# FE 542- HW3

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#Problem 1

In R create a report in pdf format using RMarkdown (or, if you choose to use Python instead,create a Jupyter notebook) to

(i) Download daily price data for January 1, 1980 through December 31, 2019 of Boeingstock from Yahoo Finance. You may use the quantmod package in R for this purpose.

```
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
```

```
getSymbols(Symbols = "BA",src="yahoo",from="1980-01-01", to="2019-12-
31",periodicity="monthly")
```

```
## '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] "BA"
```

- Calculating Monthly returns

```
R= BA$BA.Close/lag(BA$BA.Close) -1

R= R[2:length(R)]

head(R)

##                BA.Close
## 1985-02-01  0.050100203
## 1985-03-01 -0.045801583
## 1985-04-01 -0.034000021
## 1985-05-01  0.101449347
## 1985-06-01  0.009398436
## 1985-07-01  0.078212316
```

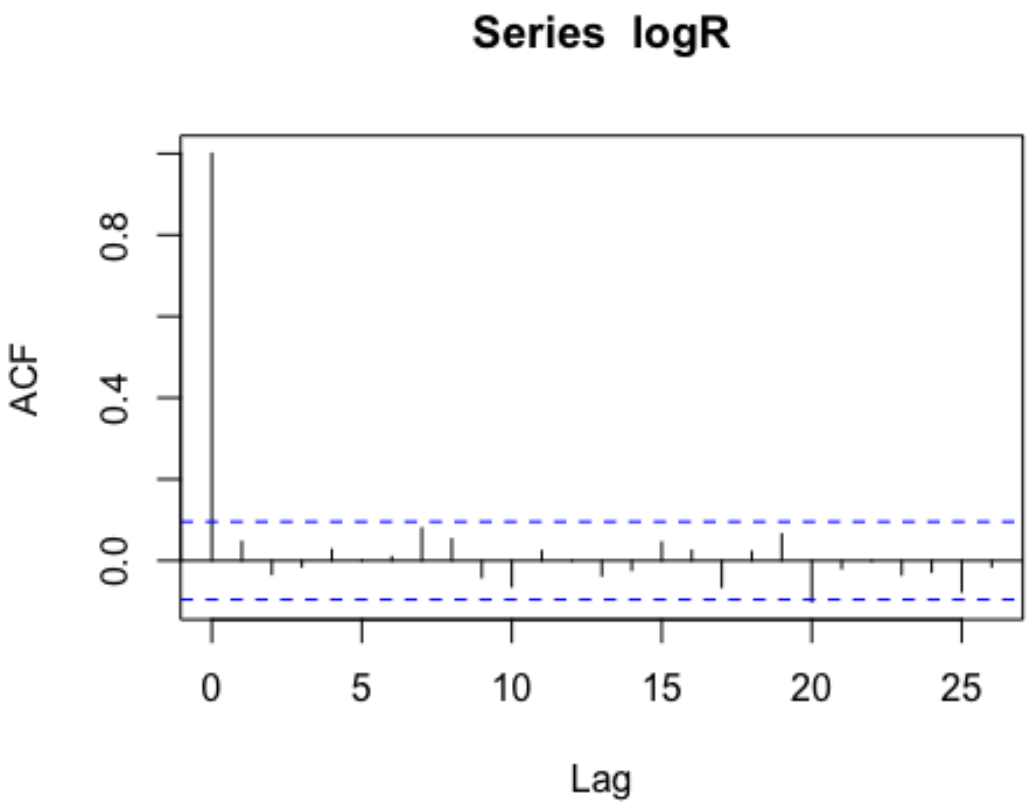
- Calculating Monthly log returns

```
logR=log(1+R)

head(logR)

##                BA.Close
## 1985-02-01  0.048885591
## 1985-03-01 -0.046883644
## 1985-04-01 -0.034591466
## 1985-05-01  0.096626900
## 1985-06-01  0.009354545
## 1985-07-01  0.075304407
```

(ii) Is there any evidence of serial correlations in the monthly log returns. Use autocorrelations and 5% significance level to answer the question. If yes, remove the serial correlations.

- The p-value of Box-Ljung test is higher than 0.05( 0.3433), so we fail to reject null hypothesis(no serial correlation)
- We could say that there is no serial correlation

```
acf(logR)
```




```
Box.test(logR,type="Ljung-Box")

##
##  Box-Ljung test
##
## data:  logR
## X-squared = 0.89804, df = 1, p-value = 0.3433
```

(iii) Is there any evidence of ARCH effects in the monthly log returns? Use the residual series if there are serial correlations in part (ii). Use Ljung-Box statistics for the squared returns (or residuals) with 6 and 12 lags of autocorrelations and 5% significance level to answer the question.

