

Assignment-5.R

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2021-04-29

```
setwd("D:/")
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 objects are masked from 'package:fBasics':
##
##      tr, 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)
##KRITTAPHONG KAEWVICHAIAN 6104640609

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"

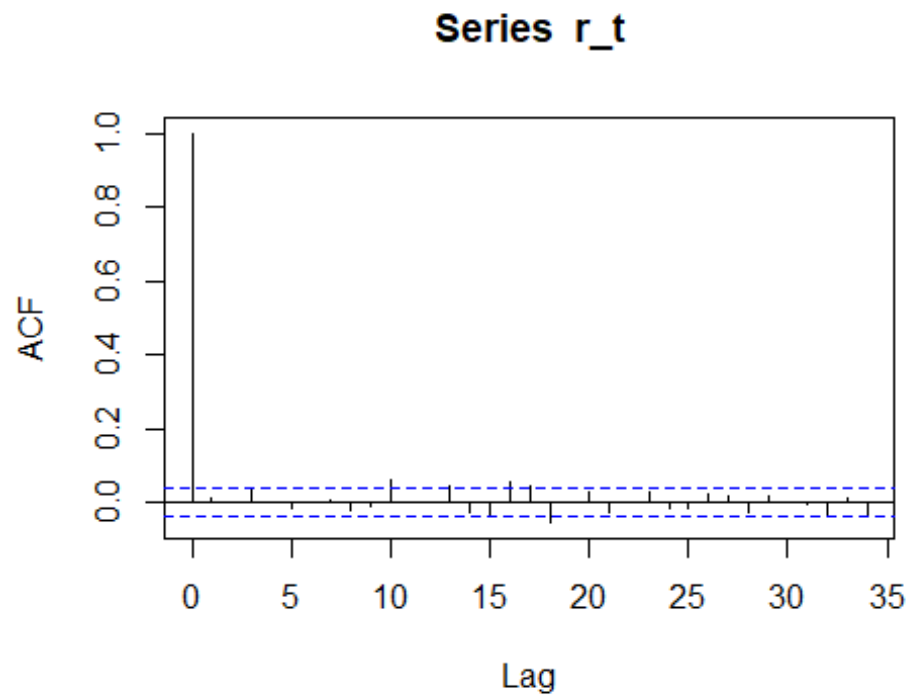
```

```
r_t<-diff(log(as.numeric(CAT[,6])))
```

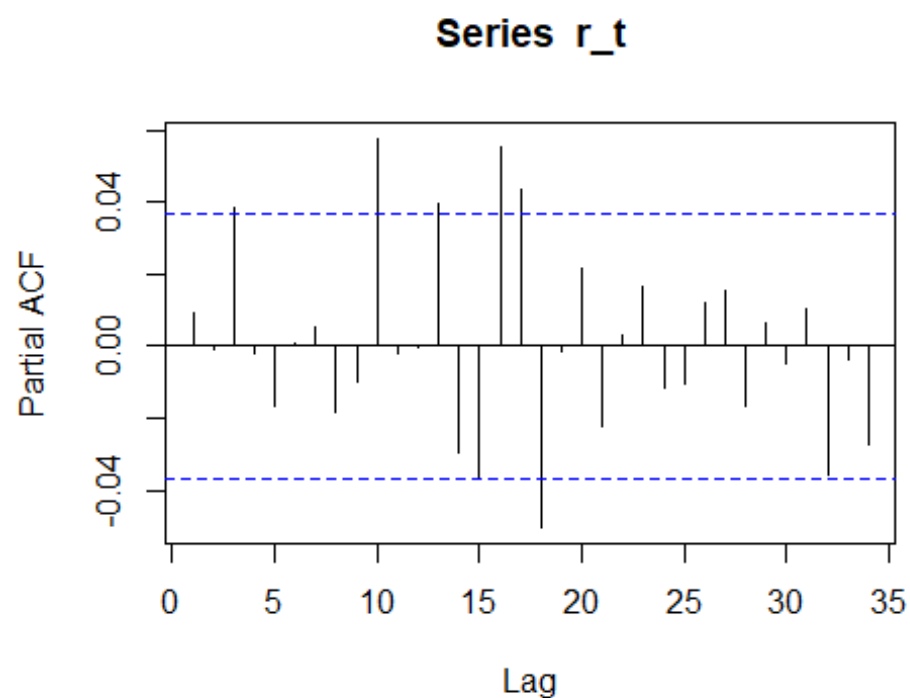
```
#question 1
```

```
#1A
```

```
acf(r_t)
```



```
pacf(r_t)
```



```
Box.test(r_t, lag=10, type="Ljung")
```

```
##
```

```
## Box-Ljung test
```

```
##
```

```
## data: r_t
```

```
## X-squared = 16.229, df = 10, p-value = 0.09325
```

```
# Since the computed value doesn't fall into the rejection region.
```

