Assignment5_6104640427.R

user

2021-04-29

```
setwd("/Users/user/Desktop/Arm/EE435 R")
cat(rep("\n",50))

#install.packages("fGarch")
library(fGarch)

## Warning: package 'fGarch' was built under R version 4.0.5

## Loading required package: timeDate

## Loading required package: timeSeries

## Loading required package: fBasics

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(fBasics)
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
```

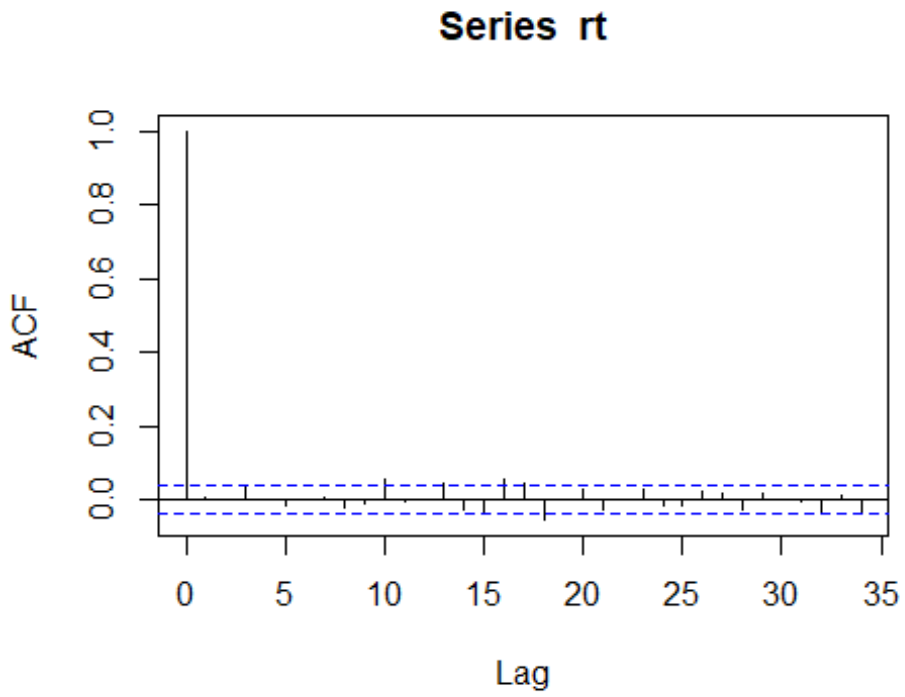
```
##
## Attaching package: 'car'
```

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

```
library(tseries)
library(forecast)

#Question 1
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.
##
```

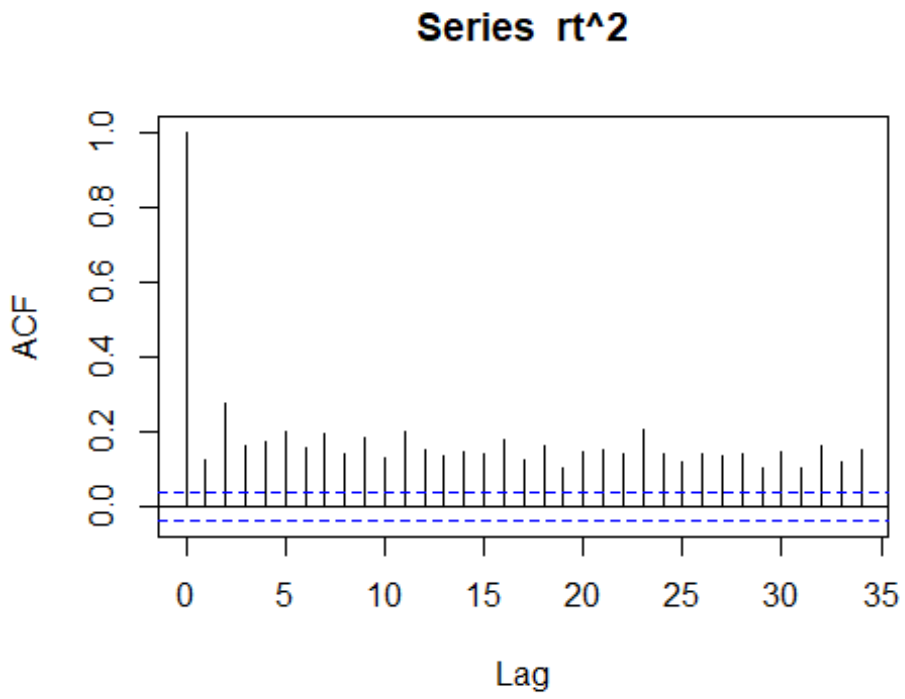
```
## This message is shown once per session and may be disabled by setting
## options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.

## [1] "CAT"

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

par=(mfrow=c(2,2))
rt<-diff(log(as.numeric(CAT[,6])))
```




```
acf(rt)
```

