GARCH Model EUR And USD

Jane

28/04/2021

Forcasting Exchange Rate Using GARCH Model for EUR And USD

Reading EUR and USD Currency into r

```
library(readr)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
EURUSDGARCH<-  read.csv ("EURUSD_Candlestick_1_D_BID_01.01.2000-31.12.2020.csv")%>%
  select('GMT.TIME', CLOSE)%>%
  rename(Date = ('GMT.TIME'), RateEURUSD = ("CLOSE"))


head(EURUSDGARCH)
```

```
##         Date RateEURUSD
## 1 2000-01-03     1.0243
## 2 2000-01-04     1.0295
## 3 2000-01-05     1.0321
## 4 2000-01-06     1.0324
## 5 2000-01-07     1.0296
## 6 2000-01-10     1.0253
```

Conversion of Gmt time to date format

```r
library(dplyr)
library(lubridate)
```

```
##
## Attaching package: 'lubridate'
```

```
## The following objects are masked from 'package:base':
##
##     date, intersect, setdiff, union
```

```r
EURUSDGARCH$Date <- lubridate::ymd(EURUSDGARCH$Date)
head(EURUSDGARCH)
```

```
##         Date RateEURUSD
## 1 2000-01-03     1.0243
## 2 2000-01-04     1.0295
## 3 2000-01-05     1.0321
## 4 2000-01-06     1.0324
## 5 2000-01-07     1.0296
## 6 2000-01-10     1.0253
```

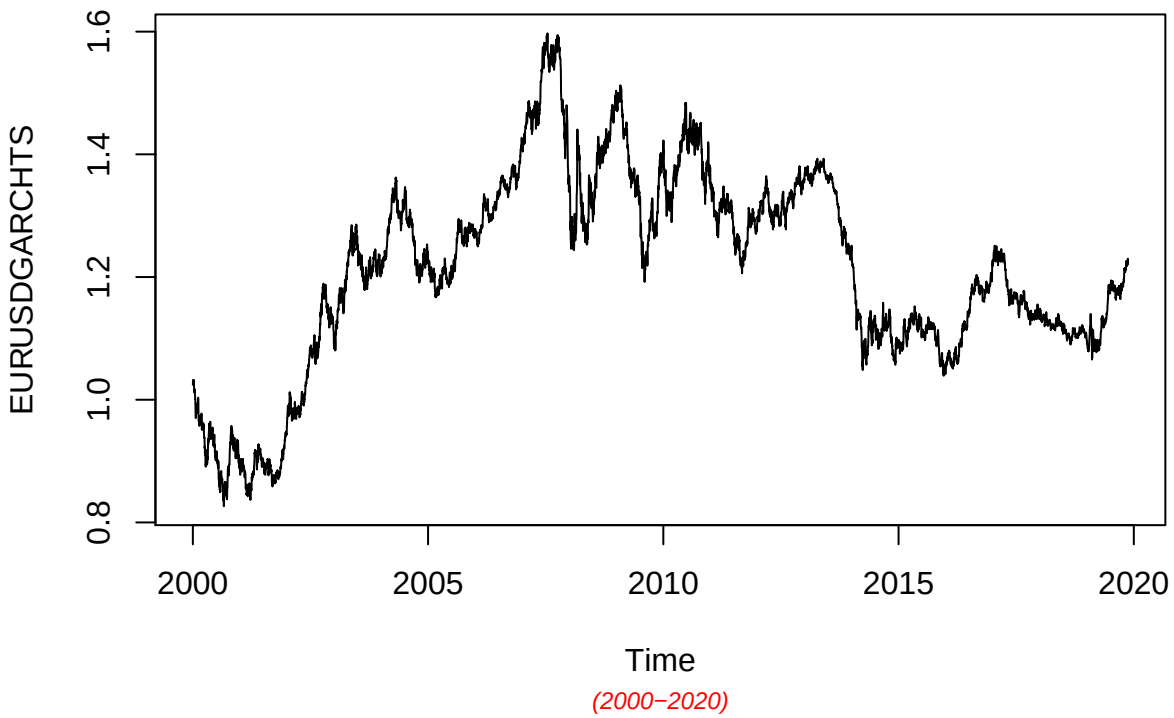
##Checking for obvious errors or missingg value

```r
#Checking for obvious errors
which(is.na(EURUSDGARCH))
```

```
## integer(0)
```

