Assigment5_6004641236.R

Admin

2021-04-29

```
#setwd("D:/MyGames/RStudio/works")
#(rep("\n",50))
```

```
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)
library(Matrix)
library(tinytex)
library(timeDate)
```

```
#question1



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

```
## 'getSymbols' currently uses auto.assign=TRUE by default, but will
## use auto.assign=FALSE in 0.5-0. You will still be able to use
## 'loadSymbols' to automatically load data. getOption("getSymbols.env")
## and getOption("getSymbols.auto.assign") will still be checked for
## alternate defaults.
##
## This message is shown once per session and may be disabled by setting
## options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.
```

```
## [1] "CAT"
```

```
head(CAT)
```

```
##            CAT.Open CAT.High CAT.Low CAT.Close CAT.Volume CAT.Adjusted
## 2006-01-03    57.87    58.11   57.05     57.80    3697500     38.08682
```

```
## 2006-01-04    57.95    59.43   57.55     59.27    4577200     39.05544
## 2006-01-05    59.02    59.86   59.00     59.27    4590700     39.05544
## 2006-01-06    59.47    60.76   59.38     60.45    5692300     39.83300
## 2006-01-09    60.45    61.68   60.45     61.55    4408800     40.55783
## 2006-01-10    61.35    61.52   60.64     61.30    3188100     40.39312
```

```
tail(CAT)
```

```
##            CAT.Open CAT.High CAT.Low CAT.Close CAT.Volume CAT.Adjusted
## 2017-04-06    94.42    96.42   94.26     95.82    5421600     85.75500
## 2017-04-07    95.87    96.62   95.42     95.52    4463800     85.48653
## 2017-04-10    96.31    97.89   96.10     97.14    5168300     86.93636
## 2017-04-11    97.30    97.31   95.67     97.10    4250400     86.90057
## 2017-04-12    96.69    96.77   94.66     94.86    4773900     84.89585
## 2017-04-13    94.60    94.86   93.09     93.10    4706000     83.32072
```

```
dim(CAT)
```

```
## [1] 2840    6
```

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

```
## [1]  0.0251138827  0.0000000000  0.0197134625  0.0180332657 -0.0040696057
## [6]  0.0004890727
```

```
tail(rt)
```

```
## [1]  0.0166264890 -0.0031356788  0.0168176184 -0.0004118458 -0.0233393226
## [6] -0.0187280011
```

```
#ts.plot(rt)
Box.test(rt,lag=10,type="Ljung")
```

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

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

```
##
##  One Sample t-test
##
## data:  rt
## t = 0.7159, df = 2838, p-value = 0.4741
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -0.0004794893  0.0010309714
## sample estimates:
##    mean of x
## 0.0002757411
```

```
#Question 1.a
#H0:p1=p2=..=p10=0
#Ha:pi /=0
#since p-value > 0.05, H0 is significance, therefore is no serial correlation
```

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

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

```r
#Question 1.b
#H0:p1=p2=..=p10=0
#Ha:pi /=0
#since p-value < 0.05, H0 is not significance, therefore is  serial correlation
```

```r
Q1m1 = garchFit(~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.
```

```r
summary(Q1m1)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = rt, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x0000000026b7e870>
##  [data = rt]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##         mu       omega      alpha1       beta1
## 4.9258e-04  4.4243e-06  4.9485e-02  9.3903e-01
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     4.926e-04   3.075e-04    1.602 0.109167
## omega  4.424e-06   1.259e-06    3.514 0.000441 ***
## alpha1 4.949e-02   8.096e-03    6.112 9.83e-10 ***
## beta1  9.390e-01   1.016e-02   92.407  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  7379.812    normalized:  2.599441
##
## Description:
```

```
##  Thu Apr 29 13:58:07 2021 by user: Admin
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  3249.183  0
##  Shapiro-Wilk Test  R    W      0.9666933 0
##  Ljung-Box Test     R    Q(10)  13.769    0.1837915
##  Ljung-Box Test     R    Q(15)  16.04338  0.3791746
##  Ljung-Box Test     R    Q(20)  20.59485  0.4213143
##  Ljung-Box Test     R^2  Q(10)  1.013167  0.9998172
##  Ljung-Box Test     R^2  Q(15)  3.722275  0.9985142
##  Ljung-Box Test     R^2  Q(20)  7.0086    0.9966568
##  LM Arch Test       R    TR^2   2.756883  0.9970306
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -5.196063 -5.187679 -5.196067 -5.193039
```

```
##plot(Q1m1)
#13

#Question 1.c

#mean equation:
#rt = 4.9258e-4
#(3.075e-04)
#variance equation:
#VAR(rt) = 4.424e-06+4.949e-02a^2+9.390e-01(o')^2
#           (1.259e-6)  (8.096e-03) (1.016e-2)
```

```
0
```

```
## [1] 0
```

```
Q1m2 = 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(Q1m2)
```

```
##
## 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: 0x000000001f77d998>
##  [data = rt]
##
## 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 13:58:08 2021 by user: Admin
##
##
## 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(Q1m2)
#13


#Question 1.c
#From the QQ-#plot, the model is not adequate because the normality assumption is not accepted
```

```
#Question 1.e
#mean equation:
#rt = 5.901e-4
#     (2.703e-04)
#variance equation:
#VAR(rt) =4.214e-06 +7.239e-02 a^2+9.203e-01(o')^2
#           ( 1.574e-06)  (1.375e-02) (1.474e-02)
```

```
#1.f
pm2 = predict(Q1m2,5)
pm2
```

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

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

```
## [1] 1.992374
```

```
ucl = pm2$meanForecast+1.99*pm2$standardDeviation
lcl = pm2$meanForecast-1.99*pm2$standardDeviation
CI = cbind(ucl,lcl)
CI
```

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

```
#Question2

da1= read.table("m-kovw-5116.txt", header = T)
head(da1)
```

```
##   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
```

```
tail(da1)
```

```
##     PERMNO     date        ko    vwretd
## 775  11308 20160729 -0.037503  0.038740
## 776  11308 20160831 -0.004584  0.002788
## 777  11308 20160930 -0.017499  0.003016
## 778  11308 20161031  0.001890 -0.021589
## 779  11308 20161130 -0.040094  0.040416
## 780  11308 20161230  0.027509  0.018779
```