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

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

```
## data:  rt
## X-squared = 16.291, df = 10, p-value = 0.09159

# as p-value > 0.05 then we can not reject H0, so there is no autcorrelation
between log return

#1b
```




```
acf(rt^2)
```

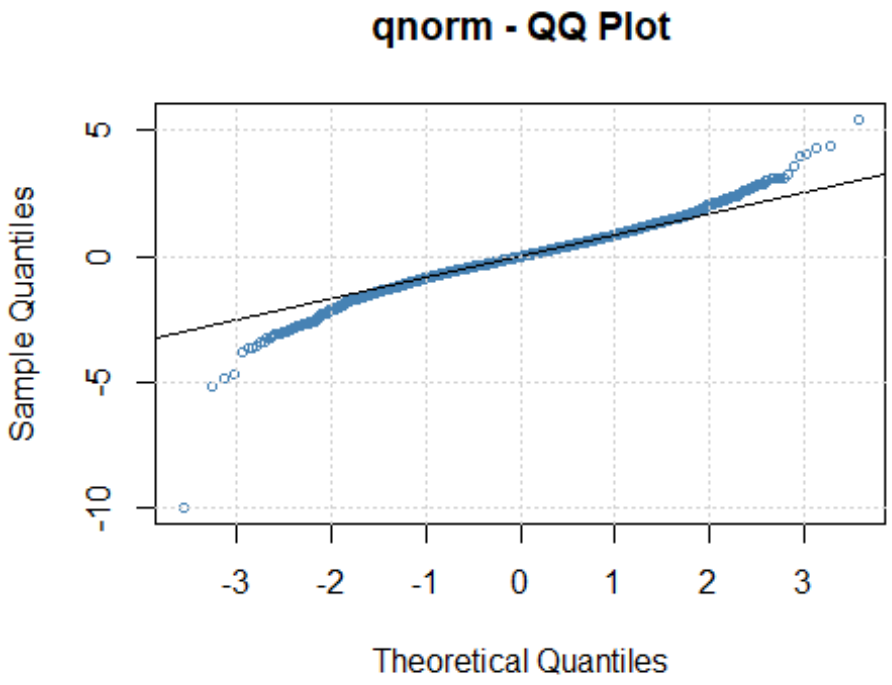
```
Box.test(rt^2,lag=10,type='Ljung')

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

#as p-value < 0.05 then we reject H0, so there is autcorrelation between log
return, hence there is ARCH effects in rt with 95% CI

#1c
m1=garchFit(~arma(1,0)+garch(1,1),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(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: 0x00000000217b2f70>
##  [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:
##  Thu Apr 29 09:57:20 2021 by user: 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 R we can't reject H0 then we say that the model is adequate in mean equation
#also can't reject H0 for R^2, the volatility model is adequate

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



#write fitted model

mean eq": $\hat{r}_t = \underset{(3.075e-04)}{4.830e-04}(1-\hat{\phi}_1) + \underset{(0.020)}{0.0269}\, r_{t-1}$

vol. eq": $\hat{\sigma}_t^2 = \underset{(1.278e-06)}{4.478e-06} + \underset{(0.0082)}{0.0497}\, a_{t-1}^2 + \underset{(0.010)}{0.939}\, \sigma_{t-1}^2$ (satisfy wk)

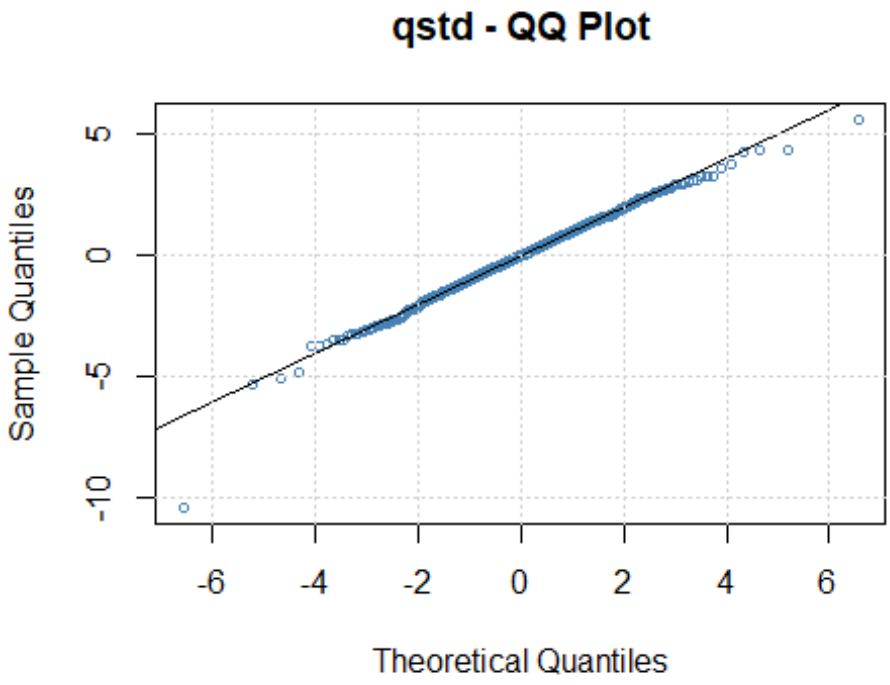
#1d