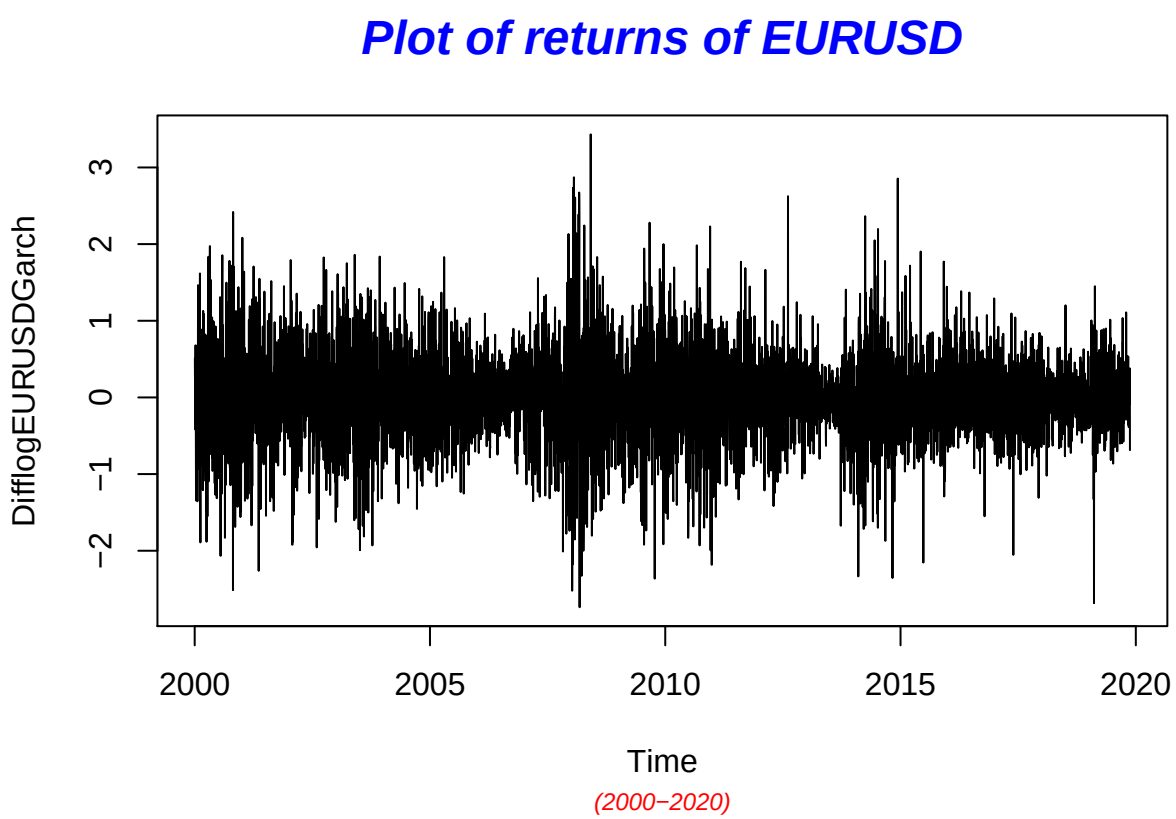
##Converting the data set into time series object

```r
#Converting the data set into time series object
EURUSDGARCHTS<- ts(as.vector(EURUSDGARCH$Rate),  frequency = 322, start= c(2000,01,03))
plot.ts(EURUSDGARCHTS)
title("Time Series plot of EURUSDTimeseries ", sub = "(2000-2020)",
      cex.main = 1.5,   font.main= 4, col.main= "blue",
      cex.sub = 0.75, font.sub = 3, col.sub = "red")
```



##Dealing with Conditional Heteroscedaticity:

```
DifflogEURUSDGarch= diff(log(EURUSDGARCHTS))*100
plot(DifflogEURUSDGarch)
title("Plot of returns of EURUSD", sub = "(2000-2020)",
      cex.main = 1.5,   font.main= 4, col.main= "blue",
      cex.sub = 0.75, font.sub = 3, col.sub = "red")
```



##nature as almost at all lags the p-values fall below the significance levels.

```
library(TSA)
```

```
## Warning: package 'TSA' was built under R version 4.0.5
```

