

Solution_Assignment5.R

wasinsiwasarit

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```
#EE435 Wasin Siwasarit #Assignment5
# Spring/2020
#Step1: You need to set your current directory
setwd("/Users/wasinsiwasarit/Dropbox/My Mac (Wasins-MacBook-Pro.local)/Desktop/Solution_assignment")
library(fBasics)

## Loading required package: timeDate
## Loading required package: timeSeries

library(timeDate)
library(timeSeries)
library(fGarch)
library(quantmod)

## Loading required package: xts
## Loading required package: zoo
##
## Attaching package: 'zoo'
## The following object is masked from 'package:timeSeries':
##
##   time<-
## The following objects are masked from 'package:base':
##
##   as.Date, as.Date.numeric
## Loading required package: TTR
##
## Attaching package: 'TTR'
## The following object is masked from 'package:fBasics':
##
##   volatility
## Registered S3 method overwritten by 'quantmod':
##   method      from
##   as.zoo.data.frame zoo

library(forecast)
# Step2: You need to clear the previous work
cat(rep("\n",50)) #clear R Console

getSymbols("CAT",from="2006-01-03",to="2017-04-14")
```

```
## '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"
```

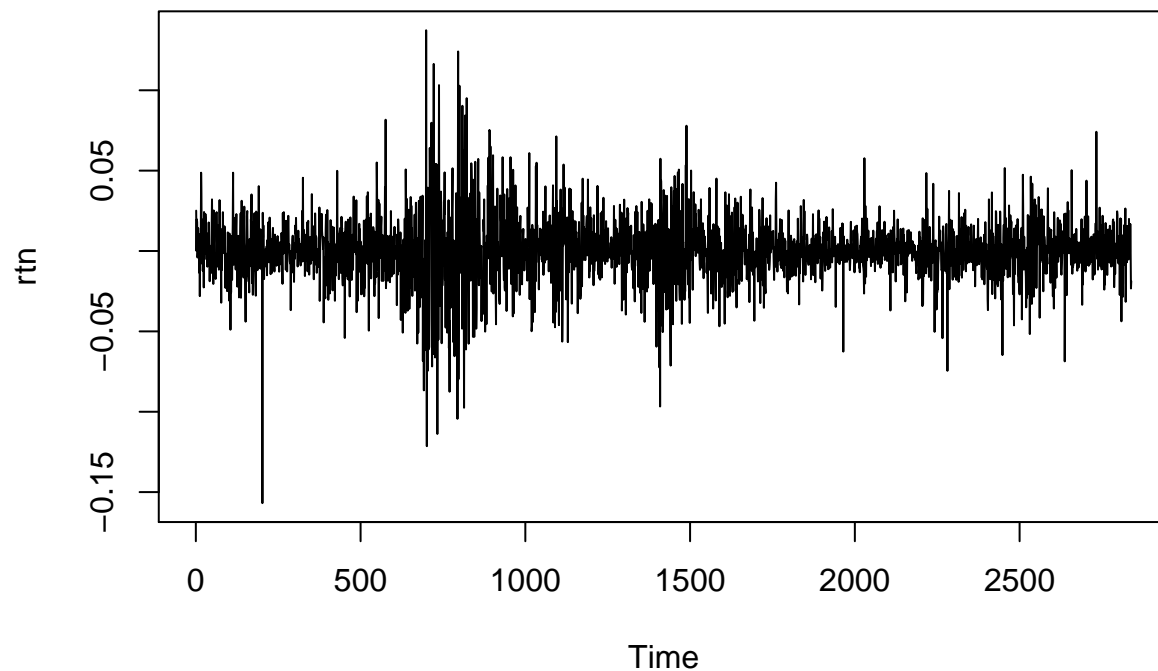
```
head(CAT)
```

```
##          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
## 2017-04-06   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
## 2017-04-13   94.60   94.86   93.09   93.10   4706000   83.32072
```

