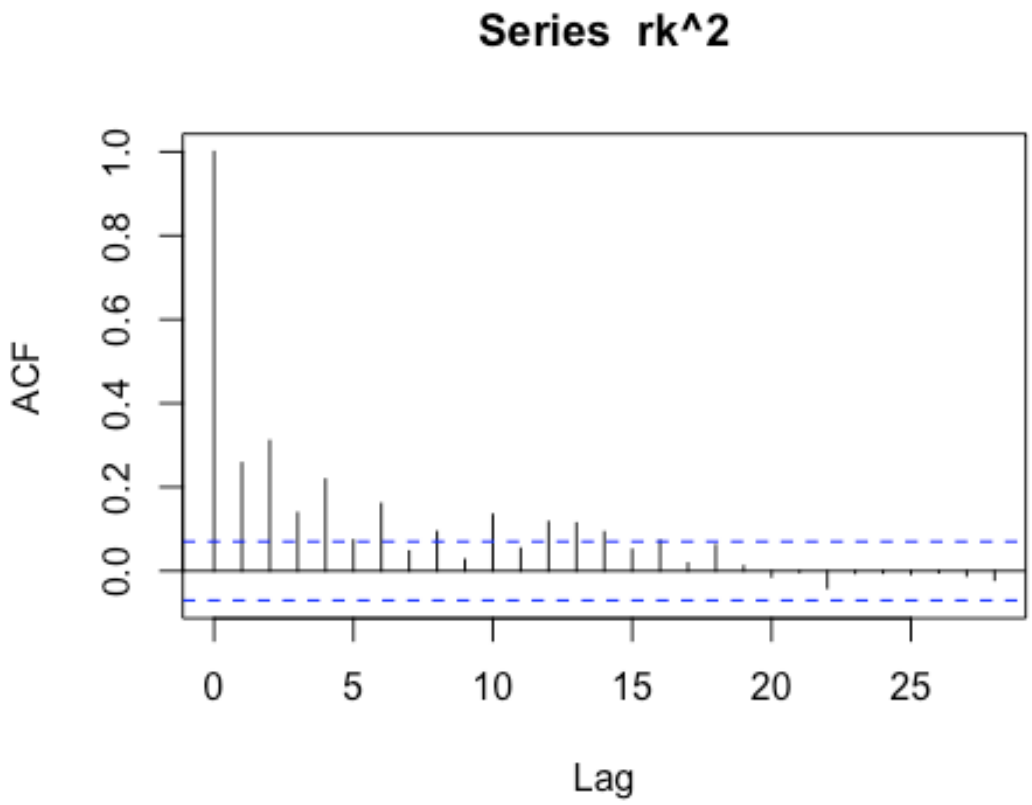



```
table.Stats(rk)

##
## Observations    780.0000
## NAs               0.0000
## Minimum          -0.3400
## Quartile 1       -0.0208
## Median            0.0108
## Arithmetic Mean   0.0103
## Geometric Mean    0.0086
## Quartile 3        0.0443
## Maximum           0.2288
## SE Mean           0.0021
## LCL Mean (0.95)   0.0063
## UCL Mean (0.95)   0.0144
## Variance          0.0033
## Stdev             0.0578
## Skewness         -0.4728
## Kurtosis          3.0868

t.test(rk)

##
##  One Sample t-test
```

```
##
## data:  rk
## t = 4.9853, df = 779, p-value = 7.628e-07
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.00625636 0.01438347
## sample estimates:
##  mean of x
## 0.01031992
```

```
#since p value is less than0.05, we cannot reject H0 then the expected value
of log return is 0
```

```
acf(rk^2)
```




```
Box.test(rk,lag=10,type='Ljung')
```

```
##
##  Box-Ljung test
##
## data:  rk
## X-squared = 5.9201, df = 10, p-value = 0.8219
```

```r
#since p value is more than 0,05 then we cannot refect H0 means that there is no correlation between log return

Box.test(rk^2,lag=10,type='Ljung')
```

```
##
##  Box-Ljung test
##
## data:  rk^2
## X-squared = 228.23, df = 10, p-value < 2.2e-16
```

```r
#since p value is less than 0,05 then we refect H0 means that there is correlation between log return-squared, there is ARCH effect in rt with 95% CI

#2b
mk1=garchFit(~arma(1,0)+garch(1,1),data=rk,trace=F)
summary(mk1)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 1), data = rk, trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x7f9b8aa9f8d8>
##  [data = rk]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##          mu          ar1        omega       alpha1        beta1
##  0.01124544  -0.02633742   0.00018112   0.09535029   0.84861593
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu      1.125e-02   1.897e-03    5.929 3.05e-09 ***
## ar1    -2.634e-02   3.881e-02   -0.679  0.49740
## omega   1.811e-04   5.852e-05    3.095  0.00197 **
## alpha1  9.535e-02   1.915e-02    4.978 6.42e-07 ***
## beta1   8.486e-01   2.766e-02   30.675  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Log Likelihood:
##  1170.664    normalized:  1.500852
##
## Description:
##  Wed Apr 28 13:20:57 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  92.91946  0
##  Shapiro-Wilk Test  R    W      0.9857081 6.655604e-07
##  Ljung-Box Test     R    Q(10)  9.306169  0.5033144
##  Ljung-Box Test     R    Q(15)  22.9901   0.0843502
##  Ljung-Box Test     R    Q(20)  27.44814  0.1231201
##  Ljung-Box Test     R^2  Q(10)  12.63377  0.2448749
##  Ljung-Box Test     R^2  Q(15)  13.62088  0.5544545
##  Ljung-Box Test     R^2  Q(20)  15.19817  0.7649584
##  LM Arch Test       R    TR^2   10.65102  0.5590389
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -2.988883 -2.959016 -2.988965 -2.977396
```

#P-value is more than 0.05 for all means that model is adequate in both mean and volatility equation.

#fitted model

#2c

```
mk2=garchFit(~arma(1,0)+garch(1,1),data=rk,cond.dist="std",trace=F)