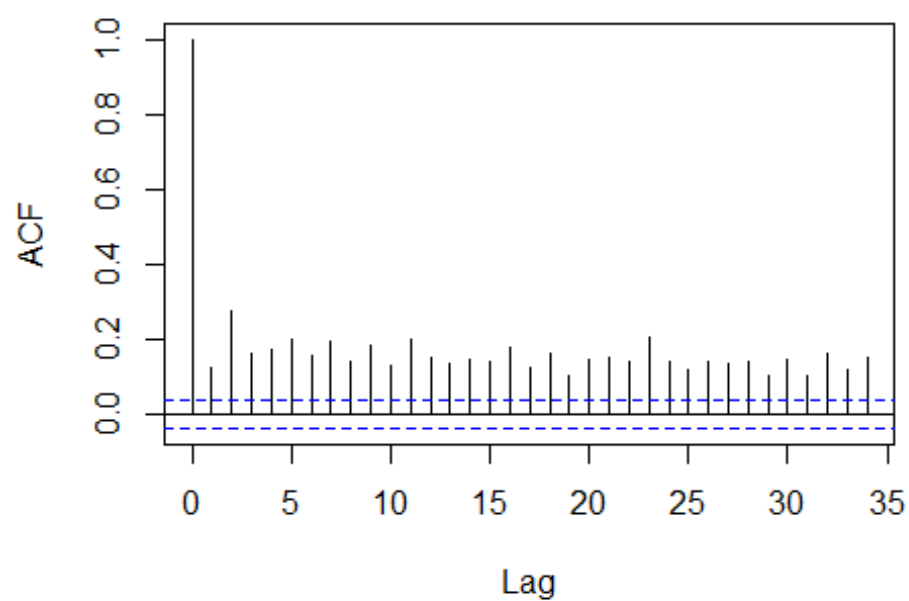
```
# There is no serial correlation in r_t,
```

```
# That is we do not reject H0 at 0.05 level of confidence
```

```
#1B
```

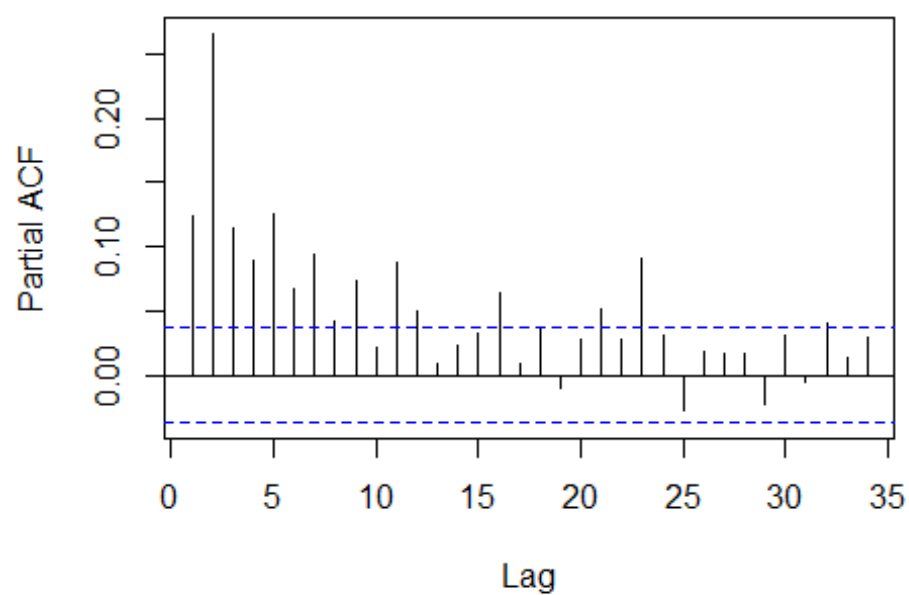
```
acf(r_t^2)
```

Series r_t^2



```
pacf(r_t^2)
```

Series r_t^2



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

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

# Since the computed value falls into the rejection region.
# There is arch in r_t,
#That is we reject H0 at 0.05 level of confidence

#1C
m1=garchFit(formula = ~arma(1,0)+garch(1,1),data = r_t, 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 = r_t, trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x000000002250d618>
## [data = r_t]
##
## 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:
## Thu Apr 29 14:09:40 2021 by user: Krittaphong
##
## 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)
#selection 13

# Adequate mean and variance, however, it's not a normal dist.
# The fitted model
# mean equation = rhatt = 4.830e-04(1-0.1768)+0.1768(rt-1)
# variance equation = sigmahatt= 4.486e-06+0.04976at-1 + 0.9386sigma^2t-1

#1D
m2=garchFit(formula =~garch(1,1),data = r_t, 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 = r_t, cond.dist = "std",
## trace = F)
##
## Mean and Variance Equation:
## data ~ garch(1, 1)
## <environment: 0x00000001d4066e8>

```

```

## [data = r_t]
##
## 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:
## Thu Apr 29 14:09:40 2021 by user: Krittapong
##
##
## 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

```

```

#@plot(m2, type="qqplot")
#selection 13

```

*#Since the computed value of Ljung box test does not fall into
#the rejection region at 0.05 level of confidence*

#the model is adequate both mean and variance equation.

#1e

#mean equation : 0.0003901 (2.702e-04)

#variance equation : $\sigma^2 = 4.214e-06 + 0.07239at^{-1} + 0.9203\sigma^2$

#1f

predict(m2,5)