```
dim(da1)
```

```
## [1] 780   4
```

```
#2.a
```

```r
ko = log(da1$ko+1)
ko
```

```
##   [1]  0.0240973135  0.0094789326  0.0163742080 -0.0165288520  0.0281704603
##   [6]  0.0452563084  0.0088893722 -0.0088893938 -0.0317486983 -0.0046618496
##  [11]  0.0578716594 -0.0146974808  0.0553855098  0.0565599014 -0.0384061650
##  [16] -0.0226669656  0.0130149371 -0.0395654926  0.0256852905 -0.0393532819
##  [21]  0.0091321745 -0.0138565602  0.0342893431  0.0158910655  0.0737865634
##  [26]  0.0020898148  0.0338669844 -0.0195182477 -0.0125261254 -0.0073801666
##  [31]  0.0074432303 -0.0257527744  0.0129586725 -0.0579225881  0.0249160023
##  [36]  0.0313930413  0.0282939250  0.0296005489 -0.0189280099  0.0460330334
##  [41] -0.0061538964  0.1053604157  0.0166515896 -0.0055202084 -0.0520704384
##  [46] -0.0147999814  0.0157798408 -0.0079837858 -0.0020060107  0.0020059867
##  [51]  0.0159048447  0.0206601027 -0.0591652497 -0.0357556833  0.0021576706
##  [56] -0.0373260292 -0.0481193892 -0.0215577065 -0.0048547653 -0.0225861577
##  [61]  0.0591308007 -0.0193245216  0.0024360305  0.0194653155  0.0355070954
##  [66] -0.0140512582  0.0059343568 -0.0472530461 -0.0200506781  0.0177446287
##  [71]  0.0538023441 -0.0497618361  0.0654150119  0.0747901680 -0.0133932910
##  [76]  0.0615578333 -0.0193765181  0.0383838246 -0.0106050351 -0.0259190143
##  [81] -0.0132159472  0.0330062510  0.0830351489  0.0551319174 -0.0714594825
##  [86]  0.0714588950 -0.0212982051  0.0424779027  0.1074381559  0.0143278642
##  [91]  0.0404516860 -0.0064930342  0.0081100247  0.0193240814  0.0079423757
##  [96] -0.0295585822 -0.0185031320  0.0185037449  0.0671912495 -0.0312151633
## [101]  0.1365751308  0.0514209862  0.0360763517  0.0078431618  0.0073945925
## [106] -0.0019589174  0.1368594734  0.1031169006  0.0092877351  0.0982476793
## [111]  0.0122160789 -0.0512932944  0.0840828430 -0.0598190089  0.0085840514
## [116]  0.0225361427  0.0339568835  0.0054053647  0.1178425894 -0.0024129087
## [121] -0.1042877579 -0.0162167841  0.0411054743 -0.0266684633 -0.0963919647
## [126] -0.0857136739  0.1141453161 -0.0073156946 -0.0734076021  0.0126585415
## [131]  0.0884256265 -0.0116617345  0.0569954561 -0.0027738435  0.0453451894
## [136] -0.0107526026  0.0053904454  0.0152067885  0.0184949099  0.0682948946
## [141]  0.0041473877  0.0145989154  0.0196133937  0.0975830494  0.0213915604
## [146]  0.0031699703  0.0653297705  0.0059462857  0.0098325021  0.0336736257
## [151]  0.0491977002 -0.0090992731 -0.0073398711 -0.0339012068  0.0320479348
## [156]  0.0491453392  0.0899677526  0.0224725892 -0.0649193937  0.0722806608
## [161] -0.0015862574 -0.0185846294  0.0016246795  0.0192936743  0.0053993970
## [166] -0.0160521491  0.0557014641  0.0568169111 -0.0029112335 -0.0756787436
## [171]  0.0606989720 -0.0741084337  0.0158989394 -0.0504631128  0.0296073448
## [176] -0.0279397037 -0.0003330555  0.1004831406  0.0485729977  0.0412868465
## [181]  0.0582424927  0.0562810847  0.0320673038  0.0924442588 -0.0044247749
## [186]  0.0932926915  0.0348815047 -0.0636898147  0.0370905614  0.0000000000
## [191]  0.1127874674 -0.0406709643 -0.0503011551  0.0118346929  0.0499095374
## [196]  0.0929236981  0.0068028083  0.0006777703 -0.0487901142  0.0453834154
## [201] -0.0182546061 -0.0017465243  0.0434483028 -0.0394219334  0.0034908997
## [206] -0.0481802502  0.0387985087  0.0192485523  0.0390870504 -0.0714240387
## [211] -0.0236586723  0.0727912485  0.0624601127  0.0776783764 -0.0654114353
## [216]  0.0530543927 -0.0371558065  0.0447257250 -0.0277104116 -0.0844658922
## [221] -0.0362418743 -0.0197364895  0.0475026690 -0.0138413511  0.0424318979
## [226]  0.0554791714  0.0658467276  0.0118692806  0.0262026914  0.0014359685
## [231]  0.0827893936  0.0196987003  0.0457512657  0.0235221718 -0.0271625855
## [236]  0.0874282901 -0.0009634640  0.0045974157 -0.0032623156  0.1195778684
## [241] -0.0186151926  0.0419065262  0.0122170668  0.0341327916  0.0189934765
## [246]  0.0077588223  0.0617251924 -0.0052959991  0.0011323586  0.0193162345
## [251] -0.0058601371  0.0412427060 -0.0186926236 -0.0384664377 -0.0005351432
```