summary(mk2)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 1), data = rk, cond.dist =
"std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x7f9b8be10268>
##  [data = rk]
##
## Conditional Distribution:
##  std
```

```
##
## Coefficient(s):
##          mu          ar1        omega       alpha1        beta1
shape
##  0.01124020  -0.01887601   0.00017395   0.09642928   0.85044150
7.47877780
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu      1.124e-02   1.810e-03    6.211 5.27e-10 ***
## ar1    -1.888e-02   3.691e-02   -0.511  0.60904
## omega   1.739e-04   6.596e-05    2.637  0.00836 **
## alpha1  9.643e-02   2.338e-02    4.124 3.72e-05 ***
## beta1   8.504e-01   3.267e-02   26.028  < 2e-16 ***
## shape   7.479e+00   1.840e+00    4.066 4.79e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1184.863    normalized:  1.519055
##
## Description:
##  Wed Apr 28 13:20:58 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  93.6433   0
##  Shapiro-Wilk Test  R    W      0.9857385 6.832848e-07
##  Ljung-Box Test     R    Q(10)  8.966733  0.5352637
##  Ljung-Box Test     R    Q(15)  22.44818  0.09657967
##  Ljung-Box Test     R    Q(20)  26.86769  0.1390276
##  Ljung-Box Test     R^2  Q(10)  12.48941  0.2536355
##  Ljung-Box Test     R^2  Q(15)  13.37442  0.5734021
##  Ljung-Box Test     R^2  Q(20)  14.90709  0.7816988
##  LM Arch Test       R    TR^2   10.48089  0.5738501
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.022725 -2.986885 -3.022843 -3.008941

#P-value is more than 0.05 for all means that model is adequate in both mean
and volatility equation.

#fitted model
```

```r
#2d
mk3=garchFit(~garch(1,1),data=rk,trace=F)
summary(mk3)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = rk, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x7f9b8a9ce7c0>
##  [data = rk]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##         mu       omega      alpha1       beta1
## 0.01098417  0.00018497  0.09479925  0.84780406
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.098e-02   1.846e-03    5.950 2.68e-09 ***
## omega  1.850e-04   5.899e-05    3.135  0.00172 **
## alpha1 9.480e-02   1.912e-02    4.958 7.11e-07 ***
## beta1  8.478e-01   2.787e-02   30.416  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1170.393    normalized:  1.500504
##
## Description:
##  Wed Apr 28 13:20:58 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  95.07163  0
##  Shapiro-Wilk Test  R    W      0.9856773 6.481596e-07
##  Ljung-Box Test     R    Q(10)  8.125181  0.6166108
##  Ljung-Box Test     R    Q(15)  21.27199  0.128362
##  Ljung-Box Test     R    Q(20)  25.62765  0.1784646
##  Ljung-Box Test     R^2  Q(10)  12.90586  0.228983
```

```
##  Ljung-Box Test     R^2  Q(15)  13.87463  0.5350581
##  Ljung-Box Test     R^2  Q(20)  15.35522  0.755734
##  LM Arch Test       R    TR^2   10.96004  0.532346
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -2.990752 -2.966858 -2.990804 -2.981562

#P-value is more than 0.05 for all means that model is adequate in both mean
and volatility equation.