```
##   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
```

#1q

#1-step CI 0.0059 +- 1.96(0.01558),

#2-step CI 0.0059 +- 1.96(0.01566)

#3-step CI 0.0059 +- 1.96(0.01573)

#4-step CI 0.0059 +- 1.96(0.01581)

#5-step CI 0.0059 +- 1.96(0.01588)

#####

#Question 2

m.kovw=read.table("m-kovw-5116.txt",header = T)

k=m.kovw[,3]

logreturnK0=log(k+1)

2A

t.test(logreturnK0)

##

One Sample t-test

##

data: logreturnK0

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

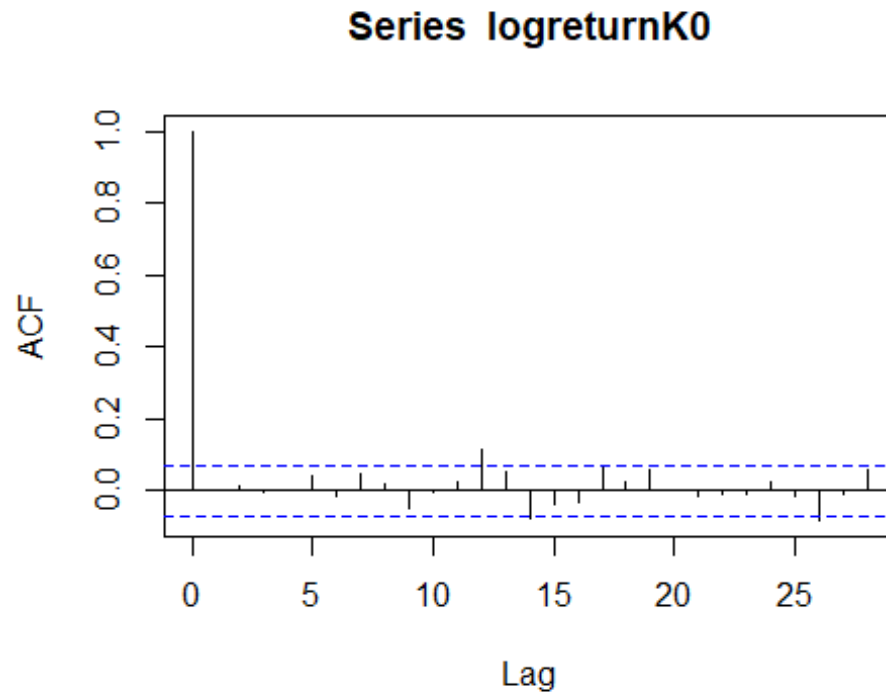
0.01031992

H0 u=0, Ha u≠ 0

the computed value falls into the rejection region

```
# we reject  $H_0$  at 0.05 level of confidence. That is  $u \neq 0$ 
```

```
acf(logreturnK0)
```



```
# Test serial correlation
```

```
Box.test(logreturnK0, lag=10, type='Ljung')
```

```
##
```

```
## Box-Ljung test
```

```
##
```

```
## data: logreturnK0
```

```
## X-squared = 5.9201, df = 10, p-value = 0.8219
```

```
#  $H_0$  :  $e$  simultaneous 0,  $H_a$  : some is not equal to 0
```

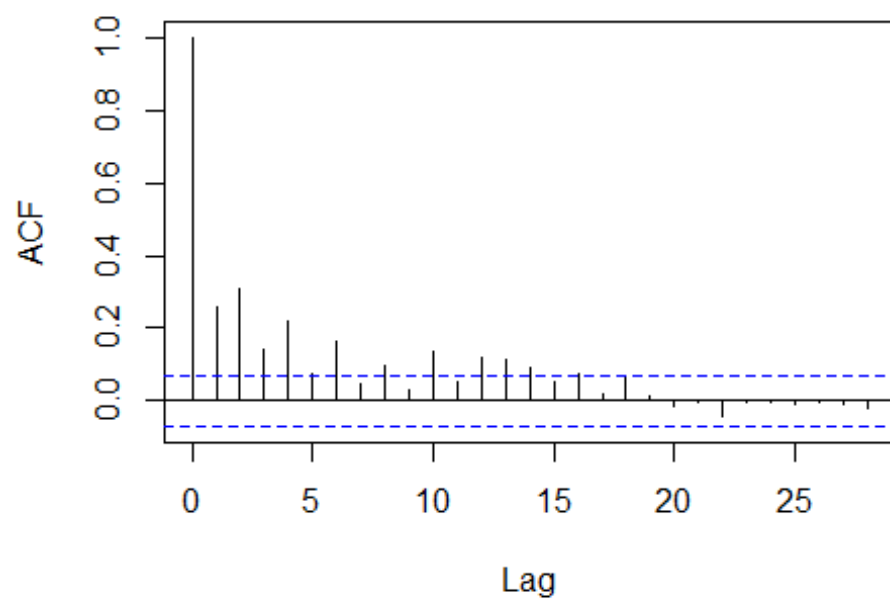
```
# Since the computed value doesn't fall into the rejection region
```

```
# we cannot reject  $H_0$  at 0.05 level of confidence, that is
```

```
# There is no serial correlation in LogreturnK0
```

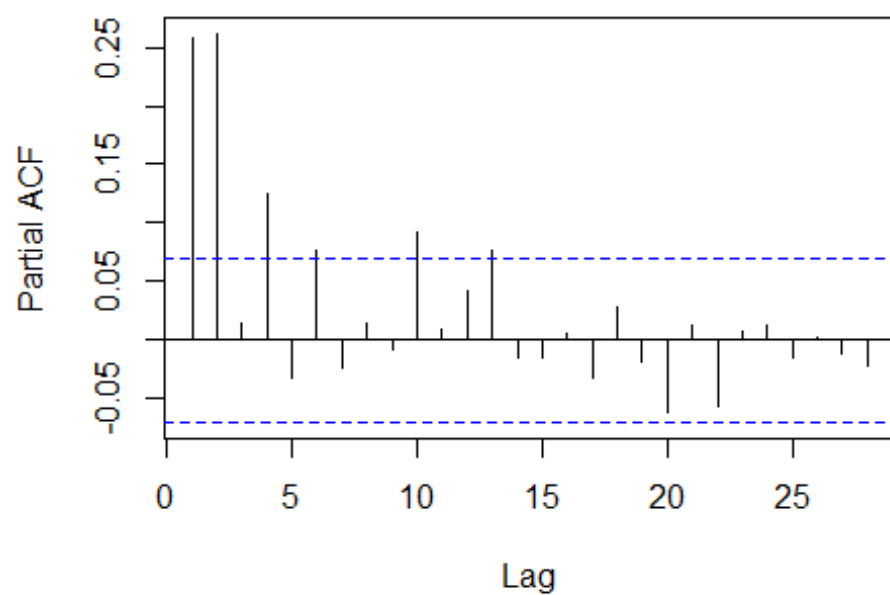
```
acf(logreturnK0^2)
```

Series logreturnK0^2