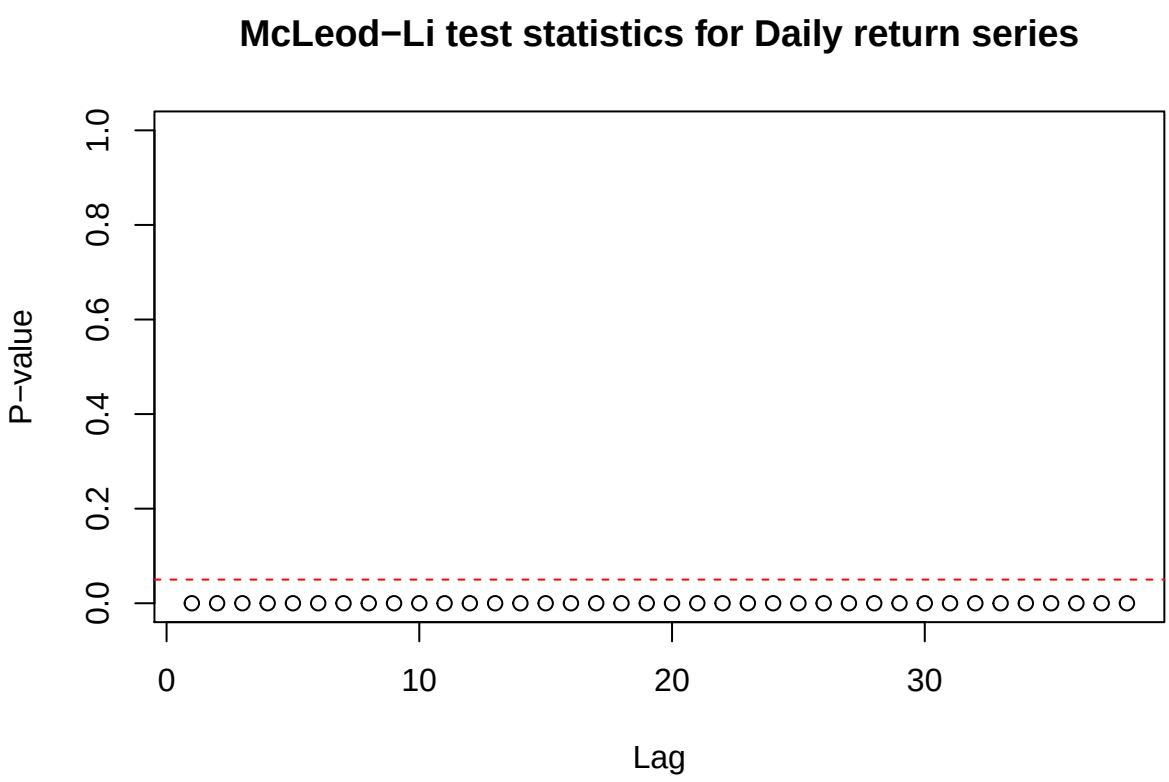
```
##
## Attaching package: 'TSA'
```

```
## The following object is masked from 'package:readr':
##
##     spec
```

```
## The following objects are masked from 'package:stats':
##
##     acf, arima
```

```
## The following object is masked from 'package:utils':
##
##     tar
```

```
McLeod.Li.test(y= DifflogEURUSDGarch,main="McLeod-Li test statistics for Daily return series")
```