```
## [256] -0.0126010609  0.0197320366  0.0196977198  0.0060953853 -0.0219399297
## [261]  0.0406869454 -0.0250983449 -0.0909547784 -0.0253670400 -0.0738037108
## [266] -0.0215066183 -0.0387179596 -0.0429054133  0.0152855780  0.0128224400
## [271] -0.2380110265 -0.1570913326 -0.3399765696  0.2064188703 -0.1443381472
## [276] -0.0186926236  0.2287875937  0.0476275839  0.1299917605  0.0141405495
## [281]  0.1134402862  0.0160268807 -0.1278333715 -0.0350915698 -0.0765582023
## [286]  0.1383783770  0.0806579030 -0.0618754037  0.1201446892 -0.0931564009
## [291]  0.0466745946 -0.0631165992 -0.0152679644  0.0426168628  0.0307270516
## [296] -0.0043323712  0.0018792331 -0.0431298639 -0.0303963229 -0.0015812495
## [301] -0.0552981452  0.0247745605  0.0132241739 -0.0381152444 -0.0291363715
## [306]  0.0461533575  0.0491101130  0.0158477583  0.0065197005 -0.0584578460
## [311]  0.0234030009 -0.0166396747 -0.0411012002  0.0034908997  0.0656706925
## [316]  0.1093134923  0.0088368399 -0.0103766517  0.0207414022  0.0542211042
## [321] -0.0126354927 -0.0736712983  0.0196231994  0.0616932271 -0.0028530661
## [326] -0.0378503725 -0.0091810169 -0.0339012068 -0.0157981360 -0.0130791605
## [331]  0.0258080878  0.0189277349 -0.0748582535 -0.0634010350 -0.0075927521
## [336]  0.0256891890  0.0179538606 -0.0662007018 -0.0257271225  0.0540676423
## [341]  0.0149260502 -0.0062414373  0.1144102431 -0.0413856950 -0.0794090751
## [346] -0.0517017989  0.0094244500  0.0941868218  0.0074630818  0.0647703693
## [351]  0.0430997185 -0.0629579043  0.0764257127 -0.0562698675 -0.0218193195
## [356] -0.0374578679  0.0471163832  0.0885537702 -0.0183360832 -0.0248676529
## [361] -0.0631006221 -0.0755827514  0.0981606588  0.0411275478 -0.0451051123
## [366]  0.0532449886  0.0817504794  0.0723997282  0.0494252006  0.0710361160
## [371]  0.1359285172  0.0492710009 -0.0342333308 -0.0099998321  0.0851165830
## [376]  0.0389514461 -0.0697960511 -0.0259734075 -0.0754587302  0.1075207806
## [381]  0.0008736183  0.0242730124  0.0702776458 -0.0321864715 -0.0527701739
## [386]  0.0219248835  0.0687169668  0.0000000000  0.0022754093  0.0585264221
## [391]  0.0320198490  0.0391399407  0.0230063135  0.0372225643 -0.0381817331
## [396]  0.0080485236 -0.0388198335  0.0566950287  0.1079715041 -0.0216619347
## [401] -0.0091658786  0.0324691262  0.0406053311 -0.0086886371 -0.0159728901
## [406]  0.0265270266  0.1592533533  0.0149033907 -0.0074234860  0.1376213922
## [411]  0.0967727461  0.0576857192  0.0395658459  0.0849117577 -0.0669317827
## [416] -0.0324705071 -0.1039681521  0.0780539622  0.0036792233  0.0336736257
## [421]  0.1214553954  0.0514399836  0.0254123535 -0.0707508444  0.0058478678
## [426]  0.0434722395  0.0678689067  0.0610875735 -0.0396913839 -0.1593322477
## [431] -0.1011936535  0.0299519288  0.0057464574 -0.0066671763  0.0309539451
## [436]  0.0000000000 -0.0065574532  0.0336388172 -0.0161558050  0.0414729826
## [441]  0.0964458983 -0.0143890273  0.0126733527  0.0284105705  0.0465199702
## [446]  0.0211644447  0.0773489289  0.0568877661  0.0625202358 -0.0180845440
## [451]  0.1874815544 -0.0223059380  0.0125528819  0.0771684270  0.0695773673
## [456]  0.0000000000 -0.1147533797  0.0233189867  0.0638729872  0.0198683114
## [461]  0.1685665557 -0.0122628827  0.0222848382 -0.0713574506 -0.0622531346
## [466]  0.1275802195  0.0344951421  0.0053904454  0.0472527925  0.0717242047
## [471]  0.0395879534 -0.0280394570  0.0818638177 -0.0448331535  0.0982250184
## [476]  0.0894338571 -0.0154802024  0.0324149138  0.0439001322  0.1456204002
## [481] -0.0348689160  0.0533881486  0.0034191480  0.0151752709  0.0584962408
## [486] -0.0918159916  0.0458095360  0.0265114453 -0.0564476077  0.0030812481
## [491] -0.0182576614  0.0520790356  0.0118692806  0.0000000000  0.0098631983
## [496] -0.0793094766  0.0525620891  0.0394524171  0.0057971639  0.0028858320
## [501] -0.0222629915  0.0262786712 -0.0281741913  0.0606246218 -0.0877760329
## [506]  0.0419218694 -0.0432687354  0.0273155112 -0.0365892984  0.0140616697
## [511]  0.0882928888  0.0359654204  0.0594983407  0.0353574913  0.0185852199
## [516]  0.0073082297  0.0192308953  0.0465199702  0.0285874569  0.0305699414
## [521]  0.0584717177  0.0373468432  0.0289877654 -0.0211746080  0.0745080350
```