```
pacf(logreturnK0^2)
```

Series logreturnK0^2



```

#TEST ARCH effect
Box.test(logreturnK0^2,lag=10,type='Ljung')

##
## Box-Ljung test
##
## data: logreturnK0^2
## X-squared = 228.23, df = 10, p-value < 2.2e-16

# H0 : p simultaneous 0, Ha : some is not equal to 0
# Since the computed value falls into the rejection region
# We could reject H0 at 0.05 level of confidence
# That's, there is ARCH effect

#2B

m1=garchFit(formula = ~arma(1,0)+garch(1,1),data = logreturnK0, 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 = logreturnK0,
## trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x000000021e078d0>
## [data = logreturnK0]
##
## 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:
## Thu Apr 29 14:09:40 2021 by user: Krittaphong
##
##
## 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

# Mean and variance equations are adequate
# But their distribution are not normal dist.
# Mean equation rhatt = 0.0125(1+0.02634) - 0.02634(rt-1)
# Variance equation sigma^2t = 0.0001811+0.09535a^2t-1 +0.8486sigma^2t-1

#2c
m2=garchFit(formula = ~arma(1,0)+garch(1,1),data =
logreturnK0,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 = logreturnK0,
## cond.dist = "std", trace = F)

```

```

##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x00000001f2ecc88>
## [data = logreturnK0]
##
## Conditional Distribution:
## std
##
## Coefficient(s):
##          mu          ar1          omega          alpha1          beta1
shape
## 0.01124020 -0.01887601 0.00017395 0.09642927 0.85044151
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:
## Thu Apr 29 14:09:40 2021 by user: Krittaphong
##
##
## Standardised Residuals Tests:
##
##          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 0.7816987
## 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

#Since the computed value of Ljung box test does not fall into
#the rejection region at 0.05 level of confidence
#the model is adequate both mean and variance equation.

#mean equation : rhatt = 0.0124(1+0.01888) - 0.01888rt-1
#variance equation : sigma^2t = 1.739e-04 + 0.09643a^2t-1 +0.08504sigma^2t-1

#2d
m3=garchFit(formula = ~garch(1,1),data = logreturnK0, 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 = logreturnK0, trace = F)
##
## Mean and Variance Equation:
## data ~ garch(1, 1)
## <environment: 0x00000000213325e8>
## [data = logreturnK0]
##
## 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:
## Thu Apr 29 14:09:40 2021 by user: Krittapong
##
## 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

# mean and variance equations are adequate.
# But dist. are not normal.

# Mean equation: rhatt = 0.01098 (0.001846)
# variance equation: sigmahatt = 1.85e-04 +0.0448a^2t-1 + 0.8478sigma^2t-1

m4=garchFit(formula = ~garch(1,1),data=logreturnK0,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 = logreturnK0, cond.dist = "std",
## trace = F)
##
## Mean and Variance Equation:
## data ~ garch(1, 1)
## <environment: 0x000000001d769c70>
## [data = logreturnK0]
##

```

```

## 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:
## Thu Apr 29 14:09:41 2021 by user: Krittaphong
##
##
## 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

#Since the computed value of Ljung box test does not fall into
#the rejection region at 0.05 level of confidence
#the model is adequate both mean and variance equation.

#mean equation : rhatt = 0.0105 (0.001757)
#variance equation : sigmahatt = 1.753e-04 + 0.09633a^2t-1 + 0.8501sigma^2t-1

```

#2f

#we choose M4 because

#1) Mean and variance equation are adequate

#2) AIC and BIC are the lowest compared to m1,m2,m3

#3) Significant coefficient

##

#Question 3

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

[1] "^GSPC"

st <- diff(log(as.numeric(GSPC[,6])))

#3A

t.test(st)

##

One Sample t-test

##

data: st

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

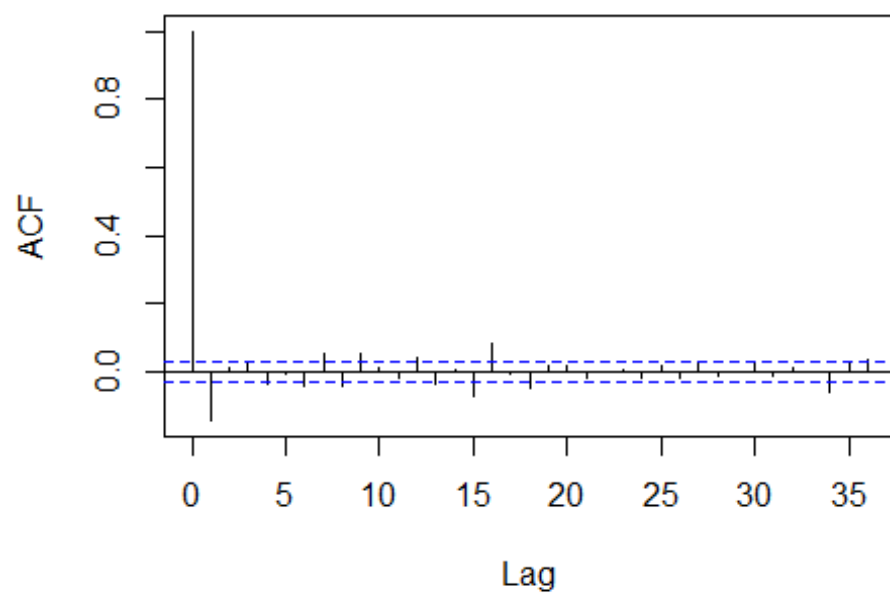
H0 u=0, Ha u≠ 0

the computed value doesn't fall into the rejection region

we do not reject H0 at 0.05 level of confidence. That is u=0

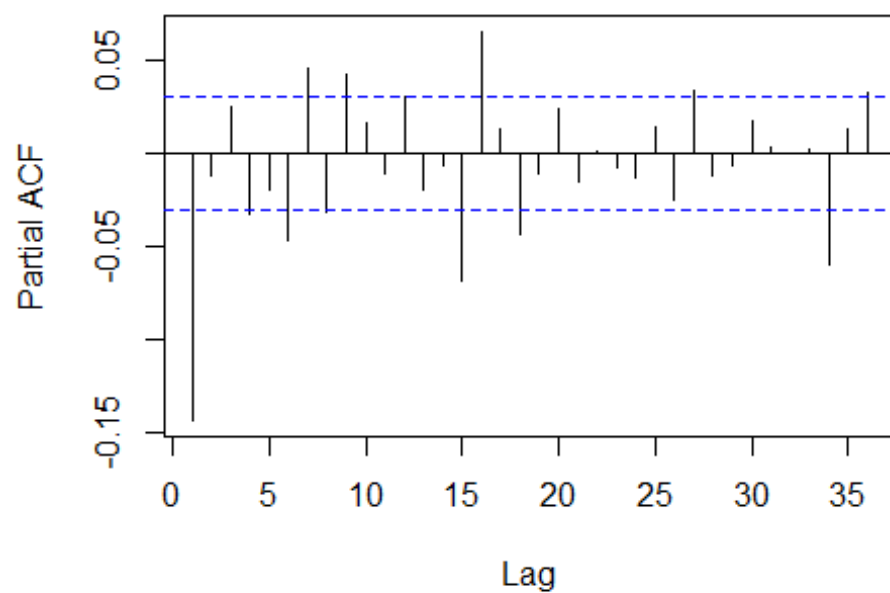
acf(st)

Series st