- First, find the difference between logreturns and its mean value to come up with residuals
- Then take the square of residuals

```
y= logR-mean(logR)

head(y)

##                BA.Close
## 1985-02-01  0.040383112
```

```
## 1985-03-01 -0.055386124
## 1985-04-01 -0.043093946
## 1985-05-01  0.088124421
## 1985-06-01  0.000852066
## 1985-07-01  0.066801928
```

- Use Ljung Box test(lag value 6) to test ARCH effects
- The p value of the Ljung-Box statistic is 0.02026, with 5% significance level, we can say there is ARCH effect in the log returns

```
Box.test(y^2,lag=6,type="Ljung")

##
##  Box-Ljung test
##
## data:  y^2
## X-squared = 15, df = 6, p-value = 0.02026
```

- Use Ljung Box test(lag value 12) to test ARCH effects

```
Box.test(y^2,lag=12,type="Ljung")

##
##  Box-Ljung test
##
## data:  y^2
## X-squared = 20.738, df = 12, p-value = 0.05435
```

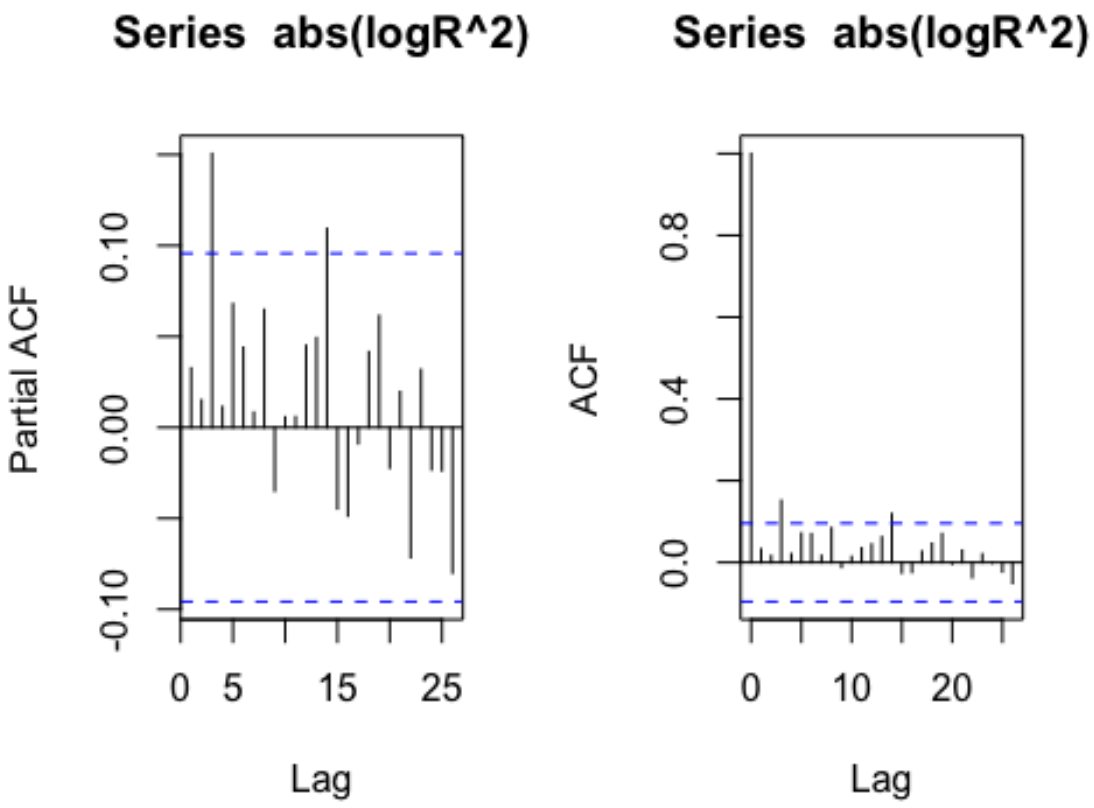
(iv) Identify an ARCH model for the data and fit the identified model. Write down the fitted model and justify your choice of parameters.

- According to PACF and ACF, ARCH(3) model could be appropriate to fit
- Different models tried and modified depending on the significance of coefficients and
- Among ARCH(3,0), ARCH(1,0) and ARMA(1,0)+ARCH(1,1), ARCH(3,0) model fits the better into the data
- fitted model Coefficient(s):

```
     mu       omega      alpha1      alpha2      alpha3
```

0.0122236 0.0035564 0.0754545 0.0606447 0.3513973

```
par(mfrow=c(1,2))

pacf(abs(logR^2))

acf(abs(logR^2))
```