```
## [526]  0.0408223145  0.0554101087 -0.0200006869  0.0150383550  0.0688821987
## [531]  0.0274828626 -0.0152212578  0.1211852416  0.0657268773 -0.0443354512
## [536]  0.0695260626  0.0148147181 -0.0073983001  0.0147418037  0.0289178202
## [541]  0.0950937928  0.0525886550 -0.0874878541  0.1321294103  0.0738274328
## [546] -0.0052688561  0.0164086389 -0.1873976182  0.0646475777 -0.0744229448
## [551]  0.1009533182  0.0648509723 -0.0294833951  0.0581236146  0.1227493497
## [556] -0.0203843565  0.0324178182  0.0887642565 -0.0602596884 -0.2119489454
## [561] -0.1197524737  0.1590964294  0.0384733185 -0.0446951104 -0.0255096213
## [566] -0.0222558339 -0.0373218771  0.1034235409  0.0064074285 -0.0971223207
## [571] -0.0234580000 -0.0124613208 -0.2115077605  0.2011416754  0.1323282942
## [576] -0.1427428308 -0.0140461874 -0.1665600249 -0.0317053444  0.0066359334
## [581]  0.1218901455  0.0763099033  0.0652866787 -0.1527922696  0.0494908710
## [586]  0.0909716912  0.0393005177 -0.0273156999 -0.0494056035 -0.0895855965
## [591] -0.1566678452  0.0225517861  0.0258587616 -0.0479672529 -0.0089287429
## [596]  0.0873293264 -0.0342767945  0.0217468146 -0.0155756735  0.0040378370
## [601] -0.0748420877  0.0799196232  0.1016401035  0.0603318731  0.0009005943
## [606]  0.0114531614 -0.1145290855  0.0210028871 -0.0572965410 -0.0313451668
## [611] -0.0138646719 -0.0402377902 -0.0802333092 -0.0059496642  0.0118633513
## [616] -0.0019779549  0.1204195570  0.0229945864 -0.0315195633 -0.0327752896
## [621] -0.0078436814  0.0770304832  0.0068733245  0.0874594433 -0.0302056314
## [626]  0.0145161293  0.0117398179  0.0053536436  0.0153062593 -0.0121474828
## [631] -0.1405744223  0.0191945993 -0.1038461074  0.0151161728 -0.0274266968
## [636]  0.0575818797 -0.0036085028  0.0310857911 -0.0200598604  0.0415996121
## [641]  0.0270254990 -0.0600228654  0.0470209810  0.0054690176 -0.0121181288
## [646] -0.0095383457  0.0044311679 -0.0573653764  0.0261978207  0.0141573107
## [651]  0.0049915216  0.0021476921  0.0481547242 -0.0160257288  0.0338244487
## [656]  0.0069418495  0.0040089534  0.0446463523  0.0089498305  0.0298713747
## [661] -0.0076975503 -0.0253824255  0.0349433089  0.0836902013  0.0152126979
## [666] -0.0064366710 -0.0038303263  0.0315451776  0.0722601946  0.0719931661
## [671]  0.0109498312 -0.0118246363 -0.0393834464 -0.0091951461  0.0466211469
## [676] -0.0334089144 -0.0277289175 -0.0894598265 -0.0092768977  0.0110071979
## [681]  0.0225967593 -0.1824731683  0.0699000599 -0.0347332768 -0.0579776905
## [686] -0.0447599464  0.0824312375 -0.0206905814  0.1327180620 -0.0155807520
## [691]  0.0378255095 -0.0217028115  0.1039040555 -0.0072895040  0.0775719656
## [696] -0.0035031288 -0.0494486809 -0.0286083441  0.0503061573 -0.0285867349
## [701] -0.0391088794 -0.0164770033  0.0949110092  0.0139196703  0.0536080632
## [706]  0.0467375829  0.0366645644  0.0403345157 -0.0454127241  0.0168816989
## [711]  0.0442206924  0.0167420662 -0.0096817169  0.0141188582  0.0106431601
## [716]  0.0352484109 -0.0349548648  0.0111862005 -0.0091164286  0.0399473721
## [721] -0.0354945440  0.0339211182  0.0645744580  0.0307348095 -0.0210530688
## [726]  0.0517619346  0.0328349831 -0.0771586207  0.0207717654 -0.0199711015
## [731]  0.0264101611 -0.0450392078  0.0269437354  0.0389726055  0.0503632120
## [736]  0.0456767511 -0.0568666917  0.0099523110 -0.0007482799 -0.0485654394
## [741] -0.0005241373  0.0436483965  0.0224892113  0.0274867541 -0.0882663460
## [746]  0.0099978545  0.0198281172  0.0536317580  0.0029376808  0.0420043353
## [751] -0.0752344525  0.0600107864  0.0294053924 -0.0184532182  0.0748495543
## [756] -0.0599835773 -0.0251844835  0.0504430831 -0.0575115350  0.0002469695
## [761]  0.0098136879 -0.0347777975  0.0460798279 -0.0437878466  0.0283337804
## [766]  0.0540932209  0.0140685719  0.0079453519 -0.0009314336  0.0048810682
## [771]  0.0803811119 -0.0348761644 -0.0044739934  0.0239264655 -0.0382243297
## [776] -0.0045945387 -0.0176539174  0.0018882162 -0.0409199160  0.0271374265
```

```
t.test(ko)
```

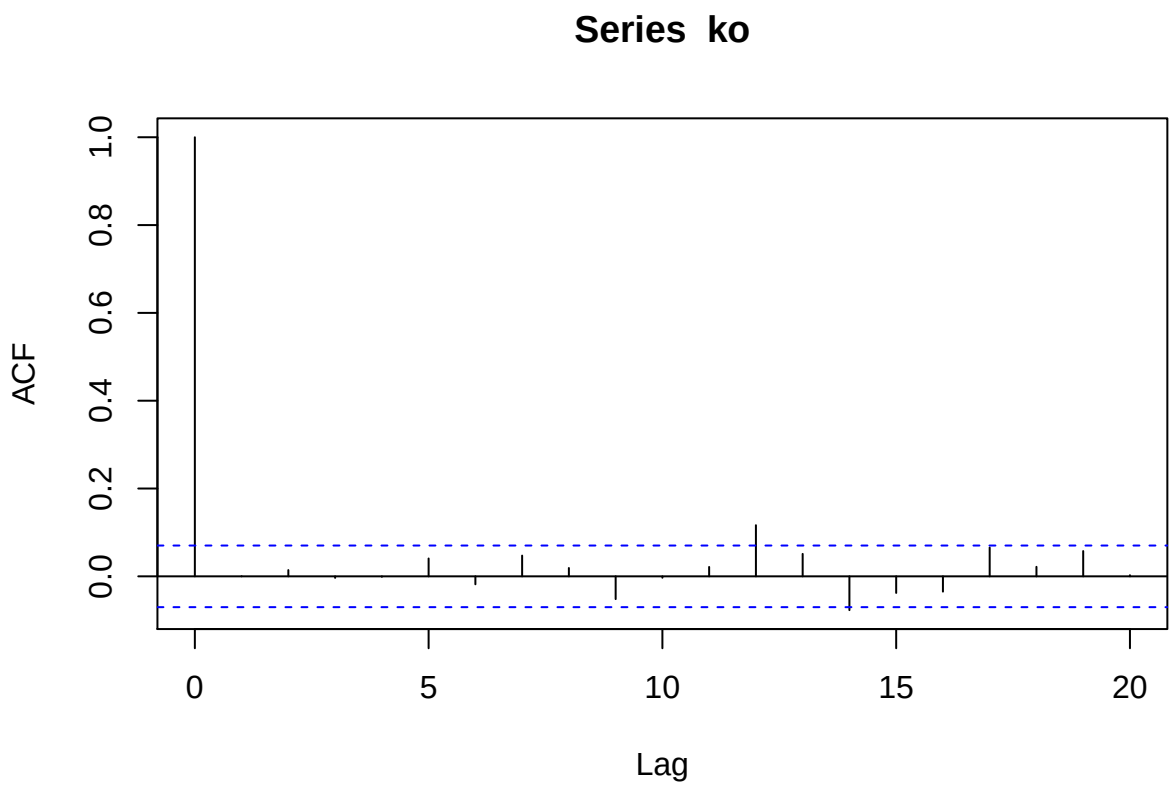
```
##
```

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

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

```
##
##  Box-Ljung test
##
## data:  ko
## X-squared = 17.06, df = 12, p-value = 0.1474
```

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




```
#H0 = E(rt)=0
#Ha= E(rt)!= 0
#P-value is less than 0.05, therefore, the H0 is rejected.
#As for Box test, P-value is 0.147, therefore, there is no serial correlations in returns.

