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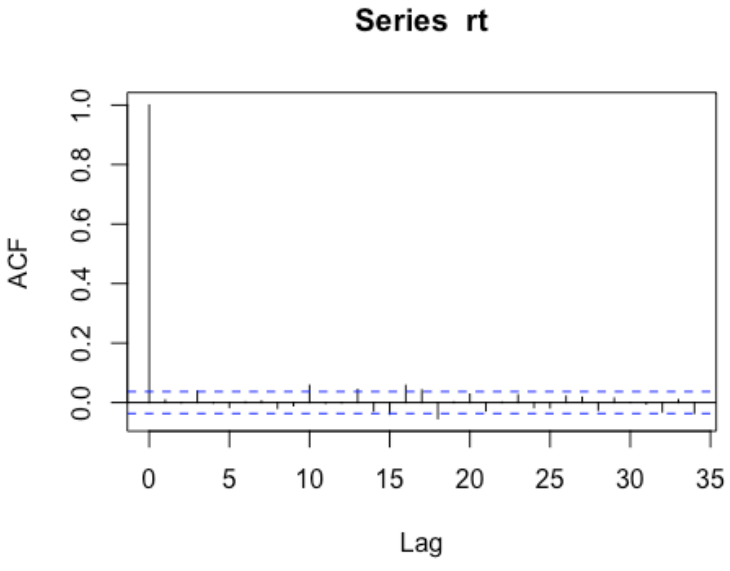
assignment5-final-.R

mew
2021-04-28

```
setwd("/Users/mew/Desktop")
cat(rep("\n",50))  #clear R Console
#install.packages("fBasics")
#install.packages("sn")
#install.packages("PerformanceAnalytics")
#install.packages("car")
#install.packages("tseries")
#install.packages("forecast")
#install.packages("quantmod")
library(quantmod)
## Loading required package: xts
## Loading required package: zoo
##
## Attaching package: 'zoo'
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
## Loading required package: TTR
## Registered S3 method overwritten by 'quantmod':
##   method           from
##   as.zoo.data.frame zoo
library(fBasics)
## Loading required package: timeDate
## Loading required package: timeSeries
##
## Attaching package: 'timeSeries'
## The following object is masked from 'package:zoo':
##
##     time<-
##
## Attaching package: 'fBasics'
## The following object is masked from 'package:TTR':
##
##     volatility
library(sn)
## Loading required package: stats4
##
## Attaching package: 'sn'
## The following object is masked from 'package:fBasics':
##
##     vech
## The following object is masked from 'package:stats':
```

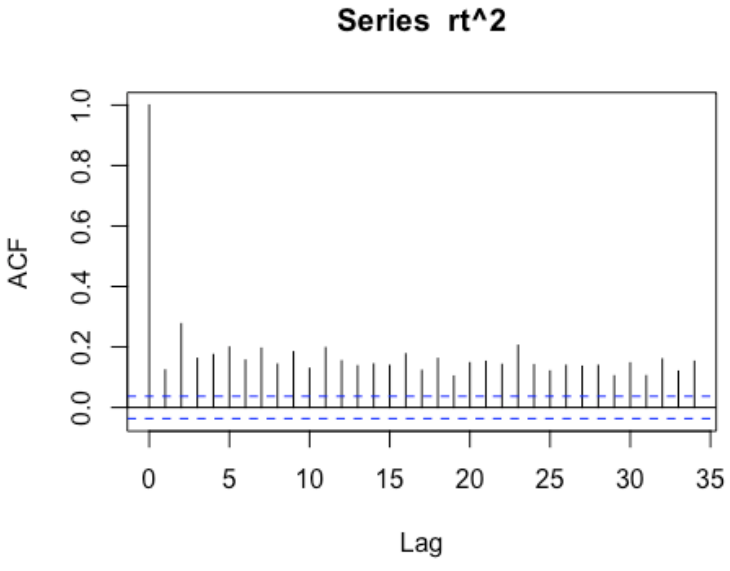
```
##
##     sd
library(PerformanceAnalytics)
##
## Attaching package: 'PerformanceAnalytics'
## The following objects are masked from 'package:timeDate':
##
##     kurtosis, skewness
## The following object is masked from 'package:graphics':
##
##     legend
library(car)
## Loading required package: carData
##
## Attaching package: 'car'
## The following object is masked from 'package:fBasics':
##
##     densityPlot
library(tseries)
library(forecast)
library(fGarch)
#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"
da=CAT
rt<-diff(log(as.numeric(CAT[,6])))
#1a
acf(rt)
```




```
Box.test(rt,lag = 10,type = 'Ljung')
##
##  Box-Ljung test
##
## data:  rt
## X-squared = 16.291, df = 10, p-value = 0.09159
#1b
acf(rt^2)
```

as p-value > 0.05, we cannot reject H_0.