#fitted model

#2e
mk4=garchFit(~garch(1,1),data=rk,cond.dist = "std",trace=F)
summary(mk4)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = rk, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x7f9b8b963188>
##  [data = rk]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##         mu       omega      alpha1       beta1       shape
## 0.01105016  0.00017528  0.09632874  0.85006800  7.48604505
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.105e-02   1.757e-03    6.291 3.16e-10 ***
## omega  1.753e-04   6.627e-05    2.645  0.00817 **
## alpha1 9.633e-02   2.337e-02    4.123 3.75e-05 ***
## beta1  8.501e-01   3.277e-02   25.941  < 2e-16 ***
## shape  7.486e+00   1.840e+00    4.069 4.72e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Log Likelihood:
##  1184.68    normalized:  1.518821
##
## Description:
##  Wed Apr 28 13:20:58 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  95.31715  0
##  Shapiro-Wilk Test  R    W      0.9857263 6.761141e-07
##  Ljung-Box Test     R    Q(10)  8.228765  0.6065024
##  Ljung-Box Test     R    Q(15)  21.34759  0.1260864
##  Ljung-Box Test     R    Q(20)  25.67699  0.1767469
##  Ljung-Box Test     R^2  Q(10)  12.61146  0.2462139
##  Ljung-Box Test     R^2  Q(15)  13.4693   0.5660982
##  Ljung-Box Test     R^2  Q(20)  14.93694  0.7800047
##  LM Arch Test       R    TR^2   10.62989  0.560875
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.024822 -2.994954 -3.024903 -3.013334
```

#P-value is more than 0.05 for all means that model is adequate in both mean and volatility equation.

#fitted model

#2f
#we compare between AIC and BIC in both model mk1 and mk4
#and we found that the lower value the higher effectiveness of medel
#we choose (e) that gives us the lower AIC and BIC

#Question3
#3a

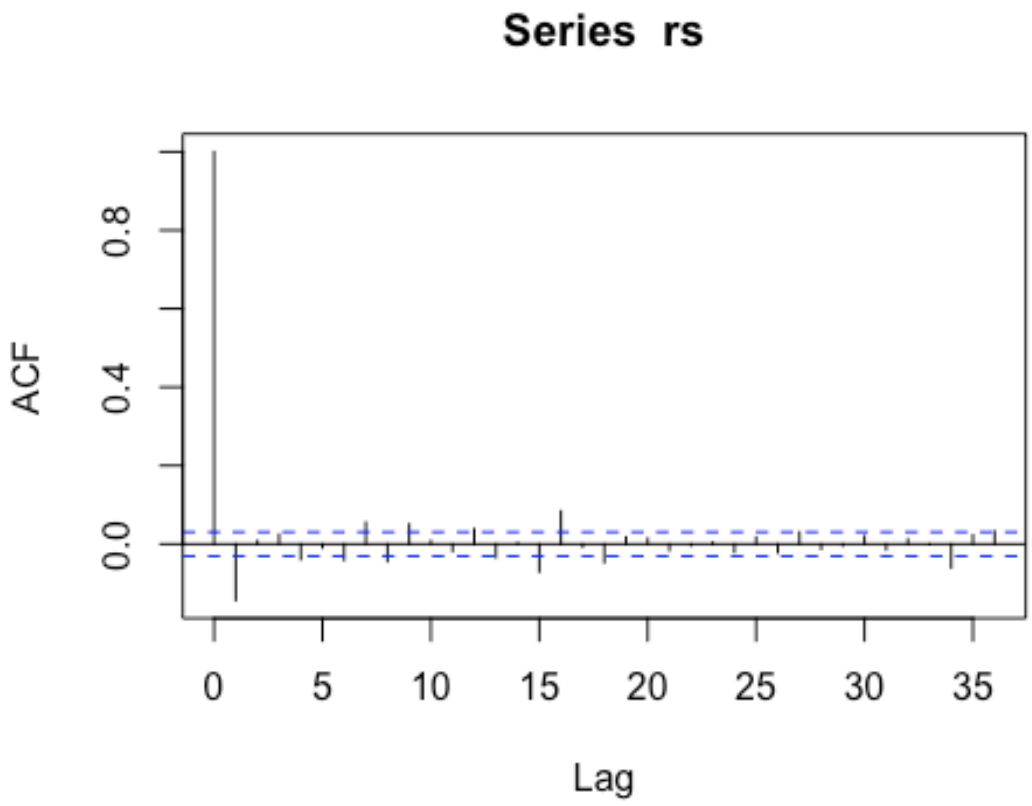
```
getSymbols("^GSPC",from="2005-01-02",to="2021-03-31")
```

```
## [1] "^GSPC"
```

```
rs<-diff(log(as.numeric((GSPC[,6]))))
table.Stats(rs)
```

```
##
## Observations    4087.0000
## NAs                0.0000
## Minimum           -0.1277
## Quartile 1        -0.0039
## Median             0.0007
## Arithmetic Mean    0.0003
## Geometric Mean     0.0002
```

```
## Quartile 3         0.0056
## Maximum            0.1096
## SE Mean            0.0002
## LCL Mean (0.95)   -0.0001
## UCL Mean (0.95)    0.0007
## Variance           0.0002
## Stdev              0.0125
## Skewness          -0.5633
## Kurtosis          14.0029

t.test(rs)

##
##  One Sample t-test
##
## data:  rs
## t = 1.4961, df = 4086, p-value = 0.1347
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -9.051939e-05  6.737464e-04