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

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

```
#since p-value is less than 0.05,therefore, there is ARCH effect in CI
```

```
#2.b



Q2m1 = garchFit(~arma(1,0)+garch(1,1),data=ko,trace=F)
```

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

```
summary(Q2m1)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 1), data = ko, trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x000000002734b838>
##  [data = ko]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##          mu          ar1        omega       alpha1        beta1
##  0.01124544  -0.02633742   0.00018112   0.09535029   0.84861593
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu      1.125e-02   1.897e-03    5.929 3.05e-09 ***
## ar1    -2.634e-02   3.881e-02   -0.679  0.49740
## omega   1.811e-04   5.852e-05    3.095  0.00197 **
## alpha1  9.535e-02   1.915e-02    4.978 6.42e-07 ***
## beta1   8.486e-01   2.766e-02   30.675  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1170.664    normalized:  1.500852
##
```

```
## Description:
##  Thu Apr 29 13:58:08 2021 by user: Admin
##
##
## 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
```

```
#plot(Q2m1)

#13
#mean equation:
#rt = 1.125e-02-2.634e-02
#     (1.897e-03)(3.881e-02)
#variance equation:
#VAR(rt) =1.811e-04  +9.535e-02  a^2+8.486e-01(o')^2
#           (5.852e-05)  (1.915e-02) (2.766e-02)


#mean equation and volatility are adequate but QQ-#plot is not
```

```
#2.c

Q2m2 = garchFit(~arma(1,0)+garch(1,1),cond.dist = "std",data=ko,trace=F)
```

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

```
summary(Q2m2)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 1), data = ko, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x0000000021bf97e0>
##  [data = ko]
##
## 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 13:58:08 2021 by user: Admin
##
##
## 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
```

```
#plot(Q2m2)
#

#mean equation:
#rt = 1.124e-02-1.888e-02
#     (1.810e-03)(3.691e-02)
#variance equation:
#VAR(rt) =1.739e-04  +9.643e-02  a^2+8.504e-01(o')^2
#           (6.596e-05)  (2.338e-02) (3.267e-02)

#mean equation and volatility and  QQ-#plot are adequate
```

```r
#2.d

Q2m3 = garchFit(~garch(1,1),data = ko, trace =F)
```

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

```r
#plot(Q2m3)
#13
summary(Q2m3)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = ko, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x0000000026428a80>
##  [data = ko]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##         mu       omega      alpha1       beta1
## 0.01098417  0.00018497  0.09479925  0.84780406
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.098e-02   1.846e-03    5.950 2.68e-09 ***
## omega  1.850e-04   5.899e-05    3.135  0.00172 **
## alpha1 9.480e-02   1.912e-02    4.958 7.11e-07 ***
## beta1  8.478e-01   2.787e-02   30.416  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1170.393    normalized:  1.500504
##
## Description:
##  Thu Apr 29 13:58:08 2021 by user: Admin
##
##
## 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
```

```
# this model is not adequate because the normality assumption is not accepted in QQ-#plot
```

```
#2.e

Q2m4 = garchFit(~garch(1,1),data = ko, cond.dist = "std",trace =F)
```

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

```
#plot(Q2m4)
#13

summary(Q2m4)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = ko, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x00000000277f8dc0>
##  [data = ko]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##         mu       omega      alpha1       beta1       shape
## 0.01105016  0.00017528  0.09632874  0.85006800  7.48604505
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.105e-02   1.757e-03    6.291 3.16e-10 ***
## omega  1.753e-04   6.627e-05    2.645  0.00817 **
## alpha1 9.633e-02   2.337e-02    4.123 3.75e-05 ***
## beta1  8.501e-01   3.277e-02   25.941  < 2e-16 ***
## shape  7.486e+00   1.840e+00    4.069 4.72e-05 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1184.68    normalized:  1.518821
##
## Description:
##  Thu Apr 29 13:58:08 2021 by user: Admin
##
##
## 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
```

```
#2.f
#we compare the models by measuring the BIC. We select m4 because it has the least BIC out of other mod
```

```
#question 3



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

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

```
head(GSPC)
```

```
##            GSPC.Open GSPC.High GSPC.Low GSPC.Close GSPC.Volume GSPC.Adjusted
## 2005-01-03   1211.92   1217.80  1200.32    1202.08  1510800000       1202.08
## 2005-01-04   1202.08   1205.84  1185.39    1188.05  1721000000       1188.05
## 2005-01-05   1188.05   1192.73  1183.72    1183.74  1738900000       1183.74
## 2005-01-06   1183.74   1191.63  1183.27    1187.89  1569100000       1187.89
## 2005-01-07   1187.89   1192.20  1182.16    1186.19  1477900000       1186.19
## 2005-01-10   1186.19   1194.78  1184.80    1190.25  1490400000       1190.25
```