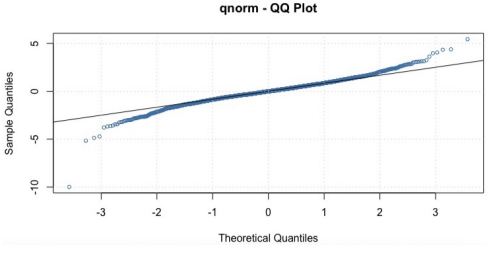
so, there is no auto correlation in logreturn at 95% C.I.




```
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
```

since p-value < 0.05, we reject H_0.
so, there are ARCH effects in logreturn at 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: 0x7fd5a4db7a78>
##  [data = rt]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
```



```
##         mu        ar1      omega     alpha1      beta1
## 4.8298e-04  1.6866e-02  4.4779e-06  4.9720e-02  9.3866e-01
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     4.830e-04   3.075e-04    1.571 0.116297
## ar1    1.687e-02   2.006e-02    0.841 0.400353
## omega  4.478e-06   1.278e-06    3.503 0.000461 ***
## alpha1 4.972e-02   8.191e-03    6.070 1.28e-09 ***
## beta1  9.387e-01   1.031e-02   91.048  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  7378.56    normalized:  2.599916
##
## Description:
##  Wed Apr 28 18:39:01 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  3298.441  0
##  Shapiro-Wilk Test  R    W      0.9663735 0
##  Ljung-Box Test     R    Q(10)  12.37554  0.2607088
##  Ljung-Box Test     R    Q(15)  14.79514  0.4662719
##  Ljung-Box Test     R    Q(20)  19.20107  0.5087928
##  Ljung-Box Test     R^2  Q(10)  0.980939  0.9998424
##  Ljung-Box Test     R^2  Q(15)  3.682825  0.9986048
##  Ljung-Box Test     R^2  Q(20)  6.9285    0.996913
##  LM Arch Test       R    TR^2   2.723165  0.9972029
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -5.196308 -5.185823 -5.196314 -5.192526
#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)
```

mean eq. $\hat{r}_t = 4.83e\text{-}04\ (1 - 1.687e\text{-}02) + 1.687e\text{-}02\, r_{t-1}$
$(3.075e\text{-}04)$ $(2e\text{-}02)$

volatility eq: $\sigma_t^2 = 4.5e\text{-}06 + 4.97e\text{-}02\, a_{t-1}^2 + 0.94\sigma_{t-1}^2$
$(1.28e\text{-}06)$ $(8.2e\text{-}03)$ (0.010)

p-value < 0.05, reject H_0 - not normal distribution

since p-value > 0.05, we cannot reject H_0
$\therefore$ mean equation is adequate

since p-value > 0.05, we cannot reject H_0
$\therefore$ volatility equation is adequate

no arch effect at 95% CI.