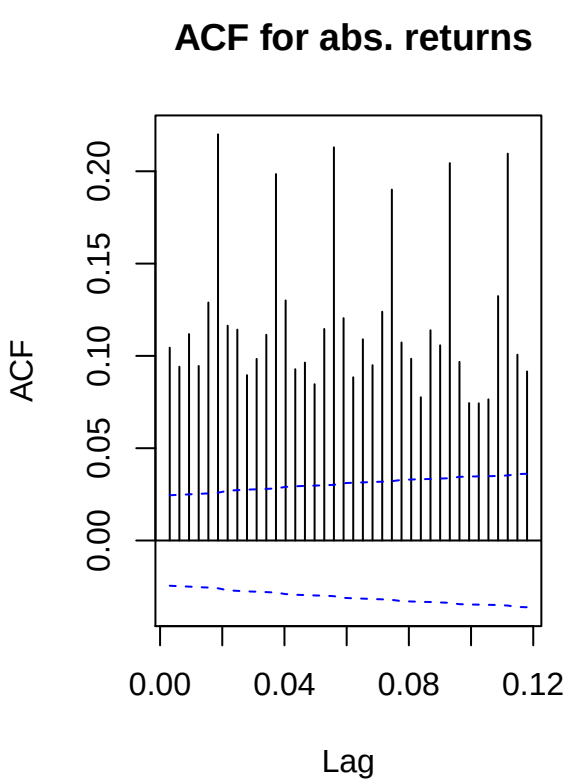


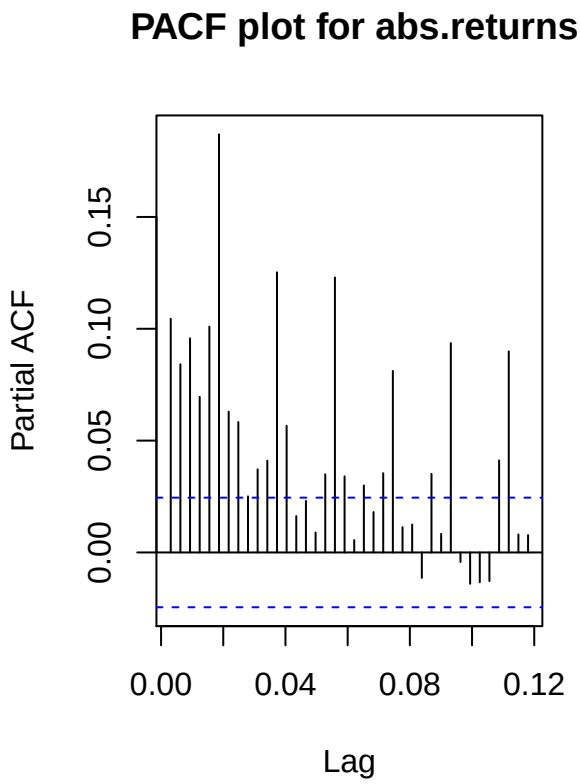
In order to get an order of GARCH , we further transform the return series into absolute values and squared return values.

```
abs = abs(DifflogEURUSDGarch)
sqr = DifflogEURUSDGarch^2
```

GARCH Model specification:

```
par(mfrow=c(1,2))
acf(abs, ci.type="ma",main=" ACF for abs. returns")
pacf(abs, main=" PACF plot for abs.returns")
```





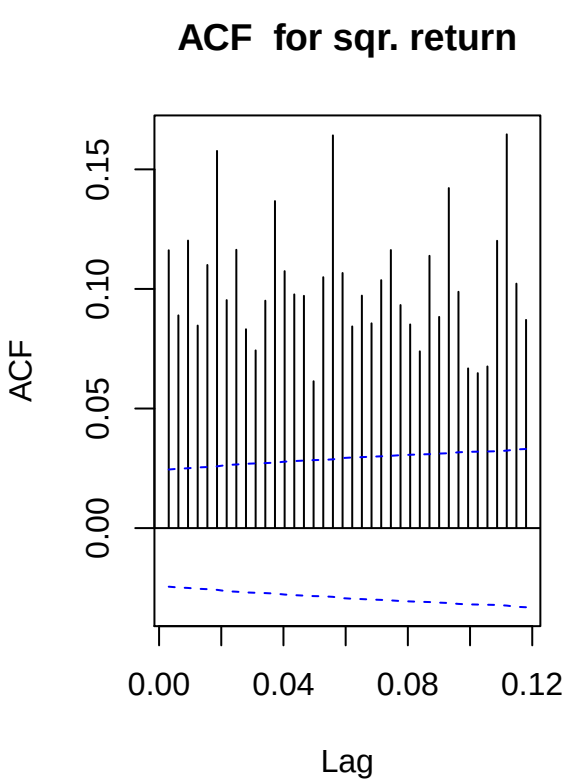
##From ACF and PACF we see many lags are significant. Hence, we plot EACF to get the candidate models