```
tail(GSPC)
```

```
##            GSPC.Open GSPC.High GSPC.Low GSPC.Close GSPC.Volume GSPC.Adjusted
## 2021-03-23   3937.60   3949.13  3901.57    3910.52  4645340000       3910.52
## 2021-03-24   3919.93   3942.08  3889.07    3889.14  4766990000       3889.14
## 2021-03-25   3879.34   3919.54  3853.50    3909.52  4940800000       3909.52
## 2021-03-26   3917.12   3978.19  3917.12    3974.54  5467850000       3974.54
## 2021-03-29   3969.31   3981.83  3943.25    3971.09  4619840000       3971.09
## 2021-03-30   3963.34   3968.01  3944.35    3958.55  4103570000       3958.55
```

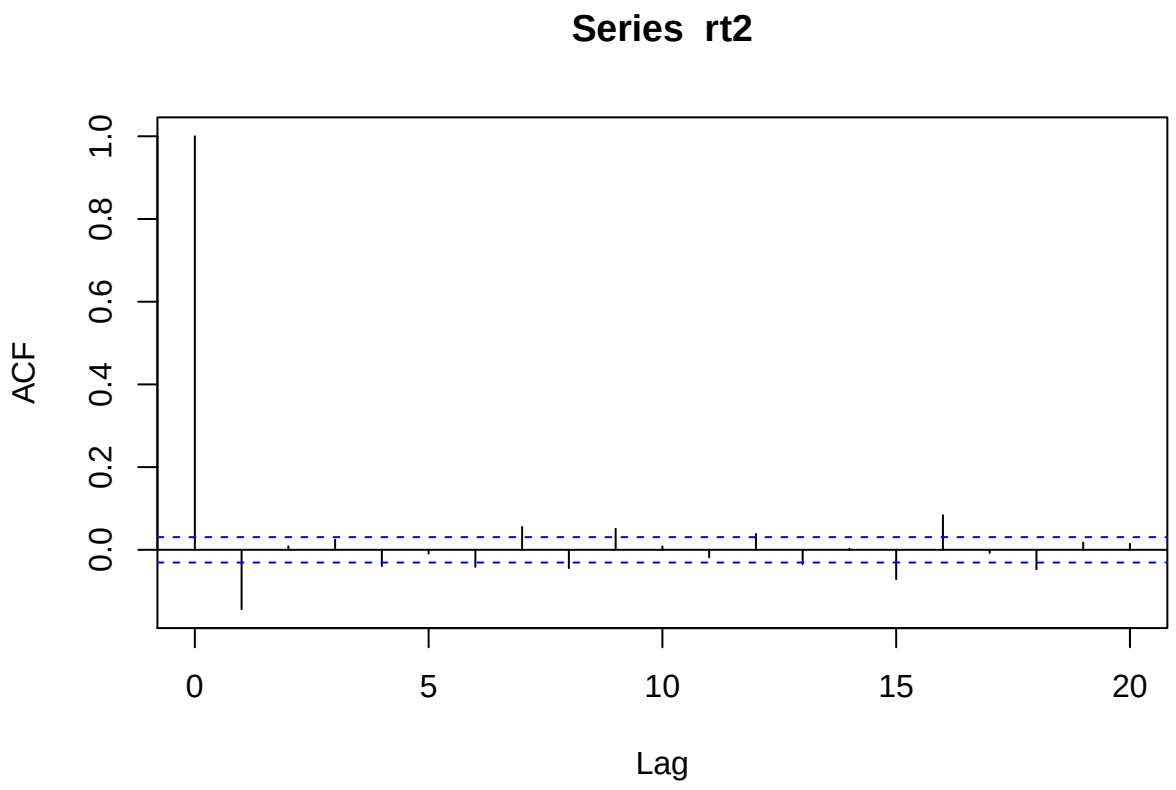
```
dim(GSPC)
```

```
## [1] 4088    6
```

```
rt2 <- diff(log(as.numeric(GSPC[,6])))
t.test(rt2)
```

```
##
##  One Sample t-test
##
## data:  rt2
## 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
```

```
acf(rt2,lag.max=20)
```




```
Q3m1 = garchFit(~arma(0,1)+garch(1,1),data=rt2,trace=F)
```

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

```
Q3m2 = garchFit(~arma(0,1)+garch(1,1),data=rt2,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(Q3m1)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(0, 1) + garch(1, 1), data = rt2, trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(0, 1) + garch(1, 1)
## <environment: 0x0000000026b09ed0>
##  [data = rt2]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##          mu          ma1        omega       alpha1        beta1
##  6.8986e-04  -7.7582e-02   2.7170e-06   1.4181e-01   8.3741e-01
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu      6.899e-04   1.080e-04    6.387 1.69e-10 ***
## ma1    -7.758e-02   1.750e-02   -4.433 9.31e-06 ***
## omega   2.717e-06   3.504e-07    7.754 8.88e-15 ***
## alpha1  1.418e-01   1.202e-02   11.801  < 2e-16 ***
## beta1   8.374e-01   1.196e-02   70.039  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  13428.46    normalized:  3.285651
##
## Description:
##  Thu Apr 29 13:58:09 2021 by user: Admin
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  1134.026  0
##  Shapiro-Wilk Test  R    W      0.9717603 0
##  Ljung-Box Test     R    Q(10)  17.7885   0.0586379
##  Ljung-Box Test     R    Q(15)  26.08443  0.03714456
##  Ljung-Box Test     R    Q(20)  31.72122  0.04636095
##  Ljung-Box Test     R^2  Q(10)  16.02024  0.09905437
##  Ljung-Box Test     R^2  Q(15)  18.27301  0.2485849
##  Ljung-Box Test     R^2  Q(20)  19.66181  0.4792555
##  LM Arch Test       R    TR^2   16.80097  0.1572388
##
```

```
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -6.568856 -6.561129 -6.568859 -6.566120
```

```
#plot(Q3m1)
#13


summary(Q3m2)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(0, 1) + garch(1, 1), data = rt2, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(0, 1) + garch(1, 1)
## <environment: 0x000000002170a800>
##  [data = rt2]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##          mu          ma1        omega       alpha1        beta1        shape
##  8.5537e-04  -7.3712e-02   1.6925e-06   1.4124e-01   8.5667e-01   5.0755e+00
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu      8.554e-04   9.733e-05    8.789  < 2e-16 ***
## ma1    -7.371e-02   1.604e-02   -4.596 4.31e-06 ***
## omega   1.693e-06   3.621e-07    4.673 2.96e-06 ***
## alpha1  1.412e-01   1.460e-02    9.675  < 2e-16 ***
## beta1   8.567e-01   1.285e-02   66.675  < 2e-16 ***
## shape   5.076e+00   4.278e-01   11.866  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  13563.99    normalized:  3.318812
##
## Description:
##  Thu Apr 29 13:58:10 2021 by user: Admin
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  1431.666  0
##  Shapiro-Wilk Test  R    W      0.969611  0
```

```
##  Ljung-Box Test     R    Q(10)  17.95782  0.05567942
##  Ljung-Box Test     R    Q(15)  26.2946   0.0350378
##  Ljung-Box Test     R    Q(20)  31.68532  0.04676904
##  Ljung-Box Test     R^2  Q(10)  13.1203   0.217023
##  Ljung-Box Test     R^2  Q(15)  17.77068  0.2749137
##  Ljung-Box Test     R^2  Q(20)  20.51701  0.4260342
##  LM Arch Test       R    TR^2   14.78812  0.2532284
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -6.634689 -6.625417 -6.634693 -6.631406
```

```
#plot(Q3m2)
Box.test(rt2,lag=10,type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  rt2
## X-squared = 131.85, df = 10, p-value < 2.2e-16
```