```
## <environment: 0x7fd5a1e3df20>
##  [data = rt]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##        mu      omega     alpha1      beta1      shape
## 5.9780e-04 4.2035e-06 7.2376e-02 9.2033e-01 5.0958e+00
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     5.978e-04   2.702e-04    2.212  0.02695 *
## omega  4.203e-06   1.571e-06    2.675  0.00747 **
## alpha1 7.238e-02   1.374e-02    5.267 1.39e-07 ***
## beta1  9.203e-01   1.472e-02   62.503  < 2e-16 ***
## shape  5.096e+00   4.825e-01   10.561  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  7507.106    normalized:  2.64521
##
## Description:
##  Wed Apr 28 18:39:01 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test  R    Chi^2  4056.502  0
##  Shapiro-Wilk Test R    W      0.9639091 0
##  Ljung-Box Test    R    Q(10)  14.77968  0.140303
##  Ljung-Box Test    R    Q(15)  16.74279  0.3344718
##  Ljung-Box Test    R    Q(20)  20.39783  0.433304
##  Ljung-Box Test    R^2  Q(10)  2.953085  0.9825066
##  Ljung-Box Test    R^2  Q(15)  5.482428  0.9871938
##  Ljung-Box Test    R^2  Q(20)  9.458146  0.9769677
##  LM Arch Test      R    TR^2   4.273688  0.977976
##
## Information Criterion Statistics:
##      AIC      BIC      SIC     HQIC
## -5.286897 -5.276412 -5.286903 -5.283115
#1e
#If,#Ig
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
```

mean eq : $\hat{r}_t^2 = 5.978e\text{-}04$ (2.7e-04)

volatility eq : $\sigma_t^2 = 4203e\text{-}06 + 0.0724\sigma_{t-1}^2 + 0.9203\sigma_{t-1}^2$ (1.57e-06) (0.014) (0.015)

p-value < 0.05, reject H_0 - not normal distribution

since p-value > 0.05, we cannot reject H_0 ∴ mean equation is adequate

since p-value > 0.05, we cannot reject H_0 ∴ volatility equation is adequate

no arch effect at 95% CI.

mean eq : $\hat{r}_t^2 = 5.978e\text{-}04$ (2.7e-04)

volatility eq : $\sigma_t^2 = 4203e\text{-}06 + 0.0724\sigma_{t-1}^2 + 0.9203\sigma_{t-1}^2$ (1.57e-06) (0.014) (0.015)

95% CI ($r_t \pm 1.96\sigma_t^2$)

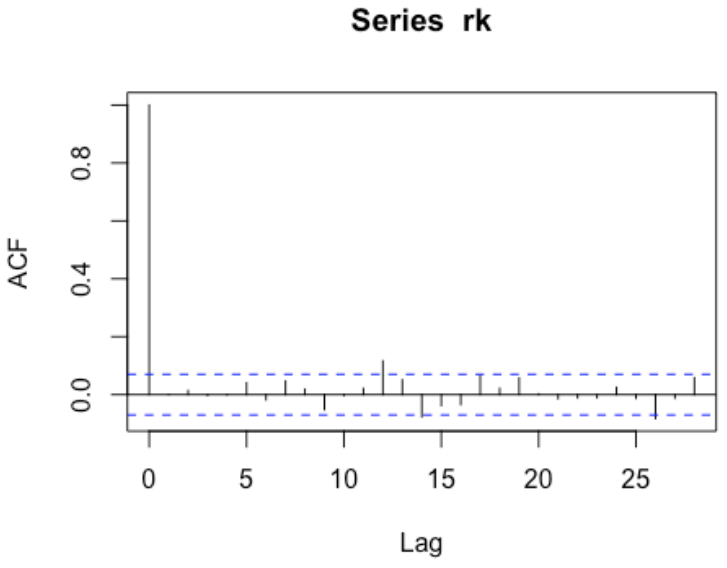
(-0.0291, 0.0303)

(-0.0293, 0.0305)

(-0.0294, 0.0306)

```
## 4 0.0005977987 0.01540384      0.01540384
## 5 0.0005977987 0.01548387      0.01548387
```
(-0.0296, 0.0308)
(-0.0298, 0.03095)

```
#2
k = read.table("m-kovw-5116.txt" ,header = TRUE)
rk=log(k$ko+1)
#2a
acf(rk)
```

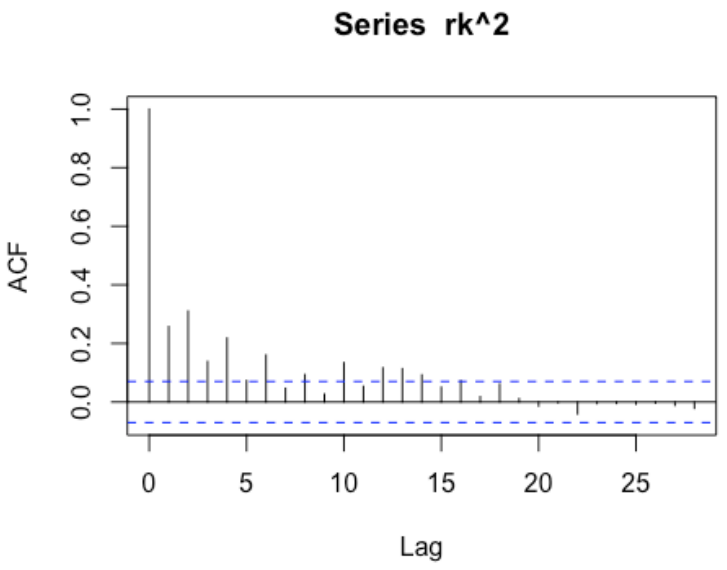



```
t.test(rk)
##
##  One Sample t-test
##
## data:  rk
## t = 4.9853, df = 779, p-value = 7.628e-07
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.00625636 0.01438347
## sample estimates:
##  mean of x
## 0.01031992
```
since P-value < 0.05, we reject H_0.
so, the expected return of k0 is not equal to zero at 95% C.I.