```
pacf(st)
```

Series st



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

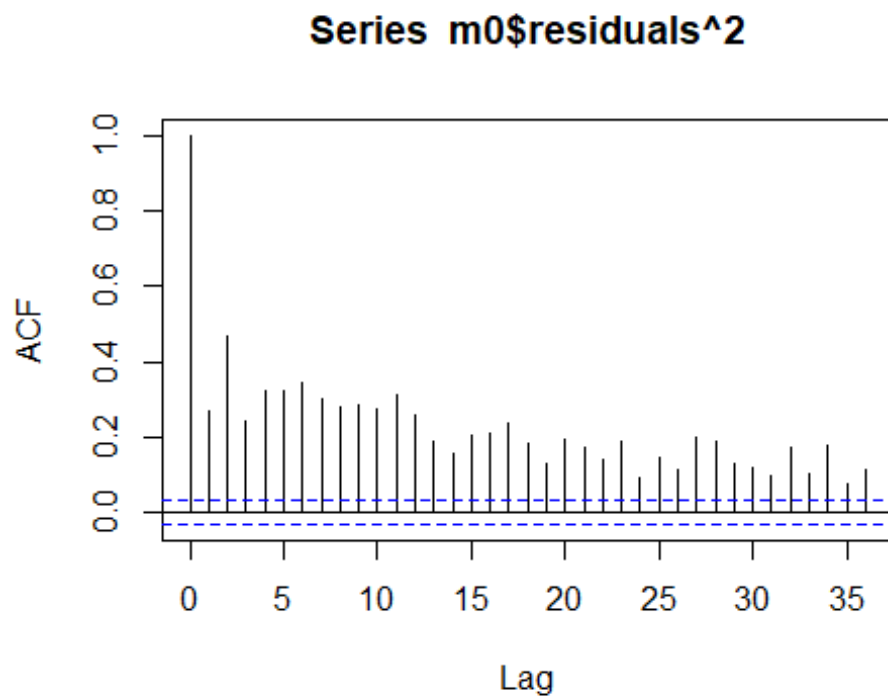
```
##
## Box-Ljung test
##
## data: st
## X-squared = 131.85, df = 10, p-value < 2.2e-16

# H0 : e simultaneous 0, Ha : some is not equal to 0
# Since the computed value falls into the rejection region
# we reject H0 at 0.05 level of confidence, that is
# There is serial correlation in st

#3B
auto.arima(st)

## Series: st
## ARIMA(1,0,0) with non-zero mean
##
## Coefficients:
##          ar1      mean
##       -0.1435    3e-04
## s.e.    0.0155    2e-04
##
## sigma^2 estimated as 0.0001521:  log likelihood=12166.05
## AIC=-24326.09   AICc=-24326.09   BIC=-24307.15

m0=auto.arima(st)
acf(m0$residuals^2)
```



```

Box.test(m0$residuals^2,lag=10,type="Ljung")

##
## Box-Ljung test
##
## data: m0$residuals^2
## X-squared = 4132.1, df = 10, p-value < 2.2e-16

m1=garchFit(formula = ~arma(1,0)+garch(1,1),data = st,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 = st, trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x000000001e5f3a28>
## [data = st]
##
## Conditional Distribution:
## norm
##
## Coefficient(s):
##          mu          ar1          omega          alpha1          beta1
## 7.4132e-04 -7.5408e-02  2.7169e-06  1.4182e-01  8.3740e-01
##
## Std. Errors:
## based on Hessian
##
## Error Analysis:
##      Estimate Std. Error t value Pr(>|t|)
## mu      7.413e-04  1.178e-04   6.292 3.14e-10 ***
## ar1     -7.541e-02  1.730e-02  -4.358 1.31e-05 ***
## omega    2.717e-06  3.504e-07   7.753 8.88e-15 ***
## alpha1   1.418e-01  1.202e-02  11.800 < 2e-16 ***
## beta1    8.374e-01  1.196e-02  70.032 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
## 13428.16 normalized: 3.285579
##

```