## sample estimates:
##    mean of x
## 0.0002916135

#the expected value of rt is 0 since p-value is more than 0.05
acf(rs)
```



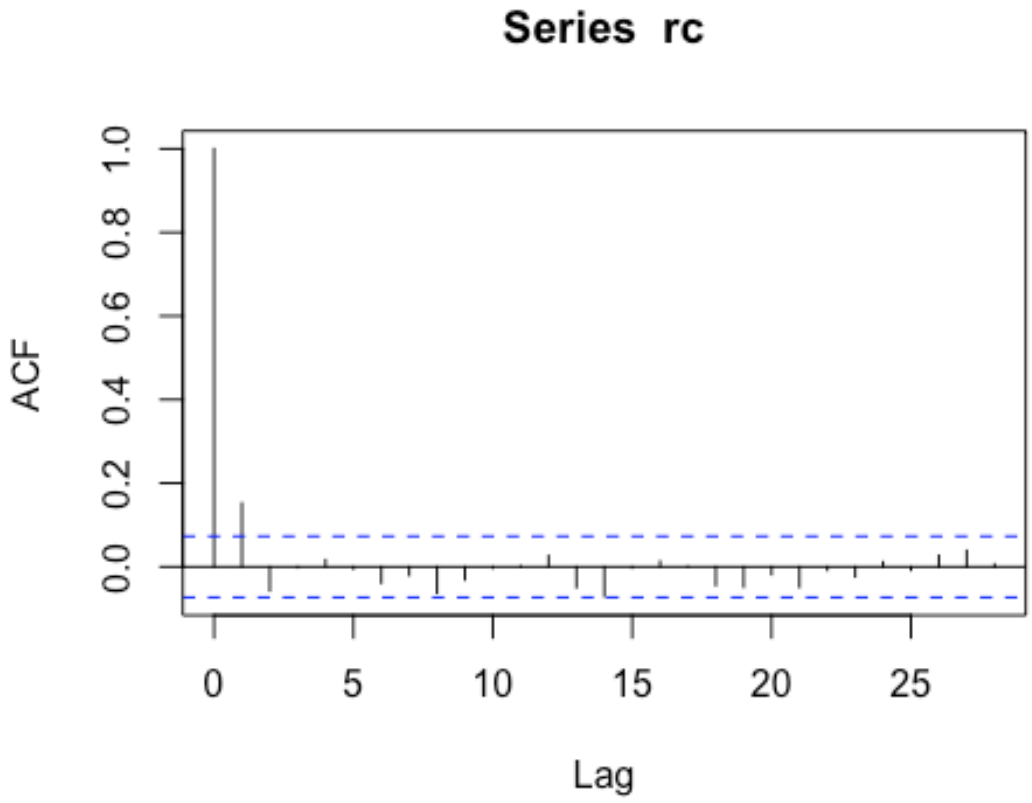

```
Box.test(rs,lag=10,type='Ljung')

##
##  Box-Ljung test
##
## data:  rs
## X-squared = 131.85, df = 10, p-value < 2.2e-16

#there is no serial correlation in rt

#3b
ms1=garchFit(arima()~garch(1,1),data=rs,trace=F)
summary(ms1)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = arima() ~ garch(1, 1), data = rs, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x7f9b87bbe760>
```

```
##  [data = rs]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##         mu       omega      alpha1       beta1
## 6.7965e-04  2.7630e-06  1.4185e-01  8.3682e-01
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     6.797e-04   1.164e-04    5.837 5.33e-09 ***
## omega  2.763e-06   3.545e-07    7.794 6.44e-15 ***
## alpha1 1.418e-01   1.200e-02   11.822  < 2e-16 ***
## beta1  8.368e-01   1.198e-02   69.853  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  13417.79    normalized:  3.283041
##
## Description:
##  Wed Apr 28 13:20:59 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  1128.761  0
##  Shapiro-Wilk Test  R    W      0.9727248 0
##  Ljung-Box Test     R    Q(10)  25.75991  0.004076864
##  Ljung-Box Test     R    Q(15)  33.37343  0.004166121
##  Ljung-Box Test     R    Q(20)  38.81779  0.007023858
##  Ljung-Box Test     R^2  Q(10)  15.24652  0.1233293
##  Ljung-Box Test     R^2  Q(15)  17.48525  0.2906928
##  Ljung-Box Test     R^2  Q(20)  18.66957  0.5433881
##  LM Arch Test       R    TR^2   15.93476  0.1942425
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -6.564125 -6.557944 -6.564127 -6.561936

#from thr box-test, volatility model is adequate but the mean equation model
is not adequate as p-value is less than0.05
#plot(ms1)
#selection:13
#fitted model
```

```r
#3c
ms2=garchFit(arima()~garch(1,1),data=rs,cond.dist = "std",trace=F)
summary(ms2)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = arima() ~ garch(1, 1), data = rs, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x7f9b846d7450>
##  [data = rs]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##         mu       omega      alpha1       beta1       shape
## 8.4344e-04  1.7504e-06  1.4341e-01  8.5400e-01  5.1216e+00
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     8.434e-04   1.047e-04    8.057 8.88e-16 ***
## omega  1.750e-06   3.696e-07    4.736 2.19e-06 ***
## alpha1 1.434e-01   1.476e-02    9.719  < 2e-16 ***
## beta1  8.540e-01   1.301e-02   65.646  < 2e-16 ***
## shape  5.122e+00   4.333e-01   11.821  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  13552.39    normalized:  3.315974
##
## Description:
##  Wed Apr 28 13:20:59 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  1437.833  0
##  Shapiro-Wilk Test  R    W      0.9705412 0
##  Ljung-Box Test     R    Q(10)  25.99939  0.003741002
```