```
rtn =diff(log(as.numeric(CAT[,6])))
ts.plot(rtn)
```



```

# (a)
Box.test(rtn,lag=10,type="Ljung")

##
## Box-Ljung test
##
## data:  rtn
## X-squared = 16.229, df = 10, p-value = 0.09325

#(b)
Box.test(rtn^2,lag=10,type="Ljung")

##
## Box-Ljung test
##
## data:  rtn^2
## X-squared = 917.58, df = 10, p-value < 2.2e-16

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

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.

summary(m1)

##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~arma(1, 0) + garch(1, 1), data = rtn, trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x7fd8dfd8b4f8>
## [data = rtn]
##
## Conditional Distribution:
## norm
##
## Coefficient(s):
##      mu      ar1      omega      alpha1      beta1
## 4.7490e-04 1.7677e-02 4.4860e-06 4.9755e-02 9.3861e-01
##
## Std. Errors:
## based on Hessian
##
## Error Analysis:
##      Estimate Std. Error t value Pr(>|t|)
## mu      4.749e-04 3.075e-04 1.544 0.122480
## ar1     1.768e-02 2.004e-02 0.882 0.377774
## omega  4.486e-06 1.280e-06 3.503 0.000459 ***
## alpha1 4.976e-02 8.200e-03 6.067 1.3e-09 ***
## beta1  9.386e-01 1.032e-02 90.934 < 2e-16 ***
## ---

```

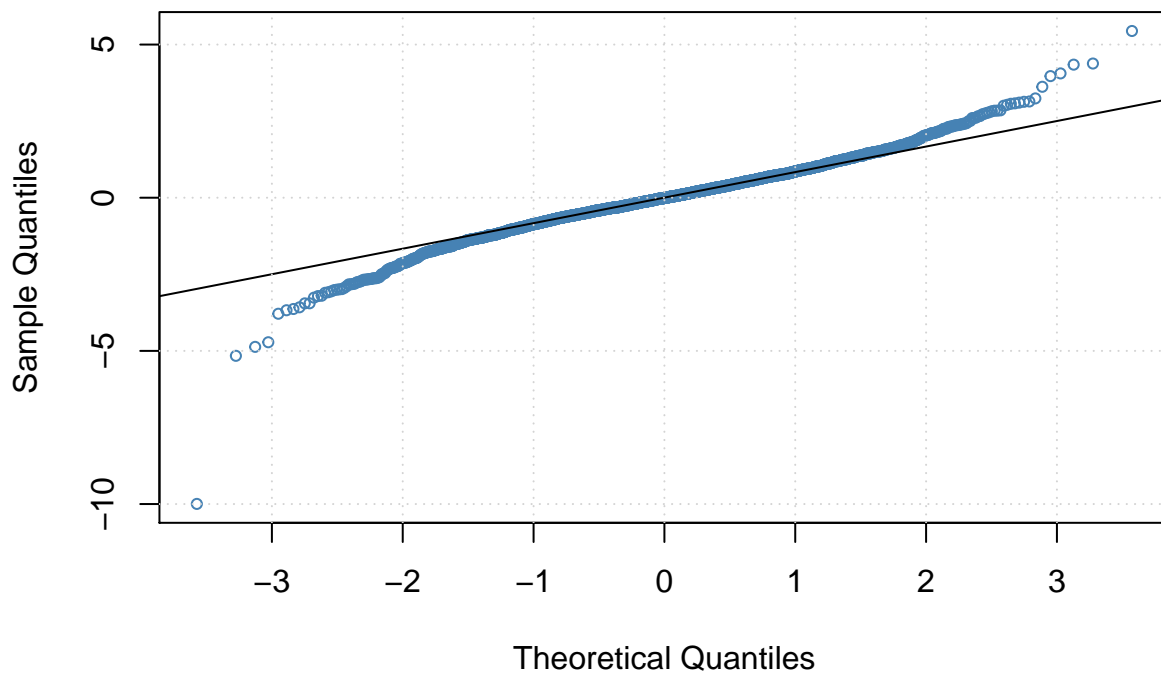
```

## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
## 7381.067    normalized:  2.599883
##
## Description:
## Mon May 17 21:26:45 2021 by user:
##
##
## Standardised Residuals Tests:
##
##                               Statistic p-Value
## Jarque-Bera Test      R      Chi^2 3293.722  0
## Shapiro-Wilk Test     R      W      0.9664334  0
## Ljung-Box Test        R      Q(10) 12.36538  0.2613468
## Ljung-Box Test        R      Q(15) 14.78355  0.4671183
## Ljung-Box Test        R      Q(20) 19.40031  0.4959589
## Ljung-Box Test        R^2    Q(10)  0.9807765  0.9998426
## Ljung-Box Test        R^2    Q(15)  3.684778  0.9986004
## Ljung-Box Test        R^2    Q(20)  6.924134  0.9969265
## LM Arch Test          R      TR^2  2.720581  0.9972158
##
## Information Criterion Statistics:
##      AIC      BIC      SIC      HQIC
## -5.196243 -5.185762 -5.196250 -5.192463

```

```
plot(m1, which = 13)
```

qnorm – QQ Plot



```

#(d)+(e)
m2 = garchFit(~garch(1,1),data=rtn,cond.dist="std",trace=F)

```

```
## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.
```

```
summary(m2)
```

```
##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~garch(1, 1), data = rtn, cond.dist = "std",
## trace = F)
##
## Mean and Variance Equation:
## data ~ garch(1, 1)
## <environment: 0x7fd8df762e80>
## [data = rtn]
##
## Conditional Distribution:
## std
##
## Coefficient(s):
##      mu      omega    alpha1      beta1      shape
## 5.9008e-04 4.2138e-06 7.2389e-02 9.2028e-01 5.1049e+00
##
## Std. Errors:
## based on Hessian
##
## Error Analysis:
##      Estimate Std. Error t value Pr(>|t|)
## mu      5.901e-04 2.703e-04  2.183 0.02904 *
## omega  4.214e-06 1.574e-06  2.678 0.00741 **
## alpha1 7.239e-02 1.375e-02  5.265 1.4e-07 ***
## beta1  9.203e-01 1.474e-02 62.448 < 2e-16 ***
## shape  5.105e+00 4.839e-01 10.549 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
## 7509.292 normalized: 2.645048
##
## Description:
## Mon May 17 21:26:45 2021 by user:
##
##
## Standardised Residuals Tests:
##
##      Statistic p-Value
## Jarque-Bera Test R Chi^2 4047.363 0
## Shapiro-Wilk Test R W 0.9639883 0
## Ljung-Box Test R Q(10) 14.87685 0.1366167
## Ljung-Box Test R Q(15) 16.83467 0.3288433
## Ljung-Box Test R Q(20) 20.67317 0.4165887
## Ljung-Box Test R^2 Q(10) 2.955969 0.9824413
## Ljung-Box Test R^2 Q(15) 5.488358 0.9871219
## Ljung-Box Test R^2 Q(20) 9.459063 0.9769545
```

```
## LM Arch Test      R      TR^2    4.275692  0.9779321
##
## Information Criterion Statistics:
##      AIC      BIC      SIC      HQIC
## -5.286574 -5.276093 -5.286580 -5.282793
```

```
##(f)
pm2 = predict(m2,5)
pm2
```

```
## meanForecast meanError standardDeviation
## 1 0.0005900796 0.01557857      0.01557857
## 2 0.0005900796 0.01565654      0.01565654
## 3 0.0005900796 0.01573356      0.01573356
## 4 0.0005900796 0.01580965      0.01580965
## 5 0.0005900796 0.01588481      0.01588481
```

```
##(g)
qstd(0.975,nu=5.1)
```

```
## [1] 1.992374
lcl = pm2$meanForecast-1.99*pm2$standardDeviation
ucl = pm2$meanForecast+1.99*pm2$standardDeviation
CI = cbind(lcl,ucl)
CI
```