```
#13



Q3pm2 = predict(Q3m2,5)
Q3pm2
```

```
##   meanForecast   meanError standardDeviation
## 1 0.0011545471 0.009040206       0.009040206
## 2 0.0008553707 0.009148267       0.009123965
## 3 0.0008553707 0.009231322       0.009206790
## 4 0.0008553707 0.009313464       0.009288706
## 5 0.0008553707 0.009394719       0.009369736
```

```
#Question 3.a
#mean equation:
#rt = 8.434e-04
#     (1.047e-04  )
#variance equation:
#VAR(rt) = 1.750e-06 +4.1.434e-01 a^2+8.540e-01 (o')^2
#           (3.696e-07)  (1.476e-02 ) (1.301e-02)

#Question 3.b

#mean equation:
#rt = 8.434e-04
#     (1.047e-04 )
#variance equation:
#VAR(rt) = 1.750e-06+4.1.434e-01a^2+8.540e-01 (o')^2
#           (3.696e-07)  (1.476e-02 ) (1.301e-02)
```

```
#Question4



```

```
da3 = read.table("m-deciles.txt",head= T)
head(da3)
```

```
##      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
```

```
tail(da3)
```

```
##        caldt   CAP1RET   CAP2RET   CAP3RET   CAP4RET   CAP5RET   CAP6RET
## 715 20100730  0.035522  0.027969  0.052060  0.060093  0.068642  0.061941
## 716 20100831 -0.038591 -0.048422 -0.061161 -0.059369 -0.078569 -0.064477
## 717 20100930  0.052519  0.051639  0.097270  0.107356  0.105025  0.096286
## 718 20101029  0.043186  0.003390  0.040742  0.046336  0.054636  0.044237
## 719 20101130 -0.004668 -0.052756  0.022628  0.017676  0.035069  0.033268
## 720 20101231  0.073749  0.066539  0.085252  0.075929  0.073406  0.069744
##       CAP7RET   CAP8RET   CAP9RET  CAP10RET
## 715  0.066430  0.067258  0.072897  0.073402
## 716 -0.050486 -0.056695 -0.045867 -0.041759
## 717  0.113869  0.116938  0.105329  0.088691
## 718  0.042623  0.036324  0.038129  0.038864
## 719  0.026487  0.032454  0.022980  0.000702
## 720  0.074657  0.071308  0.073508  0.066458
```

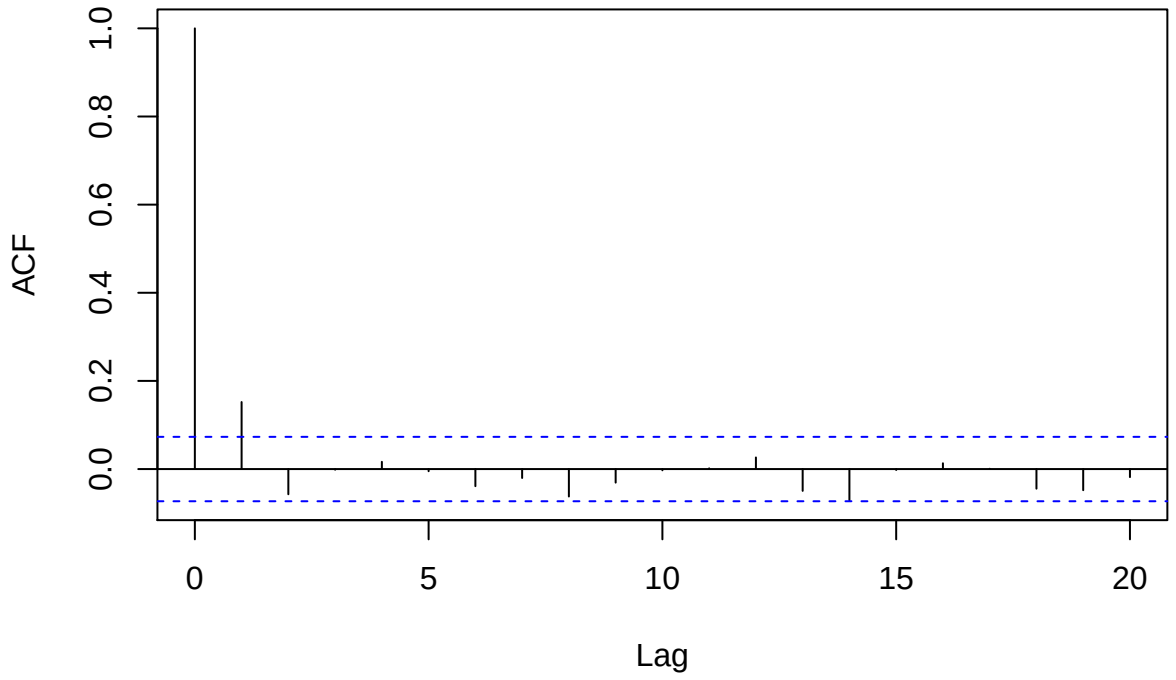
```
dim(da3)
```