```
##  Ljung-Box Test     R    Q(15)  33.61634  0.003853714
##  Ljung-Box Test     R    Q(20)  38.85139  0.006956808
##  Ljung-Box Test     R^2  Q(10)  12.3947   0.2595084
##  Ljung-Box Test     R^2  Q(15)  17.01071  0.3182243
##  Ljung-Box Test     R^2  Q(20)  19.6441   0.4803813
##  LM Arch Test       R    TR^2   13.90916  0.3065471
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -6.629501 -6.621775 -6.629504 -6.626765

#plot(ms2)13
#the mean equation is not adequate but the volatility model is adequate from
the Box test


#3d
predict(ms2,5)

##   meanForecast   meanError standardDeviation
## 1 0.0008434408 0.009016638       0.009016638
## 2 0.0008434408 0.009101650       0.009101650
## 3 0.0008434408 0.009185660       0.009185660
## 4 0.0008434408 0.009268693       0.009268693
## 5 0.0008434408 0.009350777       0.009350777

#Question4
#4a
c=read.table("m-deciles.txt",header=T)
head(c)

##      caldt   CAP1RET   CAP2RET   CAP3RET   CAP4RET   CAP5RET   CAP6RET
## 1 19510131  0.083681  0.082608  0.099147  0.079266  0.087845  0.086179
## 2 19510228 -0.000102  0.010265  0.008312  0.020972  0.009975  0.004891
## 3 19510331 -0.050423 -0.046779 -0.034764 -0.022521 -0.035481 -0.039383
## 4 19510430  0.037914  0.036413  0.045078  0.031518  0.041554  0.035598
## 5 19510531 -0.033197 -0.031897 -0.026911 -0.030087 -0.027572 -0.025027
## 6 19510629 -0.056899 -0.052380 -0.063182 -0.044404 -0.052655 -0.056175
##     CAP7RET   CAP8RET   CAP9RET  CAP10RET
## 1  0.063453  0.077874  0.054170  0.052145
## 2  0.015361  0.011638  0.017117  0.014894
## 3 -0.038677 -0.027989 -0.018675 -0.016890
## 4  0.044925  0.046933  0.044620  0.053184
## 5 -0.013628 -0.023333 -0.016724 -0.023748
## 6 -0.040582 -0.043436 -0.020323 -0.018880

rc=log(c$CAP9RET+1)
acf(rc)
```

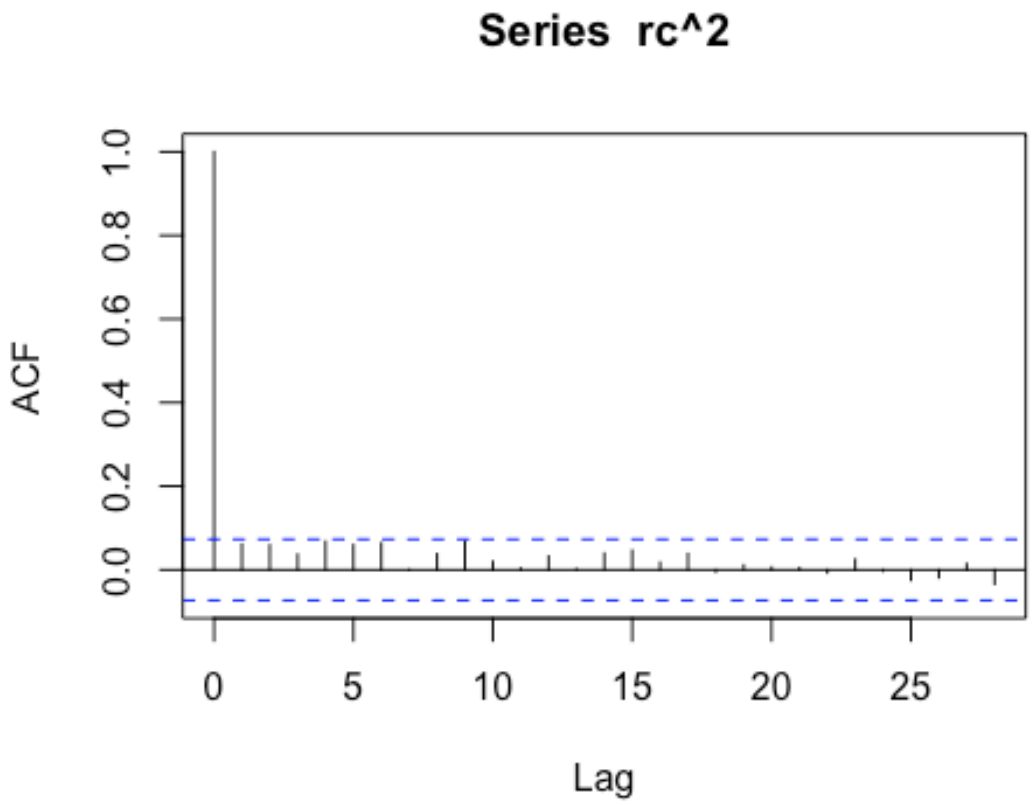



```
table.Stats(rc)

##
## Observations    720.0000
## NAs               0.0000
## Minimum          -0.3276
## Quartile 1       -0.0190
## Median            0.0144
## Arithmetic Mean   0.0096
## Geometric Mean    0.0083
## Quartile 3        0.0410
## Maximum           0.2038
## SE Mean           0.0018
## LCL Mean (0.95)   0.0059
## UCL Mean (0.95)   0.0132
## Variance          0.0025
## Stdev             0.0496
## Skewness         -0.9583
## Kurtosis          4.4354

t.test(rc)

##
##  One Sample t-test
```

```
##
## data:  rc
## t = 5.1808, df = 719, p-value = 2.873e-07
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.005946562 0.013203545