```

## Description:
## Thu Apr 29 14:09:42 2021 by user: Krittaphong
##
##
## Standardised Residuals Tests:
##
##      Jarque-Bera Test   R      Chi^2   1128.595   0
##      Shapiro-Wilk Test  R      W       0.9719221 0
##      Ljung-Box Test     R      Q(10)   17.65631  0.06104542
##      Ljung-Box Test     R      Q(15)   25.98986  0.03812936
##      Ljung-Box Test     R      Q(20)   31.68964  0.04671967
##      Ljung-Box Test     R^2   Q(10)   15.98919  0.09994225
##      Ljung-Box Test     R^2   Q(15)   18.25271  0.2496128
##      Ljung-Box Test     R^2   Q(20)   19.6233   0.4817047
##      LM Arch Test       R      TR^2    16.7807   0.1580347
##
## Information Criterion Statistics:
##      AIC      BIC      SIC      HQIC
## -6.568712 -6.560985 -6.568715 -6.565976

#@plot(m1)

#3B
#mean equation : rhatt = 7.413e-04 + (-7.541e-02)rt-1
#                  (1.178e-04) (1.730e-02)
#variance equation :sigmahat^2 = 2.171e-06 + (1.418e-01)a^2t-1

# We choose ARMA(1,0) + Garch(1,1) because
# 1 The model is adequate but mean equation is not with 20 lags.
# 2 AIC and BIC are low

#3C

m2=garchFit(formula = ~arma(1,0)+garch(1,1),data = st,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 = st, cond.dist =
"std",
## trace = F)
##

```

```

## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x0000000014609b78>
## [data = st]
##
## Conditional Distribution:
## std
##
## Coefficient(s):
##          mu          ar1          omega          alpha1          beta1
shape
## 9.1359e-04 -7.0189e-02 1.6949e-06 1.4129e-01 8.5658e-01
5.0787e+00
##
## Std. Errors:
## based on Hessian
##
## Error Analysis:
##          Estimate Std. Error t value Pr(>|t|)
## mu          9.136e-04 1.061e-04 8.612 < 2e-16 ***
## ar1         -7.019e-02 1.570e-02 -4.469 7.85e-06 ***
## omega        1.695e-06 3.625e-07 4.676 2.93e-06 ***
## alpha1       1.413e-01 1.460e-02 9.675 < 2e-16 ***
## beta1        8.566e-01 1.286e-02 66.618 < 2e-16 ***
## shape        5.079e+00 4.283e-01 11.857 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
## 13563.45    normalized: 3.318682
##
## Description:
## Thu Apr 29 14:09:42 2021 by user: Krittaphong
##
## Standardised Residuals Tests:
##
##          Jarque-Bera Test R Chi^2 1426.546 0
##          Shapiro-Wilk Test R W 0.9697692 0
##          Ljung-Box Test R Q(10) 17.75545 0.05923161
##          Ljung-Box Test R Q(15) 26.09726 0.03701271
##          Ljung-Box Test R Q(20) 31.5407 0.04844507
##          Ljung-Box Test R^2 Q(10) 13.10432 0.2178975
##          Ljung-Box Test R^2 Q(15) 17.76262 0.275351
##          Ljung-Box Test R^2 Q(20) 20.49609 0.4273063
##          LM Arch Test R TR^2 14.77776 0.2538157
##
## Information Criterion Statistics:
##          AIC          BIC          SIC          HQIC
## -6.634429 -6.625157 -6.634433 -6.631146

```

```

#@plot(m2)
# Mean equation :  $\hat{r}_t = 9.136e-04 + -(7.019e-02)r_{t-1}$ 
#                  (1.061e-04)      (1.570e-02)
# Variance equation :  $\hat{\sigma}_t^2 = 1.695e-06 + 1.143e-01(a^{2t-1})$ 
# (3.625e-07) (1.460e-02) (1.286e-02)

#3d
predict(m2,5)

##   meanForecast   meanError standardDeviation
## 1 0.0011355886 0.009054724      0.009054724
## 2 0.0008338889 0.009160372      0.009138299
## 3 0.0008550647 0.009243329      0.009220941
## 4 0.0008535784 0.009325270      0.009302675
## 5 0.0008536828 0.009406325      0.009383526

#####

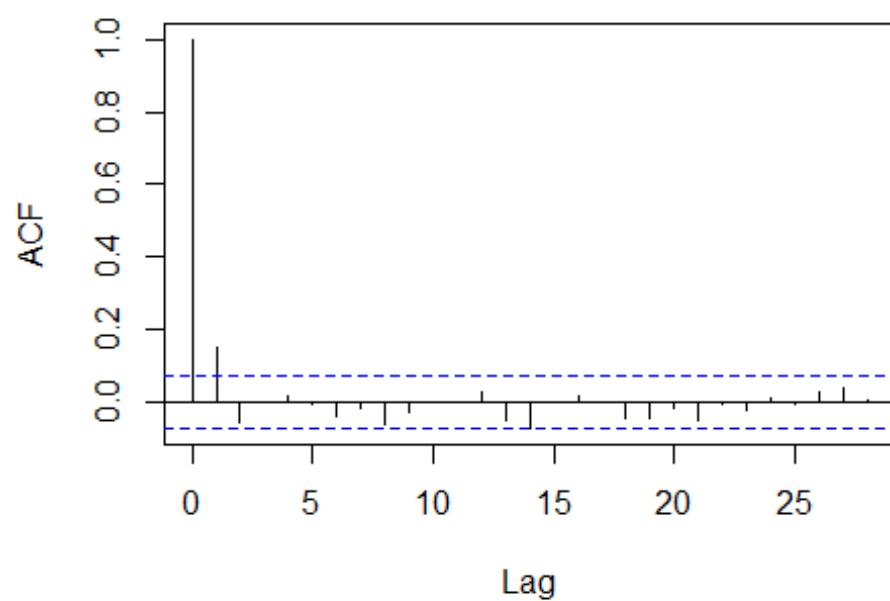
#Question 4
CRSP=read.table("m-deciles.txt",header = T)
#Simple Return
sCRSP=CRSP[,10]
#Log return
lCRSP=log(sCRSP+1)
t.test(lCRSP)