```
##          lcl          ucl
## [1,] -0.03041128 0.03159144
## [2,] -0.03056644 0.03174660
## [3,] -0.03071971 0.03189987
## [4,] -0.03087112 0.03205128
## [5,] -0.03102070 0.03220086
```

```
##Question2
da = read.table("m-kovw-5116.txt",header=T)
dim(da)
```

```
## [1] 780  4
ko =log(da$ko+1)
##(a)
t.test(ko)
```

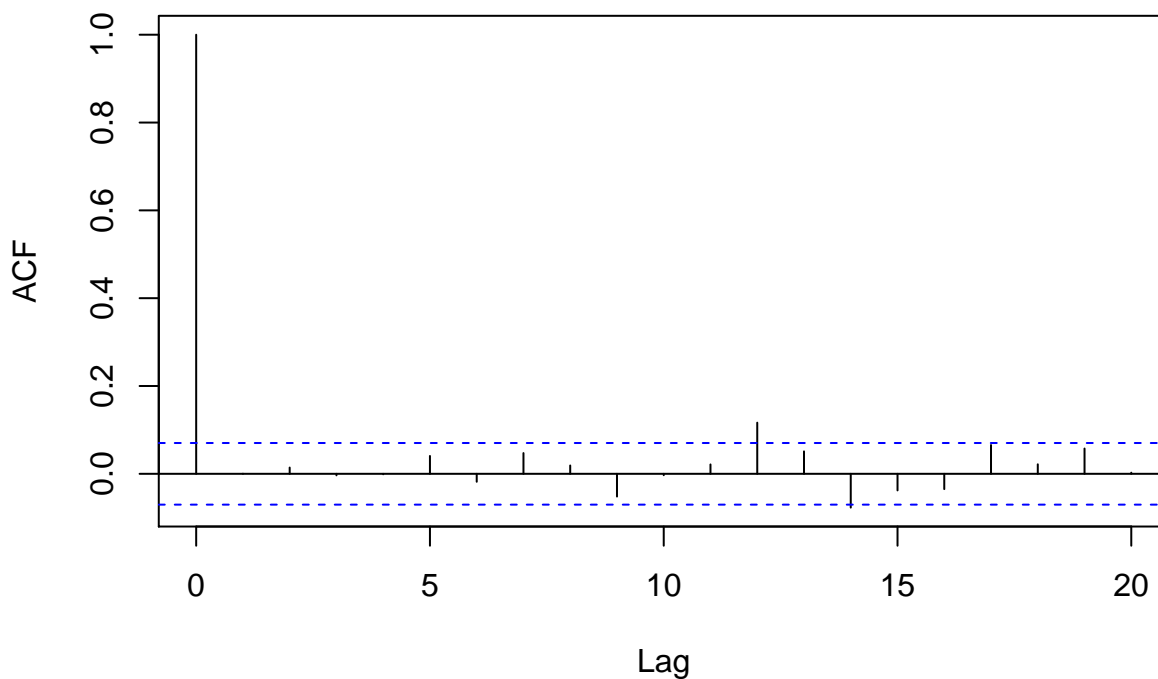
```
##
## One Sample t-test
##
## data: ko
## t = 4.9853, df = 779, p-value = 7.628e-07
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.00625636 0.01438347
## sample estimates:
## mean of x
## 0.01031992
```

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

```
##
```

```
## Box-Ljung test
##
## data: ko
## X-squared = 17.06, df = 12, p-value = 0.1474
acf(ko,lag.max = 20)
```

Series ko



```
at = ko-mean(ko)
Box.test(at^2,lag=12,type="Ljung")
```

```
##
## Box-Ljung test
##
## data: at^2
## X-squared = 255.99, df = 12, p-value < 2.2e-16
```