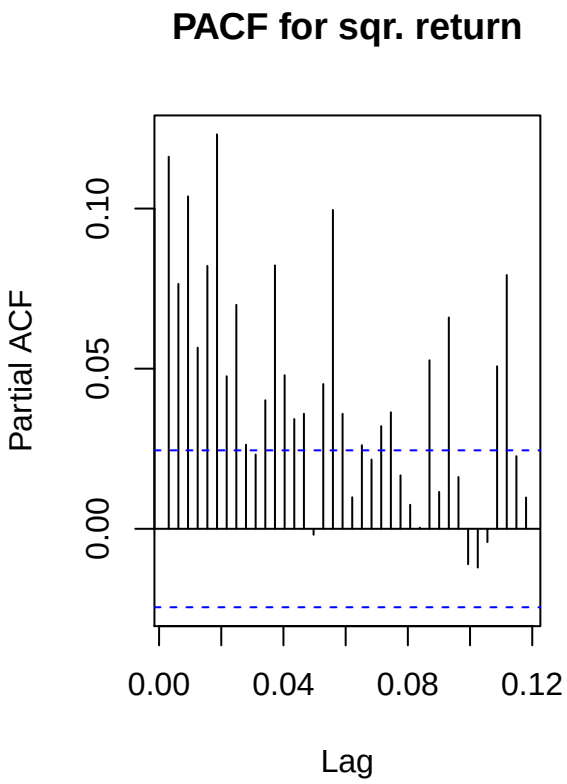
```
eacf(abs)
```

```
## AR/MA
##   0 1 2 3 4 5 6 7 8 9 10 11 12 13
## 0 x x x x x x x x x x x  x  x  x
## 1 x o o o o x x o o o o  x  o  o
## 2 x x o o o x x x o o o  x  o  x
## 3 x x x o o x x o o o o  x  o  x
## 4 x x x x o x x o o o o  x  o  o
## 5 x x x o x x x o o x x  x  x  o
## 6 x x o x x x o x x o o  o  o  o
## 7 x x x x o x x o o o o  o  o  o
```

##From the squared returns ACF and PACF plot, it is not that clear to derive the order of p and q. Hence, I approach EACF and the order of ARMA are ARMA (2,3), ARMA (3,3), ARMA (2,4). Thus, GARCH candidate models would be GARCH (3,2) GARCH (3,3) GARCH (4,2)

```
par(mfrow=c(1,2))
acf(sqr, ci.type="ma",main="ACF  for sqr. return")
pacf(sqr, main="PACF for sqr. return")
```






```
eacf(sqr)
```

```
## AR/MA
##   0 1 2 3 4 5 6 7 8 9 10 11 12 13
## 0 x x x x x x x x x x x  x  x  x
## 1 x x x x o x x x o o o  x  o  o
## 2 x x o x o x o o o o o  x  o  o
## 3 x x x o o x o o o o o  x  o  o
## 4 x o x x o x x o o x o  x  x  o
## 5 x o x x x x o o o x o  x  o  o
## 6 x x o x x x o x x o o  o  o  o
## 7 x x x x x x x o o o o  o  o  o
```

With reference to the Dickey-Fuller Test, p-value is less than the 0.02 and we can reject the null hypothesis stating the non-stationarity. Hence , we can proceed further for model selection .

#MODEL ESTIMATION: ##GARCH (2,1): for GBP and USD Curruency Pair

```
# GARCH(2,1)
library(tseries)
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
EURUSDGARCHFit.21 = garch(DifflogEURUSDGarch,order=c(2,1),trace =FALSE)
summary(EURUSDGARCHFit.21)
```

```
##
## Call:
## garch(x = DifflogEURUSDGarch, order = c(2, 1), trace = FALSE)
##
## Model:
## GARCH(2,1)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -6.630575 -0.538018  0.005751  0.567917  5.473891
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 7.595e-04   2.935e-04    2.588  0.00966 **
## a1 2.838e-02   1.006e-02    2.822  0.00478 **
## b1 9.694e-01   3.735e-01    2.595  0.00946 **
## b2 1.402e-15   3.628e-01    0.000  1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Diagnostic Tests:
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 762.31, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 0.74626, df = 1, p-value = 0.3877
```

GARCH (2,2):

##This model can be interpreted as an overfit model of GARCH(2,1) and p values from residual tests confirms that residuals are highly correlated. Thus this model is not consider to be a good fit.

```
EURUSDGARCHFit.22 = garch(DifflogEURUSDGarch, order =c(2,2),trace =FALSE)
```

```
## Warning in garch(DifflogEURUSDGarch, order = c(2, 2), trace = FALSE): singular
## information
```

```
summary(EURUSDGARCHFit.22)
```

```
##
## Call:
## garch(x = DifflogEURUSDGarch, order = c(2, 2), trace = FALSE)
##
## Model:
## GARCH(2,2)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -6.609518 -0.537467  0.005758  0.567738  5.518265
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 7.897e-04          NA       NA       NA
## a1 1.160e-02          NA       NA       NA
## a2 1.778e-02          NA       NA       NA
## b1 9.683e-01          NA       NA       NA
## b2 4.602e-14          NA       NA       NA
##
## Diagnostic Tests:
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 764.36, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 0.017615, df = 1, p-value = 0.8944
```