##
##  One Sample t-test
##
## data:  lCRSP
## 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

#  $H_0: u=0$ ,  $H_a: u \neq 0$ 
# the computed value falls into the rejection region
# we reject  $H_0$  at 0.05 level of confidence. That is  $u \neq 0$ 
acf(lCRSP)

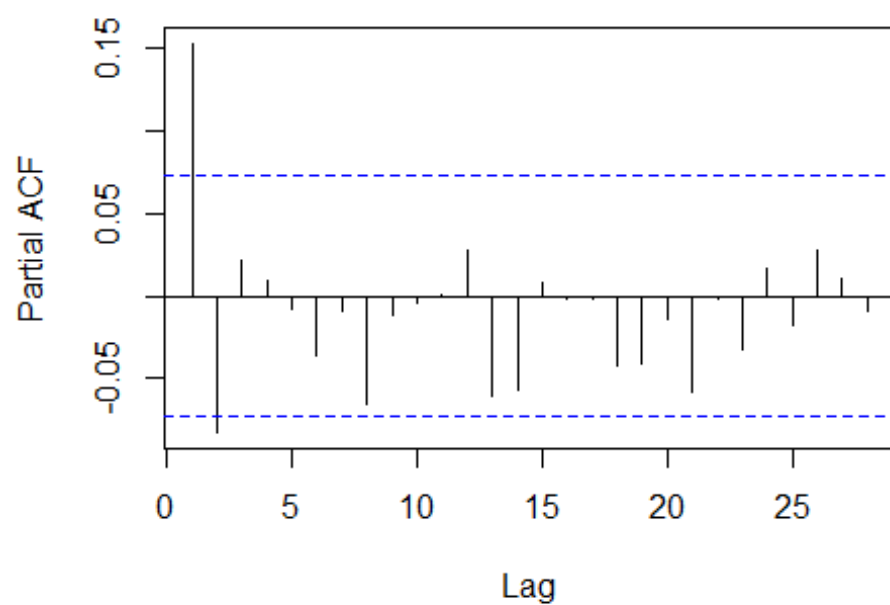
```

Series ICRSP



```
pacf(ICRSP)
```

Series ICRSP



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

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

## H0 : e simultaneous 0, Ha : some is not equal to 0
# Since the computed value falls into the rejection region
# we reject H0 at 0.05 level of confidence, that is
# There is serial correlation in LCRSP

auto.arima(lCRSP)

## Series: lCRSP
## 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

m1 <- arima(lCRSP, order=c(0,0,2))
m1

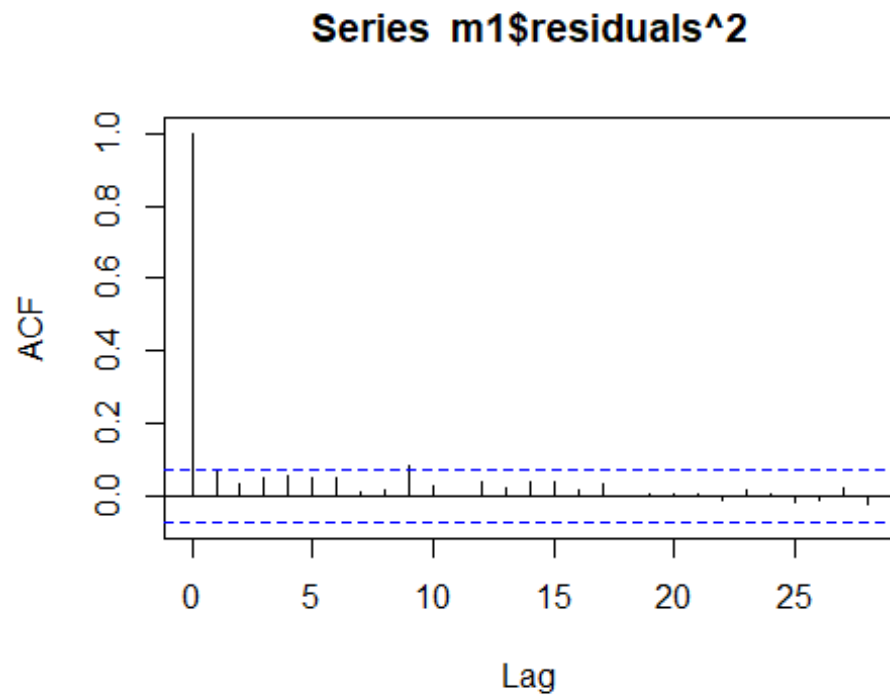
##
## Call:
## arima(x = lCRSP, order = c(0, 0, 2))
##
## Coefficients:
##          ma1          ma2  intercept
##          0.1660   -0.0558          0.0096
## s.e.   0.0373    0.0370          0.0020
##
## sigma^2 estimated as 0.002382:  log likelihood = 1152.66,  aic = -2297.32

Box.test(m1$residuals, lag=10, type='Ljung')

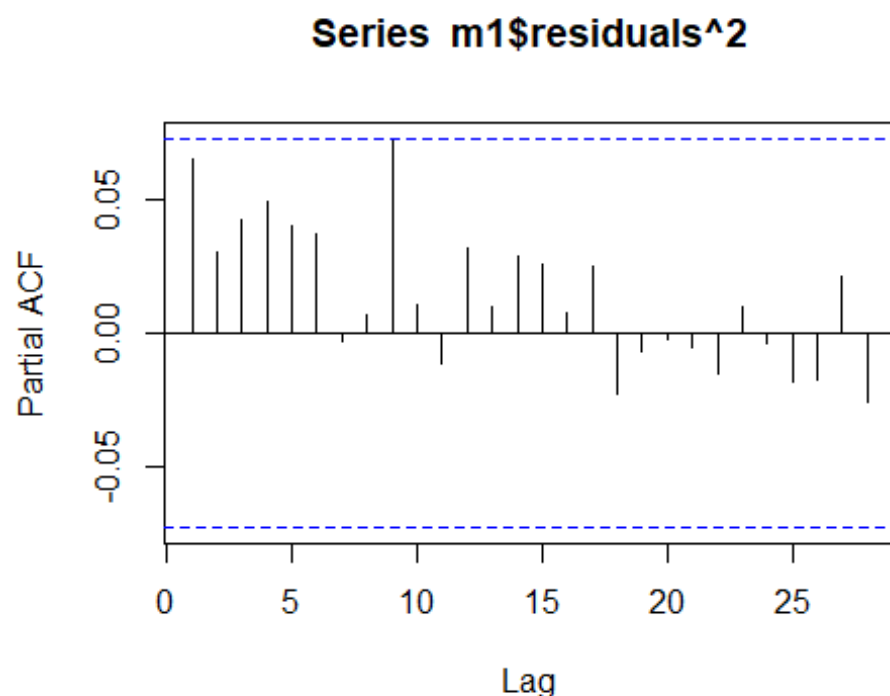
##
## Box-Ljung test
##
## data:  m1$residuals
## X-squared = 4.3881, df = 10, p-value = 0.9281

# rhat = 0.0096 + .166at-1 - 0.0558at-2
# #- H0 : e simultaneous 0, Ha : some is not equal to 0
# Since the computed value does not falls into the rejection region
# we do not reject H0 at 0.05 level of confidence, that is
# There is no serial correlation in LCRSP. This model is adequate
```

```
#4b  
acf(m1$residuals^2)
```



```
pacf(m1$residuals^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

#4b
# Test ARCH
#  $H_0$  :  $p$  simultaneous  $\theta$ ,  $H_a$  : some is not equal to  $\theta$ 
# Since the computed value doesn't falls into the rejection region
# We could not reject  $H_0$  at 0.05 level of confidence
# That's, there is no ARCH effect

#4c
m2<-garchFit(~arma(1,0)+garch(1,0),data=ICRSP, 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 = lCRSP, trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 0)
## <environment: 0x0000000016c203d8>
## [data = lCRSP]
##
## 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:
## Thu Apr 29 14:09:43 2021 by user: Krittapong
##
## Standardised Residuals Tests:
##
##      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