```
##(b)
m1 = garchFit(~arma(1,0)+garch(1,1),data=ko,trace=F)
```

```
## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.
```

```
summary(m1)
```

```
##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~arma(1, 0) + garch(1, 1), data = ko, trace = F)
##
## Mean and Variance Equation:
```

```

## data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x7fd8e4315580>
## [data = ko]
##
## 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:
## Mon May 17 21:26:45 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
##
##(c)
m2 = garchFit(~arma(1,0)+garch(1,1),data=ko,cond.dist="std",trace=F)

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.

```

```
summary(m2)
```

```
##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~arma(1, 0) + garch(1, 1), data = ko, cond.dist = "std",
## trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x7fd8e82be948>
## [data = ko]
##
## 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:
## Mon May 17 21:26:46 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
#(d)
m3 = garchFit(~garch(1,1),data=ko,trace=F)

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.
summary(m3)

##
## Title:
##   GARCH Modelling
##
## Call:
##   garchFit(formula = ~garch(1, 1), data = ko, trace = F)
##
## Mean and Variance Equation:
##   data ~ garch(1, 1)
## <environment: 0x7fd8dba5bba0>
##   [data = ko]
##
## 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:
##   Mon May 17 21:26:46 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

```

```

#(e)

```

```

m4 = garchFit(~garch(1,1),data=ko,cond.dist="std",trace=F)

```

```

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.

```

```

summary(m4)

```

```

##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~garch(1, 1), data = ko, cond.dist = "std",
## trace = F)
##
## Mean and Variance Equation:
## data ~ garch(1, 1)
## <environment: 0x7fd8e618d8a0>
## [data = ko]
##
## 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:
## Mon May 17 21:26:46 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

```

##(f) Compare the model

##Question4

You can download the data set from the folder "EE435" if your current folder is named "EE435"

```
da=read.table("m-deciles.txt",header =T )
```

#Select the column you would like to estimate, in this example, it is the column with the name "CAP9RET"

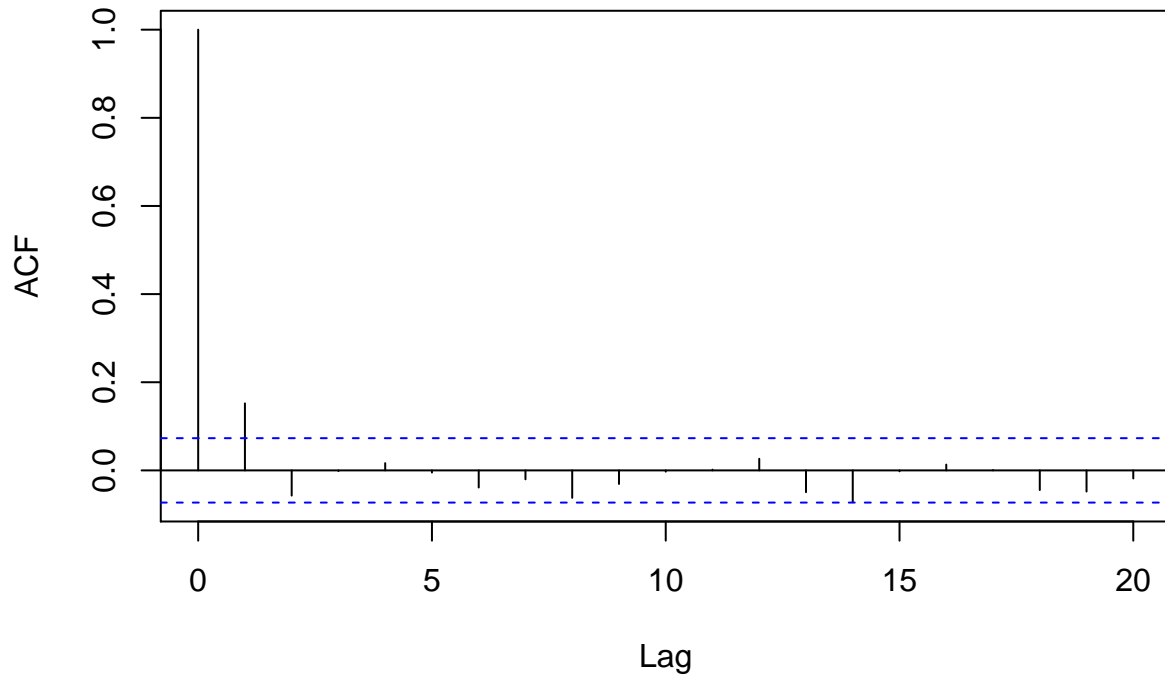
```
simple_return = da$CAP9RET
```

Transform the simple return to be log return