## sample estimates:
##   mean of x
## 0.009575054
```

```
# since p-value is lessthan alpha at 0.05 we reject the H0 and means that the expected return of log return is not 0
```

```
acf(rc^2)
```




```
Box.test(rc,lag=10,type='Ljung')
```

```
##
##  Box-Ljung test
##
## data:  rc
## X-squared = 24.257, df = 10, p-value = 0.006946
```

```
#since p-value is less than 0.05 we reject the H0 and hence there is
autocorrelation between log return

mc1=auto.arima(rc)
mc1
```

```
## Series: rc
## ARIMA(0,0,2) with non-zero mean
##
## Coefficients:
##          ma1      ma2    mean
##       0.1660  -0.0558  0.0096
## s.e.  0.0373   0.0370  0.0020
##
## sigma^2 estimated as 0.002392:  log likelihood=1152.66
## AIC=-2297.32   AICc=-2297.26   BIC=-2279
```

```
summary(mc1)
```

```
## Series: rc
## ARIMA(0,0,2) with non-zero mean
##
## Coefficients:
##          ma1      ma2    mean
##       0.1660  -0.0558  0.0096
## s.e.  0.0373   0.0370  0.0020
##
## sigma^2 estimated as 0.002392:  log likelihood=1152.66
## AIC=-2297.32   AICc=-2297.26   BIC=-2279
##
## Training set error measures:
##                        ME     RMSE        MAE       MPE     MAPE      MASE
## Training set 1.149455e-06 0.048807 0.03675026 -137.9858 502.9481 0.7525704
##                     ACF1
## Training set 0.00044559
```

```
#4b
Box.test(rc^2,lag=10,type='Ljung')
```

```
##
##  Box-Ljung test
##
## data:  rc^2
## X-squared = 19.824, df = 10, p-value = 0.03096
```

```
#we reject H0 since p-value is less than 0.05 and hence there is
autocorrelation in log return-squared
#there is ARCH effect with 95% CI

#4C
```

```
mc2=garchFit(~arma(1,0)+garch(1,0),data=rc,trace=F)
summary(mc2)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 0), data = rc, trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 0)
## <environment: 0x7f9b82962e80>
##  [data = rc]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##      mu      ar1    omega   alpha1
## 0.01053  0.14707  0.00200  0.18152
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     0.0105300   0.0019275    5.463 4.68e-08 ***
## ar1    0.1470670   0.0424301    3.466 0.000528 ***
## omega  0.0020000   0.0001482   13.493  < 2e-16 ***
## alpha1 0.1815182   0.0651142    2.788 0.005309 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1158.628    normalized:  1.609206
##
## Description:
##  Wed Apr 28 13:20:59 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  647.6357  0
##  Shapiro-Wilk Test  R    W      0.962804  1.502752e-12
##  Ljung-Box Test     R    Q(10)  8.582995  0.572082
##  Ljung-Box Test     R    Q(15)  12.95811  0.6055337
##  Ljung-Box Test     R    Q(20)  15.77362  0.7305655
##  Ljung-Box Test     R^2  Q(10)  8.153476  0.6138486
##  Ljung-Box Test     R^2  Q(15)  12.29206  0.6568012
```