```

```

#Mean and variance equations are adequate but dist. is not normal.
#Mean equation : rhatt = 0.01053 + 0.147rt-1
#                      (0.00192) (0.042)
#Variance equation: sigma^2t = .002+.1815a^2t-1
#                      (.0001) (.065)

#4d
m3=garchFit(~arma(1,0)+garch(1,0),data=LCRSP,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(m3)

##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~arma(1, 0) + garch(1, 0), data = LCRSP, cond.dist =
"std",
## trace = F)
##
## Mean and Variance Equation:
## data ~ arma(1, 0) + garch(1, 0)
## <environment: 0x00000000207faf70>
## [data = LCRSP]
##
## 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 1.3115905 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:
## Thu Apr 29 14:09:43 2021 by user: Krittaphong
##
## 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

#Mean and variance equation are adequate, with T-dist.
# Mean equation : rhatt= 0.01162+0.1076982rt-1
#                (0.00177) (0.040317)
# Variance equation : sigma^2t = 0.00192 + 0.19008a^2t-1
#                (0.00013) (0.0714)
#4e
m4=garchFit(formula = ~garch(1,0),data = lCRSP,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 = lCRSP, trace = F)
##
## Mean and Variance Equation:
## data ~ garch(1, 0)
## <environment: 0x000000001ddb7998>
## [data = lCRSP]
##
## 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:
## Thu Apr 29 14:09:43 2021 by user: Krittaphong
##
##
## Standardised Residuals Tests:
##
##      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

#Neither Mean and variance equation is not adequate, nor normal dist.
# Mean equation : rhatt= 0.01235
#                  (0.0019)
# Variance equation : sigma^2t = 0.002016 + 0.144126
#                               (0.000145) (0.00622)

#4f
m5=garchFit(formula = ~garch(1,0),data = ICRSP,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(m5)
```

```
##
```

```
## Title:
```

```
## GARCH Modelling
```

```
##
```

```
## Call:
```

```
## garchFit(formula = ~garch(1, 0), data = lcrsp, cond.dist = "std",
## trace = F)
```

```
##
```

```
## Mean and Variance Equation:
```

```
## data ~ garch(1, 0)
```

```
## <environment: 0x00000000155add88>
```

```
## [data = lcrsp]
```

```
##
```

```
## 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:
```

```
## Thu Apr 29 14:09:43 2021 by user: Krittaphong
```

```
##
```

```
##
```

```
## 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
```

```
# Variance equation is adequate, mean is not
# Mean equation : rhatt= 0.013356
#                  (0.0016881)
# Variance equation : sigma^2t = 0.001918 + 0.204163a^2t-1
#                  (0.000185) (0.0724)
```

```
#4g We choose m3 because
#1) Mean and Variance are adequate
#2) AIC and BIC has the lowest value
#3) Coefficients are significant.
```