```
rt =log(1+simple_return)
```

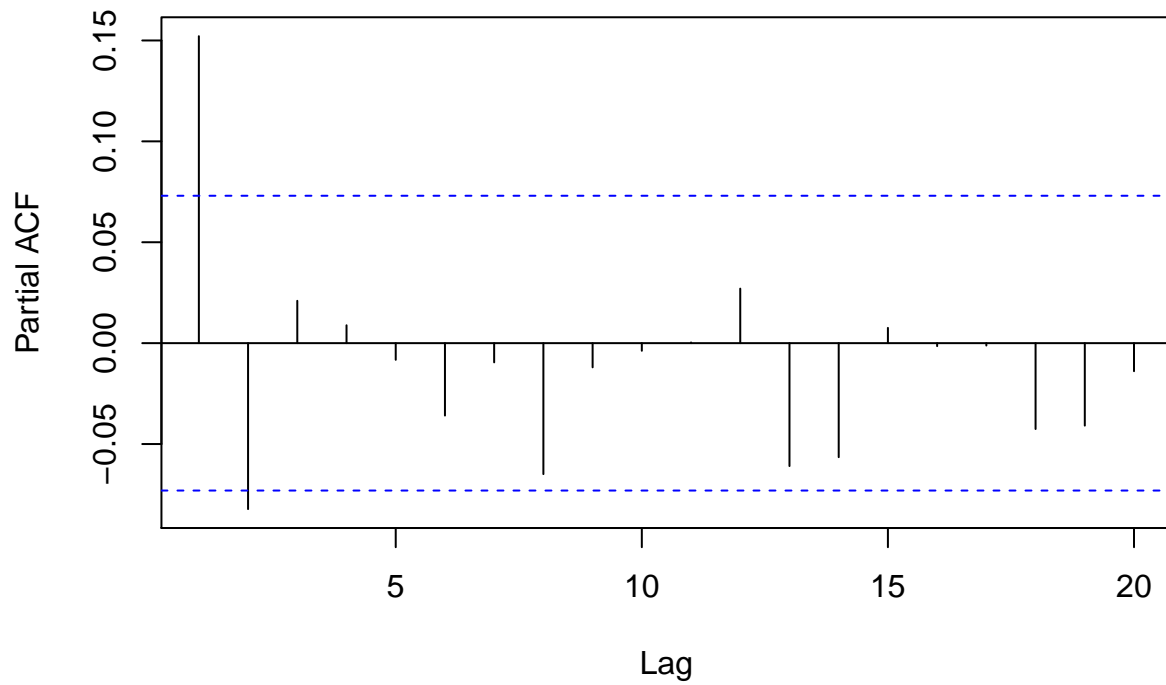
```
acf(rt,lag.max = 20)
```

Series rt



```
pacf(rt, lag.max = 20)
```

Series rt



```
t.test(rt)
```

```
##
```

```

## One Sample t-test
##
## data:  rt
## 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
auto.arima(rt)

## Series: rt
## 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
Box.test(rt,lag=12,type="Ljung")

##
## Box-Ljung test
##
## data:  rt
## X-squared = 24.768, df = 12, p-value = 0.01596
m1 <- arima(rt,order=c(0,0,2))
Box.test(m1$residuals^2,lag=10,type="Ljung")