```
Box.test(rk,lag = 10,type = 'Ljung')
##
##  Box-Ljung test
##
## data:  rk
## X-squared = 5.9201, df = 10, p-value = 0.8219
Box.test(rk^2,lag = 10,type = 'Ljung')
```
as p-value > 0.05, we cannot reject H_0.
so, there is no auto correlation in logreturn at 95% C.I.

since P-value < 0.05, we reject H_0.
so, there is an arch effect at 95% CI.

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




```
#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: 0x7fd5aa64c8d8>
##  [data = rk]
##
## Conditional Distribution:
##  norm
##
```

```
## Coefficient(s):
##         mu         ar1       omega      alpha1       beta1
##  0.01124544 -0.02633742  0.00018112  0.09535029  0.84861593
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.125e-02   1.897e-03    5.929 3.05e-09 ***
## ar1    -2.634e-02   3.881e-02   -0.679  0.49740
## omega   1.811e-04   5.852e-05    3.095  0.00197 **
## alpha1  9.535e-02   1.915e-02    4.978 6.42e-07 ***
## beta1   8.486e-01   2.766e-02   30.675  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1170.664    normalized:  1.500852
##
## Description:
##  Wed Apr 28 18:39:01 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
```

mean eq : $\hat{r}_t = 0.01125(1+0.026) - 0.0026 r_{t-1}$
(0.0019) (0.0388)

volatility eq : $\hat{\sigma}_t^2 = 1.8e\text{-}04 + 0.095\sigma_{t-1}^2 + 0.856\sigma_{t-1}^2$
(5.85e-05) (0.019) (0.02766)

p-value < 0.05, reject H_0 - not normal distribution

since p-value > 0.05, we cannot reject H_0
∴ mean equation is adequate

since p-value > 0.05, we cannot reject H_0
∴ volatility equation is adequate

no arch effect at 95% CI.

#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: 0x7fd5a9a51578>
##  [data = rk]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##         mu        ar1      omega     alpha1      beta1      shape
##  0.01124020 -0.01887601  0.00017395  0.09642928  0.85044150  7.47877780
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.124e-02   1.810e-03    6.211 5.27e-10 ***
## ar1    -1.888e-02   3.691e-02   -0.511  0.60904
## omega   1.739e-04   6.596e-05    2.637  0.00836 **
## alpha1  9.643e-02   2.338e-02    4.124 3.72e-05 ***
## beta1   8.504e-01   3.267e-02   26.028  < 2e-16 ***
## shape   7.479e+00   1.840e+00    4.066 4.79e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1184.863    normalized:  1.519055
##
## Description:
##  Wed Apr 28 18:39:02 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
#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.
summary(mk3)
##
```

mean eq: $\hat{r}_t = 0.01124(1 + 0.019) - 0.019 r_{t-1}$
(0.00181) (0.037)

volatility eq: $\sigma_t^2 = 1.739e\text{-}04 + 0.0964 a_{t-1}^2 + 0.856 \sigma_{t-1}^2$
(6.6e-05) (0.0234) (0.0327)

p-value < 0.05, reject H_0 - not normal distribution

since p-value > 0.05, we cannot reject H_0
∴ mean equation is adequate

since p-value > 0.05, we cannot reject H_0
∴ volatility equation is adequate

↘ no arch effect at 95% CI.

```
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = rk, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x7fd5aa2ff478>
##  [data = rk]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##         mu       omega      alpha1       beta1
## 0.01098417  0.00018497  0.09479925  0.84780406
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.098e-02   1.846e-03    5.950 2.68e-09 ***
## omega  1.850e-04   5.899e-05    3.135  0.00172 **
## alpha1 9.480e-02   1.912e-02    4.958 7.11e-07 ***
## beta1  8.478e-01   2.787e-02   30.416  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1170.393    normalized:  1.500504
##
## Description:
##  Wed Apr 28 18:39:02 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
```

mean eq: $\hat{r}_t = 0.01098$
(1.85e-03)

volatility eq: $\sigma_t^2 = 1.85e{-}04 + 0.095 a_{t-1}^2 + 0.85 \sigma_{t-1}^2$
(5.9e-05) (0.02) (0.028)