- ARCH(3,0) model

```
library(fGarch)
```

```
## Loading required package: timeDate
```

```
## Loading required package: timeSeries
```

```
##
## Attaching package: 'timeSeries'
```

```
## The following object is masked from 'package:zoo':
##
##     time<-
```

```
## Loading required package: fBasics
```

```
##
## Attaching package: 'fBasics'
```

```
## The following object is masked from 'package:TTR':
##
##     volatility
```

```r
g1=garchFit(logR~garch(3,0),data=logR,trace=F)

summary(g1)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = logR ~ garch(3, 0), data = logR, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(3, 0)
## <environment: 0x7fe768e1e218>
##  [data = logR]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##        mu      omega     alpha1     alpha2     alpha3
## 0.0122236  0.0035564  0.0754545  0.0606447  0.3513973
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     0.0122236   0.0034945    3.498 0.000469 ***
## omega  0.0035564   0.0005559    6.397 1.58e-10 ***
## alpha1 0.0754545   0.0603126    1.251 0.210914
## alpha2 0.0606447   0.0645787    0.939 0.347689
## alpha3 0.3513973   0.0981576    3.580 0.000344 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  481.0894    normalized:  1.148185
##
## Description:
##  Fri Mar 26 10:15:54 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  14.52636  0.0007008752
##  Shapiro-Wilk Test  R    W      0.9899087 0.00561253
##  Ljung-Box Test     R    Q(10)  6.39869   0.7807291
##  Ljung-Box Test     R    Q(15)  9.39825   0.855791
##  Ljung-Box Test     R    Q(20)  18.49104  0.5550949
```

```
##  Ljung-Box Test     R^2  Q(10)  11.42129  0.3256505
##  Ljung-Box Test     R^2  Q(15)  21.42239  0.1238679
##  Ljung-Box Test     R^2  Q(20)  26.95717  0.1364733
##  LM Arch Test       R    TR^2   11.68752  0.4710902
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -2.272503 -2.224318 -2.272783 -2.253457
```

- ARCH(1,0) model
- alpha 1 is not significant

```
m1=garchFit(logR~garch(1,0),data=logR,trace=F)

summary(m1)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = logR ~ garch(1, 0), data = logR, trace = F)
##
## Mean and Variance Equation:
##  data ~ garch(1, 0)
## <environment: 0x7fe76bdd8db8>
##  [data = logR]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##        mu      omega     alpha1
## 0.0096411  0.0056731  0.1179478
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     0.0096411   0.0038627    2.496   0.0126 *
## omega  0.0056731   0.0005354   10.596   <2e-16 ***
## alpha1 0.1179478   0.0757677    1.557   0.1195
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  466.5811    normalized:  1.113559
##
## Description:
##  Fri Mar 26 10:15:54 2021 by user:
```

```
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  99.49157  0
##  Shapiro-Wilk Test  R    W      0.9695611 1.181169e-07
##  Ljung-Box Test     R    Q(10)  7.757615  0.6524992
##  Ljung-Box Test     R    Q(15)  9.614408  0.8432685
##  Ljung-Box Test     R    Q(20)  16.72656  0.6706515
##  Ljung-Box Test     R^2  Q(10)  26.43116  0.003201593
##  Ljung-Box Test     R^2  Q(15)  33.8325   0.003594616
##  Ljung-Box Test     R^2  Q(20)  37.54332  0.01006415
##  LM Arch Test       R    TR^2   22.12598  0.03613195
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -2.212798 -2.183887 -2.212899 -2.201370
```

- ARMA(1,0)+ARCH(1,1)

```
# Next, fit an ARMA(1,0)+GARCH(1,1) model with  Gaussian noises

m2=garchFit(logR~arma(1,0)+garch(1,1),data=logR,trace=F)

summary(m2)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = logR ~ arma(1, 0) + garch(1, 1), data = logR,
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(1, 0) + garch(1, 1)
## <environment: 0x7fe7694de6d0>
##  [data = logR]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##         mu         ar1       omega      alpha1       beta1
## 0.01167004  0.03581199  0.00037567  0.12477295  0.82423311
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
```

```
## mu     0.0116700   0.0036096    3.233  0.00122 **
## ar1    0.0358120   0.0532691    0.672  0.50140
## omega  0.0003757   0.0001903    1.974  0.04839 *
## alpha1 0.1247729   0.0412386    3.026  0.00248 **
## beta1  0.8242331   0.0522078   15.788  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  479.9111    normalized:  1.145373
##
## Description:
##  Fri Mar 26 10:15:54 2021 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  38.85479  3.654171e-09
##  Shapiro-Wilk Test  R    W      0.9837601 0.0001211869
##  Ljung-Box Test     R    Q(10)  6.43435   0.7775472
##  Ljung-Box Test     R    Q(15)  8.464522  0.9038134
##  Ljung-Box Test     R    Q(20)  16.63652  0.6764339
##  Ljung-Box Test     R^2  Q(10)  9.192799  0.5139093
##  Ljung-Box Test     R^2  Q(15)  13.07299  0.5966602
##  Ljung-Box Test     R^2  Q(20)  19.77577  0.4720327
##  LM Arch Test       R    TR^2   8.617073  0.7352426
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -2.266879 -2.218694 -2.267159 -2.247832
```