```
##  Ljung-Box Test     R^2  Q(20)  13.57787  0.851238
##  LM Arch Test       R    TR^2   8.24593   0.7656286
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.207301 -3.181861 -3.207363 -3.197480

#all p-value of Box test are more that 0.05 which mean that we reject H0 and
the model is adequate in both mean equation and volatility model

#fitted model


#4d
mc3=garchFit(~arma(1,0)+garch(1,0),data=rc,cond.dist="std",trace=F)
summary(mc3)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 0), data = rc, cond.dist =
"std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 0)
## <environment: 0x7f9b8b9603e8>
##  [data = rc]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##        mu        ar1      omega     alpha1      shape
## 0.0116189  0.1076982  0.0019203  0.1900830  6.4225253
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     0.0116189   0.0017710    6.561 5.35e-11 ***
## ar1    0.1076982   0.0403169    2.671  0.00756 **
## omega  0.0019203   0.0001818   10.564  < 2e-16 ***
## alpha1 0.1900830   0.0713692    2.663  0.00774 **
## shape  6.4225253   1.3115897    4.897 9.74e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Log Likelihood:
##  1187.516    normalized:  1.649328
##
## Description:
##  Wed Apr 28 13:21:00 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  680.4834  0
##  Shapiro-Wilk Test  R    W      0.9612945 7.49198e-13
##  Ljung-Box Test     R    Q(10)  9.486455  0.4866411
##  Ljung-Box Test     R    Q(15)  13.8214   0.5391158
##  Ljung-Box Test     R    Q(20)  17.0087   0.6524086
##  Ljung-Box Test     R^2  Q(10)  7.567444  0.671006
##  Ljung-Box Test     R^2  Q(15)  11.42176  0.7221637
##  Ljung-Box Test     R^2  Q(20)  12.79422  0.8860373
##  LM Arch Test       R    TR^2   7.723697  0.8063327
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.284768 -3.252967 -3.284863 -3.272491
```

#all p-value of Box test are more that 0.05 which mean that we reject H0 and the model is adequate in both mean equation and volatility model

#fitted model

#4e

```
mc4=garchFit(~garch(1,0),data=rc,trace=F)
summary(mc4)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 0), data = rc, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 0)
## <environment: 0x7f9b885783e0>
##  [data = rc]
##
## Conditional Distribution:
##  norm
##
```

```
## Coefficient(s):
##       mu     omega    alpha1
## 0.012346  0.002016  0.194126
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.012346    0.001923    6.421 1.35e-10 ***