```
## [1] 720  11
```

```
Sim_rt4= da3$CAP9RET
head(Sim_rt4)
```

```
## [1]  0.054170  0.017117 -0.018675  0.044620 -0.016724 -0.020323
```

```
Sim_rt4 = log(1+Sim_rt4)
acf(Sim_rt4,lag.max =20)
```




```
t.test(Sim_rt4)
```

```
##
##  One Sample t-test
##
## data:  Sim_rt4
## 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(Sim_rt4,lag=12,type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  Sim_rt4
## X-squared = 24.768, df = 12, p-value = 0.01596
```

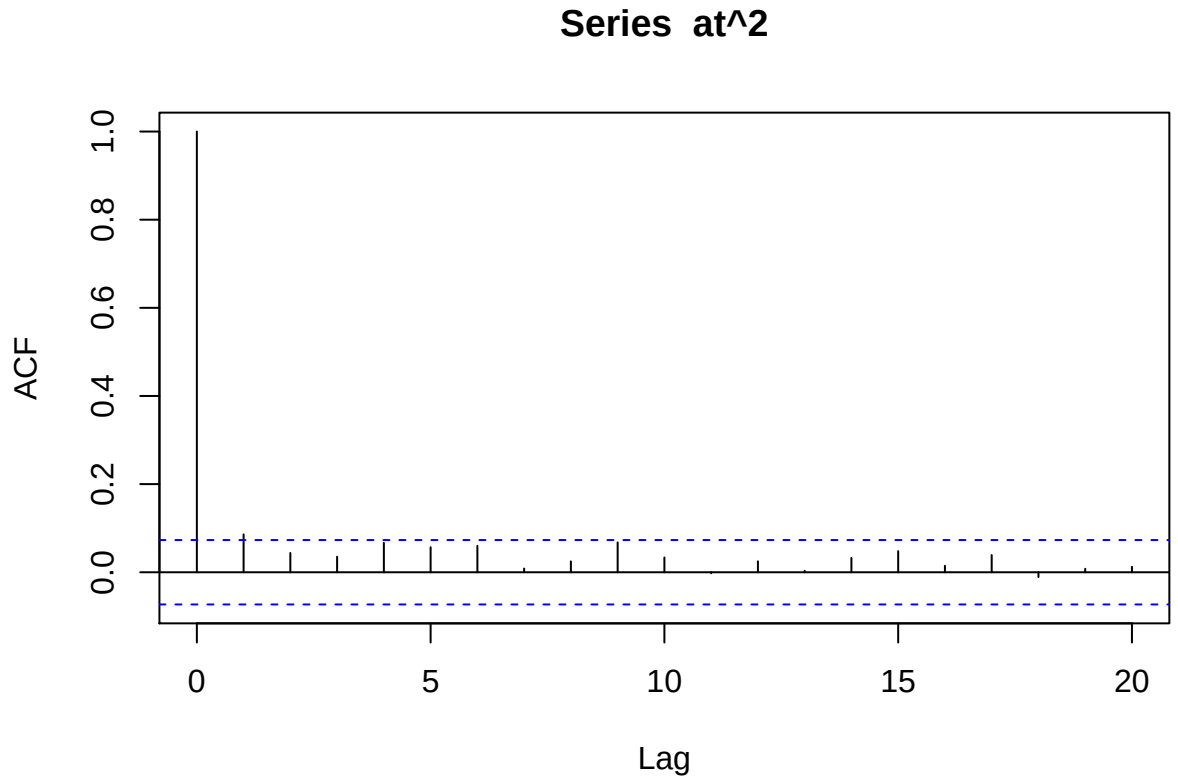
```
#4.a
#H0:u=0
#Ha:u !=0
#The t-value is  greater than 1.96, therefore, The expected value of log return is not 0
#From box test p-value is less than 0.05, there is ArCh effect or serial correlation
```

```
#4.b

at = Sim_rt4-mean(Sim_rt4)
Box.test(at^2,lag=10,type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  at^2
## X-squared = 20.53, df = 10, p-value = 0.02462
```

```
acf(at^2,lag.max =20)
```




```
#the p-value is less than 0.05, therefore, there is no ARCH effect in log return
```

```
#4.c

Q4m1 = garchFit(~arma(1,0)+garch(1,0),data = Sim_rt4,trace =F)
```

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

```
summary(Q4m1)
```

```
##
## Title:
##  GARCH Modelling
##
```

```
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 0), data = Sim_rt4,
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 0)
## <environment: 0x0000000012ffff38>
##  [data = Sim_rt4]
##
## 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 13:58:10 2021 by user: Admin
##
##
## 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
#mean equation:
#rt = 0.0105300   + 0.1470670rt-1
#     (0.0019275)   (0.0424301)
```

```
#variance equation:
#VAR(rt) = 0.0020000+4.0.1815182a^2
#           (0.0424301)  (0.0651142 )
```

```
#4.d

Q4m2 = garchFit(~arma(1,0)+garch(1,0),data=Sim_rt4,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(Q4m2)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(1, 0) + garch(1, 0), data = Sim_rt4,
##     cond.dist = "std", trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 0)
## <environment: 0x0000000026fe5598>
##  [data = Sim_rt4]
##
## 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 13:58:10 2021 by user: Admin
##
##
## 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 equation:
#rt = 0.0116189  + 0.1076982rt-1
#     (0.0017710)   (0.0403169)
#variance equation:
#VAR(rt) = 0.0019203+0.1900830a^2
#           (0.0001818)  (0.0713692)
```

```
#4.e

Q4m3 = garchFit(~garch(1,0),data=Sim_rt4,trace = F)
```

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

```
summary(Q4m3)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 0), data = Sim_rt4, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 0)
## <environment: 0x0000000027f572d0>
##  [data = Sim_rt4]
##
## 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 13:58:10 2021 by user: Admin
##
##
## 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
```

```
#rt = 0.012346
#     (.001923)
#variance equation:
#VAR(rt) = 0.002016+0.194126a^2
#           (0.000145)  (0.062209)
```

```
#4.f

Q4m4 = garchFit(~garch(1,1),data = Sim_rt4, 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(Q4m4)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~garch(1, 1), data = Sim_rt4, cond.dist = "std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 1)
## <environment: 0x0000000020263a38>
##  [data = Sim_rt4]
##
## Conditional Distribution:
```

```
##  std
##
## Coefficient(s):
##         mu       omega      alpha1       beta1       shape
## 0.01253321  0.00013013  0.11435407  0.83665662  6.46000315
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     1.253e-02   1.538e-03    8.150 4.44e-16 ***
## omega  1.301e-04   5.817e-05    2.237  0.02528 *
## alpha1 1.144e-01   3.494e-02    3.273  0.00107 **
## beta1  8.367e-01   4.591e-02   18.225  < 2e-16 ***
## shape  6.460e+00   1.315e+00    4.913 8.97e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  1201.367    normalized:  1.668565
##
## Description:
##  Thu Apr 29 13:58:10 2021 by user: Admin
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  1171.213  0
##  Shapiro-Wilk Test  R    W      0.9457868 1.420853e-15
##  Ljung-Box Test     R    Q(10)  16.52228  0.08562605
##  Ljung-Box Test     R    Q(15)  20.6328   0.1489773
##  Ljung-Box Test     R    Q(20)  25.48915  0.183354
##  Ljung-Box Test     R^2  Q(10)  2.235555  0.9941952
##  Ljung-Box Test     R^2  Q(15)  4.909806  0.9928629
##  Ljung-Box Test     R^2  Q(20)  5.757538  0.9991875
##  LM Arch Test       R    TR^2   2.506995  0.9981363
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.323241 -3.291441 -3.323337 -3.310964
```

```
#rt = 1.253e-02
#     (1.538e-03)
#variance equation:
#VAR(rt) = 1.301e-04+1.144e-01a^2+8.367e-01(o')^2
#           (5.817e-05)  (3.494e-02)(4.591e-02)
```

```
#4.g

#AIC, the model Q4m4 is the most proffered because it has th least amount of BIC
```