Jarque-Bera Test – not normal distribution

Ljung-Box Test R Q(10), Q(15), Q(20): since p-value > 0.05, we cannot reject H_0
∴ mean equation is adequate

Ljung-Box Test R^2 Q(10), Q(15), Q(20): since p-value > 0.05, we cannot reject H_0
∴ volatility equation is adequate

LM Arch Test ↘ no arch effect at 95% CI.

#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: 0x7fd5a67aca38>
##  [data = rk]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##         mu       omega      alpha1       beta1       shape
## 0.01105016  0.00017528  0.09632874  0.85006800  7.48604505
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.105e-02   1.757e-03    6.291 3.16e-10 ***
## omega  1.753e-04   6.627e-05    2.645  0.00817 **
## alpha1 9.633e-02   2.337e-02    4.123 3.75e-05 ***
## beta1  8.501e-01   3.277e-02   25.941  < 2e-16 ***
## shape  7.486e+00   1.840e+00    4.069 4.72e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1184.68    normalized:  1.518821
##
## Description:
##  Wed Apr 28 18:39:02 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
```

mean eq : $\hat{r}_t = 0.01105$ (1.76e-03)

volatility eq : $\hat{\sigma}_t^2 = 1.75e-04 + 0.096\,a_{t-1}^2 + 0.856\,\sigma_{t-1}^2$ (6.63e-05) (0.023) (0.033)

p-value < 0.05, reject H_0 – not normal distribution

since p-value > 0.05, we cannot reject H_0 ∴ mean equation is adequate

since p-value > 0.05, we cannot reject H_0 ∴ volatility equation is adequate

```
## 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
```

no arch effect at 95% CI.

#2f

I choose model MK4 since this model has lower AIC and BIC.

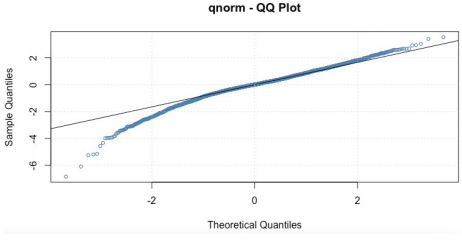
```
#3
getSymbols("^GSPC",from="2005-01-02",to="2021-03-31")
## [1] "^GSPC"
rs<-diff(log(as.numeric(GSPC[,6])))
#3a
t.test(rs)
##
##  One Sample t-test
##
## data:  rs
## t = 1.4961, df = 4086, p-value = 0.1347
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -9.051939e-05  6.737464e-04
## sample estimates:
##    mean of x
## 0.0002916135
Box.test(rs,lag = 10,type = 'Ljung')
##
##  Box-Ljung test
##
## data:  rs
## X-squared = 131.85, df = 10, p-value < 2.2e-16
#3b
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: 0x7fd5a9fe1228>
##  [data = rs]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
```

since p-value > 0.05, we cannot reject H_0

So, the expected return is equal to zero at 95% CI

as p-value < 0.05, we reject H_0.

so, there is autocorrelation in logreturn at 95% CI.



```
##         mu       omega      alpha1       beta1
## 6.7965e-04  2.7630e-06  1.4185e-01  8.3682e-01
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     6.797e-04   1.164e-04    5.837 5.33e-09 ***
## omega  2.763e-06   3.545e-07    7.794 6.44e-15 ***
## alpha1 1.418e-01   1.200e-02   11.822  < 2e-16 ***
## beta1  8.368e-01   1.198e-02   69.853  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  13417.79    normalized:  3.283041
##
## Description:
##  Wed Apr 28 18:39:02 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  1128.761  0
##  Shapiro-Wilk Test  R    W      0.9727248 0
##  Ljung-Box Test     R    Q(10)  25.75991  0.004076864
##  Ljung-Box Test     R    Q(15)  33.37343  0.004166121
##  Ljung-Box Test     R    Q(20)  38.81779  0.007023858
##  Ljung-Box Test     R^2  Q(10)  15.24652  0.1233293
##  Ljung-Box Test     R^2  Q(15)  17.48525  0.2906928
##  Ljung-Box Test     R^2  Q(20)  18.66957  0.5433881
##  LM Arch Test       R    TR^2   15.93476  0.1942425
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -6.564125 -6.557944 -6.564127 -6.561936
#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: 0x7fd5a98c0438>
```

mean eq: $\hat{r}_t = 6.797e\text{-}04$ $(1.164e\text{-}04)$

volatility eq: $\sigma_t^2 = 2.763e\text{-}06 + 0.1418\,a_{t-1}^2 + 0.8368\,\sigma_{t-1}^2$ $(3.545e\text{-}07)$ (0.012) (0.012)

p-value < 0.05, reject H_0 – not normal distribution

since p-value < 0.05, we reject H_0 ∴ mean equation is not adequate

since p-value > 0.05, we cannot reject H_0 ∴ volatility equation is adequate

↘ no arch effect at 95% CI.