## omega   0.002016    0.000145   13.900  < 2e-16 ***
## alpha1  0.194126    0.062209    3.121  0.00181 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1152.289    normalized:  1.600401
##
## Description:
##  Wed Apr 28 13:21:00 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  746.8024  0
##  Shapiro-Wilk Test  R    W      0.9570702 1.171061e-13
##  Ljung-Box Test     R    Q(10)  18.72223  0.04393591
##  Ljung-Box Test     R    Q(15)  23.27998  0.07837365
##  Ljung-Box Test     R    Q(20)  27.61004  0.1189566
##  Ljung-Box Test     R^2  Q(10)  7.012055  0.7243064
##  Ljung-Box Test     R^2  Q(15)  10.3604   0.7964784
##  Ljung-Box Test     R^2  Q(20)  11.97825  0.9168225
##  LM Arch Test       R    TR^2   7.047101  0.8544853
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.192468 -3.173388 -3.192503 -3.185102
```

```
#all p-value of Box test are more that 0.05 which mean that we reject H0 and
the model is adequate in both mean equation and volatility model

#fitted model



#4f
mc5=garchFit(~garch(1,0),data=rc,cond.dist = "std",trace=F)
summary(mc5)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 0), data = rc, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 0)
## <environment: 0x7f9b8997f030>
##  [data = rc]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##       mu     omega    alpha1     shape
## 0.013356  0.001928  0.204163  6.220222
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      0.013356    0.001685    7.927 2.22e-15 ***
## omega   0.001928    0.000185   10.421  < 2e-16 ***
## alpha1  0.204163    0.072375    2.821  0.00479 **
## shape   6.220223    1.236608    5.030 4.90e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1183.349    normalized:  1.64354
##
## Description:
##  Wed Apr 28 13:21:00 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  746.3878  0
##  Shapiro-Wilk Test  R    W      0.9574271 1.363165e-13
##  Ljung-Box Test     R    Q(10)  18.51406  0.04688705
##  Ljung-Box Test     R    Q(15)  22.99926  0.08415548
##  Ljung-Box Test     R    Q(20)  27.3947   0.1245202
##  Ljung-Box Test     R^2  Q(10)  6.667871  0.7563837
##  Ljung-Box Test     R^2  Q(15)  10.0157   0.8187514
##  Ljung-Box Test     R^2  Q(20)  11.63085  0.928196
##  LM Arch Test       R    TR^2   6.819315  0.8693193
```

```
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.275969 -3.250529 -3.276031 -3.266148

#all LjungBox test have p-value more than 0.05 except lag=10 in meanequation
#we cannot reject H0 and means that the model is adequate in volatility
equation


#4g
#we compare between AIC and BIC in both model mc2 and mc5
#and we found that the lower value the higher effectiveness of medel
#we choose (f) that gives us the lower AIC and BIC
```