```
m2=garchFit(~garch(1,1),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 = ~garch(1, 1), data = rt, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x000000001f106498>
##  [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:
##  Thu Apr 29 09:57:21 2021 by user: 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 R we can't reject H0 then we say that the model is
adequate in mean equation
#also can't reject H0 for R^2, the volatility model is adequate
```




```
plot(m2,which=13)
```

```
#write fitted model

#1e
#1f
predict(m2,5)
```

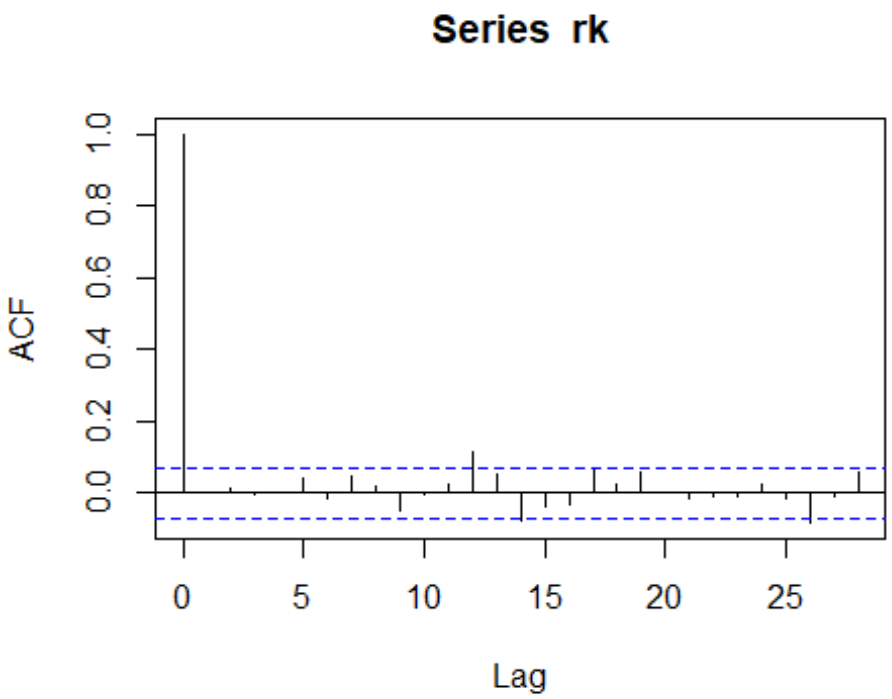
mean eq. $\hat{r}_t = 5.978\,e\text{-}04$ (0.0003)

vol. eq. $\hat{\sigma}_t^2 = 4.203e\text{-}06 + 0.042\,a_{t-1}^2 + 0.92\,\sigma_{t-1}^2$ (1.571e-06) (0.014) (0.015)