##
## Box-Ljung test
##
## data:  m1$residuals^2
## X-squared = 16.677, df = 10, p-value = 0.08183
m1a = garchFit(~arma(0,2)+garch(1,0),data=rt,trace=F)

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.
summary(m1a)

##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~arma(0, 2) + garch(1, 0), data = rt, trace = F)
##
## Mean and Variance Equation:
## data ~ arma(0, 2) + garch(1, 0)
## <environment: 0x7fd8e0683de0>

```

```

## [data = rt]
##
## Conditional Distribution:
## norm
##
## Coefficient(s):
##      mu      ma1      ma2      omega      alpha1
## 0.0121117 0.1606374 -0.0463882 0.0020155 0.1653064
##
## Std. Errors:
## based on Hessian
##
## Error Analysis:
##      Estimate Std. Error t value Pr(>|t|)
## mu      0.0121117 0.0020870 5.803 6.5e-09 ***
## ma1     0.1606374 0.0432741 3.712 0.000206 ***
## ma2    -0.0463882 0.0378336 -1.226 0.220157
## omega   0.0020155 0.0001458 13.823 < 2e-16 ***
## alpha1 0.1653064 0.0612927 2.697 0.006997 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
## 1160.515 normalized: 1.611826
##
## Description:
## Mon May 17 21:26:46 2021 by user:
##
##
## Standardised Residuals Tests:
##
##      Statistic p-Value
## Jarque-Bera Test R Chi^2 631.6898 0
## Shapiro-Wilk Test R W 0.9634802 2.065062e-12
## Ljung-Box Test R Q(10) 4.639162 0.9139437
## Ljung-Box Test R Q(15) 8.881883 0.8836119
## Ljung-Box Test R Q(20) 11.75325 0.9243071
## Ljung-Box Test R^2 Q(10) 7.863947 0.6421245
## Ljung-Box Test R^2 Q(15) 11.77367 0.6960735
## Ljung-Box Test R^2 Q(20) 12.81939 0.884998
## LM Arch Test R TR^2 8.150799 0.7732377
##
## Information Criterion Statistics:
##      AIC      BIC      SIC      HQIC
## -3.209763 -3.177963 -3.209859 -3.197487
##(c)
m1b = garchFit(~arma(1,0)+garch(1,0),data=rt,trace=F)

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.
summary(m1b)

##
## Title:

```

```

## GARCH Modelling
##
## Call:
## garchFit(formula = ~arma(1, 0) + garch(1, 0), data = rt, trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 0)
## <environment: 0x7fd8e58d9d08>
## [data = rt]
##
## 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:
## Mon May 17 21:26:46 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
##
##(d)
m2 = garchFit(~arma(1,0)+garch(1,0),data=rt,cond.dist="std",trace=F)

```

```
## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.
```

```
summary(m2)
```

```
##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~arma(1, 0) + garch(1, 0), data = rt, cond.dist = "std",
## trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 0)
## <environment: 0x7fd8e1669a18>
## [data = rt]
##
## 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:
## Mon May 17 21:26:46 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
#(e)
m3 = garchFit(~garch(1,0),data=rt,trace=F)

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.
summary(m3)

##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~garch(1, 0), data = rt, trace = F)
##
## Mean and Variance Equation:
## data ~ garch(1, 0)
## <environment: 0x7fd8e659a208>
## [data = rt]
##
## 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:
## Mon May 17 21:26:46 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
#(f)
m4 = garchFit(~garch(1,0),data=rt,cond.dist="std",trace=F)

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
## Consider formula(paste(x, collapse = " ")) instead.
summary(m4)

##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~garch(1, 0), data = rt, cond.dist = "std",
## trace = F)
##
## Mean and Variance Equation:
## data ~ garch(1, 0)
## <environment: 0x7fd8e5c97370>
## [data = rt]
##
## 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:
## Mon May 17 21:26:46 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

```