```
##  [data = rs]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##         mu      omega     alpha1      beta1      shape
## 8.4344e-04  1.7504e-06  1.4341e-01  8.5400e-01  5.1216e+00
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     8.434e-04   1.047e-04    8.057 8.88e-16 ***
## omega  1.750e-06   3.696e-07    4.736 2.19e-06 ***
## alpha1 1.434e-01   1.476e-02    9.719  < 2e-16 ***
## beta1  8.540e-01   1.301e-02   65.646  < 2e-16 ***
## shape  5.122e+00   4.333e-01   11.821  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  13552.39    normalized:  3.315974
##
## Description:
##  Wed Apr 28 18:39:03 2021 by user:
##
##
## Standardised Residuals Tests:
##                             Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  1437.833  0
##  Shapiro-Wilk Test  R    W      0.9705412 0
##  Ljung-Box Test     R    Q(10)  25.99939  0.003741002
##  Ljung-Box Test     R    Q(15)  33.61634  0.003853714
##  Ljung-Box Test     R    Q(20)  38.85139  0.006956808
##  Ljung-Box Test     R^2  Q(10)  12.3947   0.2595084
##  Ljung-Box Test     R^2  Q(15)  17.01071  0.3182243
##  Ljung-Box Test     R^2  Q(20)  19.6441   0.4803813
##  LM Arch Test       R    TR^2   13.90916  0.3065471
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -6.629501 -6.621775 -6.629504 -6.626765
#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
```

mean eq: $\hat{r}_t = 8.434e\text{-}04$ $(1.047e\text{-}04)$

volatility: $\sigma_t^2 = 1.75e\text{-}06 + 0.1434\sigma_{t-1}^2 + 0.854\sigma_{t-1}^2$ $(3.7e\text{-}07)$ (0.0148) (0.013)

p-value < 0.05, reject H_0 – not normal distribution

since p-value < 0.05, we reject H_0 ∴ mean equation is not adequate

since p-value > 0.05, we cannot reject H_0 ∴ volatility equation is adequate

↘ no arch effect at 95% CI.

```
c = read.table("m-deciles.txt" ,header = TRUE)
rc=log(c$CAP9RET+1)
#4a
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
Box.test(rc,lag = 10,type = 'Ljung')
##
##  Box-Ljung test
##
## data:  rc
## X-squared = 24.257, df = 10, p-value = 0.006946
mc1=auto.arima(rc)
mc1
## Series: rc
## ARIMA(0,0,2) with non-zero mean
##
## Coefficients:
##          ma1      ma2    mean
##       0.1660  -0.0558  0.0096
## s.e.  0.0373   0.0370  0.0020
##
## sigma^2 estimated as 0.002392:  log likelihood=1152.66
## AIC=-2297.32   AICc=-2297.26   BIC=-2279
summary(mc1)
## Series: rc
## ARIMA(0,0,2) with non-zero mean
##
## Coefficients:
##          ma1      ma2    mean
##       0.1660  -0.0558  0.0096
## s.e.  0.0373   0.0370  0.0020
##
## sigma^2 estimated as 0.002392:  log likelihood=1152.66
## AIC=-2297.32   AICc=-2297.26   BIC=-2279
##
## Training set error measures:
##                       ME     RMSE        MAE       MPE     MAPE      MASE
## Training set 1.149455e-06 0.048807 0.03675026 -137.9858 502.9481 0.7525704
##                    ACF1
## Training set 0.00044559
#4b
Box.test(rc^2,lag = 10,type = 'Ljung')
##
```

since p-value < 0.05, we reject H_0
So, the expected return is not equal to zero at 95% CI.

as p-value < 0.05, we reject H_0.
So, there is auto correlation in logreturn at 95% CI.