```
##   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

#2
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)
```

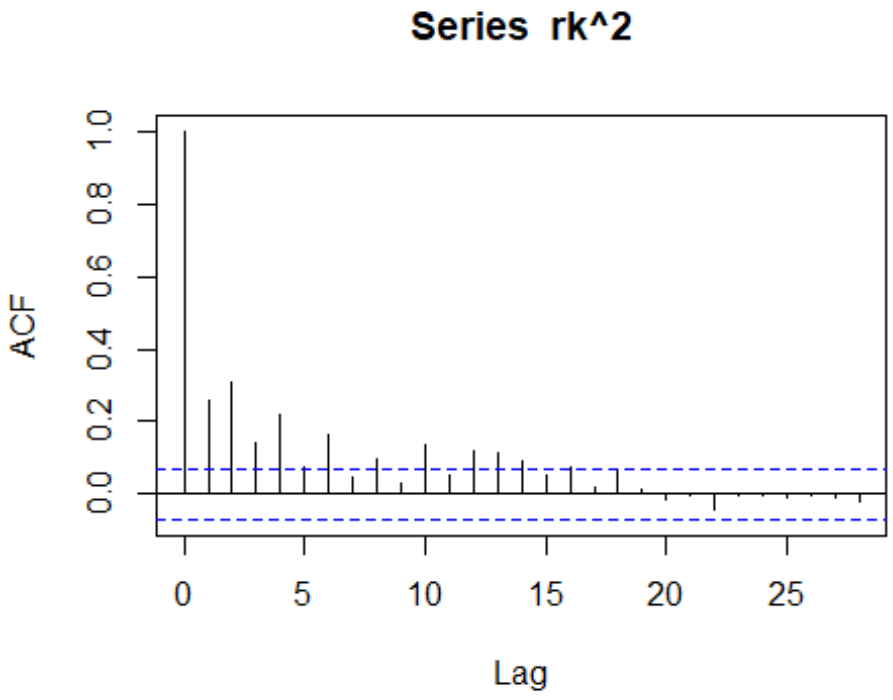
$\hat{r}_t \pm 1.96(\hat{G}_t)$

⇒ (-0.02911 , 0.0303)
⇒ (-0.0293 , 0.0305)
⇒ (-0.0294 , 0.03063)
⇒ (-0.0296 , 0.0308)
⇒ (-0.0298 , 0.03095)




```
#2a
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

#pv is less than 0.05 we reject h0 then the expected value of log return is
not equal to zero
```




```
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

#as p-value > 0.05 then we can not reject H0, so there is no autcorrelation
between log return
Box.test(rt^2,lag=10,type='Ljung')
```

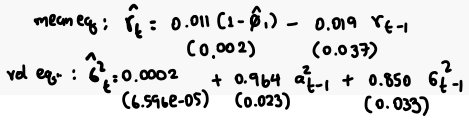
```
##
##  Box-Ljung test
##
## data:  rt^2
## X-squared = 917.21, df = 10, p-value < 2.2e-16

#as p-value < 0.05 then we reject H0, so there is autcorrelation between log
return-squared, hence there is ARCH effects in rt with 95% CI


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

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

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: 0x000000001ef81360>
##  [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:
##  Thu Apr 29 09:57:21 2021 by user: 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

#all pv is > 0.05 then the 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)

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

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: 0x000000002165eb40>
##  [data = rk]
##
## 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 09:57:22 2021 by user: 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  0.7816987
##  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
```

#all pv is > 0.05 then the model is adequate in both mean and volatility equation

#fitted model



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

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

```r
summary(mk3)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = rk, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x000000001eae0710>
##  [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:
##  Thu Apr 29 09:57:22 2021 by user: 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
```

```
#all pv is > 0.05 then the model is adequate in both mean and volatility
equation
```

mean eq: $\hat{r}_t = 0.011$ (0.002)

vol. eq: $\hat{\sigma}_t^2 = 0.0002 + 0.045\, a_{t-1}^2 + 0.848\, \sigma_{t-1}^2$ (5.899e-05) (0.019) (0.0279)

```
#fitted model

#2e
mk4=garchFit(~garch(1,1),data=rk,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(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: 0x000000002053d5c8>
##  [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:
##  Thu Apr 29 09:57:22 2021 by user: 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
```

Fitted model.

mean eq$\Rightarrow \hat{r}_t = 0.011$ (0.002)

vol. eq$\Rightarrow \hat{\sigma}_t^2 = 0.0002$ (6.627e-05) $+ 0.096\, a_{t-1}^2$ (0.023) $+ 0.850\, \sigma_{t-1}^2$ (0.033)