```
##  Box-Ljung test
##
## data:  rc^2
## X-squared = 19.824, df = 10, p-value = 0.03096
#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.
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: 0x7fd5aaace5b8>
##  [data = rc]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##      mu      ar1    omega   alpha1
## 0.01053  0.14707  0.00200  0.18152
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     0.0105300   0.0019275    5.463 4.68e-08 ***
## ar1    0.1470670   0.0424301    3.466 0.000528 ***
## omega  0.0020000   0.0001482   13.493  < 2e-16 ***
## alpha1 0.1815182   0.0651142    2.788 0.005309 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1158.628    normalized:  1.609206
##
## Description:
##  Wed Apr 28 18:39:03 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
```

since p-value < 0.05, we reject H_0
so, there is an arch effect at 95% CI.

mean equation : $\hat{r}_t = \underset{(0.002)}{0.01(1-0.147)} + \underset{(0.0424)}{0.147 r_{t-1}}$

volatility eq : $\sigma_t^2 = \underset{(0.0001)}{0.002} + \underset{(0.065)}{0.18 a_{t-1}^2}$

p-value < 0.05, reject H_0
- not normal distribution

since p-value > 0.05, we cannot reject H_0
∴ mean equation is adequate

```
##  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
#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: 0x7fd5a1b4df50>
##  [data = rc]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##        mu        ar1      omega     alpha1      shape
## 0.0116189  0.1076982  0.0019203  0.1900830  6.4225253
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     0.0116189   0.0017710    6.561 5.35e-11 ***
## ar1    0.1076982   0.0403169    2.671  0.00756 **
## omega  0.0019203   0.0001818   10.564  < 2e-16 ***
## alpha1 0.1900830   0.0713692    2.663  0.00774 **
## shape  6.4225253   1.3115897    4.897 9.74e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1187.516    normalized:  1.649328
##
## Description:
##  Wed Apr 28 18:39:03 2021 by user:
##
```

since p-value > 0.05, we cannot reject H_0
∴ volatility equation is adequate
↳ no arch effect at 95% CI.

mean eq: $\hat{r}_t = 0.012(1-0.108) + 0.108 r_{t-1}$
(0.002) (0.04)

volatility eq: $\hat{\sigma}_t^2 = 0.002 + 0.19 a_{t-1}^2$
(0.0002) (0.07)

```
##
## 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
#4e
mc4=garchFit(~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.
summary(mc4)
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 0), data = rc, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 0)
## <environment: 0x7fd5a2718070>
##  [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
```

p-value < 0.05, reject H_0 – not normal distribution

since p-value > 0.05, we cannot reject H_0
∴ mean equation is adequate

since p-value > 0.05, we cannot reject H_0
∴ volatility equation is adequate

no arch effect at 95% CI.

mean eq : $\hat{r}_t = 0.01234$ (0.0019)

volatility eq : $\hat{\sigma}_t^2 = 0.002 + 0.194 a_{t-1}^2$ (0.0001) (0.0622)

```
##
## Description:
##  Wed Apr 28 18:39:03 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
#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: 0x7fd5ab1bc310>
##  [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 **
```

p-value < 0.05, reject H_0 - not normal distribution

reject H_0 ∴ not adequate

since p-value > 0.05, we cannot reject H_0 ∴ mean equation is adequate

since p-value > 0.05, we cannot reject H_0 ∴ volatility equation is adequate

no arch effect at 95% CI.

mean eq: $\hat{r}_t = 0.013356$ (0.0017)

volatility eq: $\hat{\sigma}_t^2 = 0.0019 + 0.2042\,a_{t-1}^2$ (0.0002) (0.072)

```
## shape   6.220223    1.236608    5.030 4.90e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1183.349    normalized:  1.64354
##
## Description:
##  Wed Apr 28 18:39:04 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
```

p-value < 0.05, reject H_0

- not normal distribution

reject H_0 ∴ not adequate

since p-value > 0.05, we cannot reject H_0

∴ mean equation is adequate

since p-value > 0.05, we cannot reject H_0

∴ volatility equation is adequate

no arch effect at 95% CI.

#4g

I choose model mc3 since this model has lowest AIC and BIC