```
#all pv is > 0.05 then the model is adequate in both mean and volatility
equation

#2f
#using AIC and BIC then the lower is the more effictive model hence, in (e)
there is lower AIC and BIC which is better

#3
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
```

```
#pv is > 0.05 then can't reject H0, the expected value of rt is zero
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
```

```
#we cant rej. H0 then there is no seriel correlation in rt
ms1=garchFit(arima()~garch(1,1),data=rs,trace=F)
```

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

```
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: 0x000000001ecd9580>
##  [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:
##  Thu Apr 29 09:57:22 2021 by user: 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

plot(ms1,which=13)
```

```
#from Box test the only adequate for model is volatility equation, the mean
equation is not adequate since the pv of residual are all <0.05 then reject
H0
#fitted model
#3c
ms2=garchFit(arima()~garch(1,1),data=rs,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(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: 0x000000001e6e8338>
##  [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:
##  Thu Apr 29 09:57:23 2021 by user: 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,which=13)
```

```
#from JB test the model is not normal, and from Box test the only adequate
for model is volatility equation, the mean equation is not adequate since the
pv of residual are all <0.05 then reject H0

#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

#4
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)
```

```
#4a
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

#pv is less than 0.05 we can't reject h0 then the expected value of log
return is zero
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

#as p-value < 0.05 then we reject H0, so there is autcorrelation between log
return
#to us ARMA
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
```

```r
#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
```

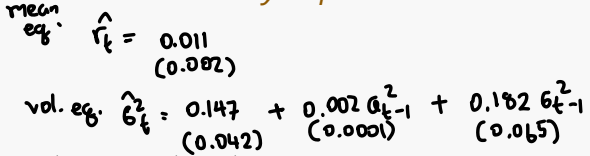
```r
#as p-value < 0.05 then we reject H0, so there is autcorrelation between log
return-squared, hence there is ARCH effects in rt with 95% CI

#4c
mc2=garchFit(~arma(1,0)+garch(1,0),data=rc,trace=F)
```

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

```r
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: 0x000000001ea631c8>
##  [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:
##  Thu Apr 29 09:57:24 2021 by user: 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 LJungBox test are having pv > 0.05 we cannot reject H0 then the model is
adequate in both mean and volatility eqation
#Fitted model
```




```
#4d
mc3=garchFit(~arma(1,0)+garch(1,0),data=rc,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(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: 0x00000000204bc258>
##  [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   1.3115905    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 09:57:24 2021 by user: 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 LJungBox test are having pv > 0.05 we cannot reject H0 then the model is
adequate in both mean and volatility eqation
#fitted model


#4e
mc4=garchFit(~garch(1,0),data=rc,trace=F)
```

mean eq: $\hat{r}_t = \underset{(0.002)}{0.012}\,(1-\hat{\phi}_1) + \underset{(0.040)}{0.108}\,r_{t-1}$

vol. eq: $\hat{\sigma}_t^2 = \underset{(0.0001)}{0.002} + \underset{(0.071)}{0.190}\,a_{t-1}^2$

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

summary(mc4)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 0), data = rc, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 0)
## <environment: 0x00000000197ba480>
##  [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:
##  Thu Apr 29 09:57:24 2021 by user: 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 LJungBox test are having pv > 0.05 we cannot reject H0 then the model is
adequate in both mean and volatility eqation
#fitted model
```

mean eq: $\hat{r}_t = \underset{(0.002)}{0.012}$

vol. eq $\Rightarrow \hat{\sigma}_t^2 = \underset{(0.0021)}{0.002} + \underset{(0.062)}{0.194}\, a_{t-1}^2$

```
#4f
mc5=garchFit(~garch(1,0),data=rc,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(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: 0x000000001ec09ad0>
##  [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:
##  Thu Apr 29 09:57:24 2021 by user: 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 are having pv > 0.05,except lag 10 in mean equation, we
cannot reject H0 then the model is adequate in volatility eqation.
#but we still have in adequate model in mean equation if project lag is 10
#fitted model  mean eq : r̂_t = 0.013 (0.002)

vol eq : σ̂²_t = 0.002 (0.0001) + 0.204 (0.072) a²_{t-1}

#4g
#using AIC and BIC then the lower is the more effective model hence, in (f)
there is lower AIC and BIC which is better
```