##GARCH (3,1): ##This model can be interpreted as an overfit model of GARCH(2,1) and GARCH (2,2). This model may not be consider to be a good fit.

```
EURUSDGARCHFit.31 = garch(DifflogEURUSDGarch,order=c(3,1),trace =FALSE)
summary(EURUSDGARCHFit.31)
```

```
##
## Call:
## garch(x = DifflogEURUSDGarch, order = c(3, 1), trace = FALSE)
##
## Model:
## GARCH(3,1)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -6.580383 -0.536264  0.005715  0.567671  5.527041
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 1.294e-03   3.622e-04    3.572 0.000355 ***
## a1 4.631e-02   1.099e-02    4.214 2.51e-05 ***
## b1 4.464e-01   1.901e-01    2.348 0.018876 *
```

```
## b2 5.037e-01   2.207e-01    2.283 0.022457 *
## b3 1.316e-05   2.383e-01    0.000 0.999956
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Diagnostic Tests:
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 763.98, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 3.3141, df = 1, p-value = 0.06869
```

##GARCH (3,2): ##This model can be interpreted as an overfitting model and p values from residual tests confirms that residuals are highly correlated. Thus this model is not consider to be a good fit.

GARCH(3,2)

```
EURUSDGARCHFit.32 = garch(DifflogEURUSDGarch,order=c(3,2),trace =FALSE)
```

```
## Warning in garch(DifflogEURUSDGarch, order = c(3, 2), trace = FALSE): singular
## information
```

```
summary(EURUSDGARCHFit.32)
```

```
##
## Call:
## garch(x = DifflogEURUSDGarch, order = c(3, 2), trace = FALSE)
##
## Model:
## GARCH(3,2)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -6.602943 -0.537983  0.005663  0.567426  5.463015
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 1.281e-03          NA       NA       NA
## a1 3.151e-02          NA       NA       NA
## a2 1.504e-02          NA       NA       NA
## b1 3.184e-01          NA       NA       NA
## b2 6.312e-01          NA       NA       NA
## b3 2.234e-14          NA       NA       NA
##
## Diagnostic Tests:
```

```
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 758.5, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 1.0591, df = 1, p-value = 0.3034
```

GARCH (3,3):

This model can be interpreted as an overfitting model and p values from residual tests confirms that residuals are highly correlated. Thus, this model is not consider to be a good fit.

GARCH(3,3)

```
EURUSDGARCHFit.33 = garch(DifflogEURUSDGarch,order=c(3,3),trace =FALSE)
summary(EURUSDGARCHFit.33)
```

```
##
## Call:
## garch(x = DifflogEURUSDGarch, order = c(3, 3), trace = FALSE)
##
## Model:
## GARCH(3,3)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -6.743809 -0.544253  0.005759  0.568081  5.668121
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 2.674e-03   3.595e-04    7.437 1.03e-13 ***
## a1 3.142e-02   7.069e-03    4.445 8.80e-06 ***
## a2 1.001e-02   5.259e-03    1.903   0.0571 .
## a3 4.712e-02   7.183e-03    6.560 5.39e-11 ***
## b1 6.027e-15   6.285e-02    0.000   1.0000
## b2 9.945e-02   4.830e-02    2.059   0.0395 *
## b3 8.037e-01   5.328e-02   15.084  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Diagnostic Tests:
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 811.37, df = 2, p-value < 2.2e-16
##
```

```
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 1.162, df = 1, p-value = 0.281
```

##GARCH (4,2): ##This model can be interpreted as an overfitting model and p values from residual tests confirms that residuals are highly correlated. Thus, this model is not considered to be a good fit.

```
EURUSDGARCHFit.42 = garch(DifflogEURUSDGarch,order=c(4,2),trace =FALSE)
summary(EURUSDGARCHFit.42)
```

```
##
## Call:
## garch(x = DifflogEURUSDGarch, order = c(4, 2), trace = FALSE)
##
## Model:
## GARCH(4,2)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -6.611767 -0.535213  0.005769  0.567766  5.486081
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 2.180e-03   3.996e-04    5.455 4.89e-08 ***
## a1 3.426e-02   8.302e-03    4.127 3.68e-05 ***
## a2 4.464e-02   8.554e-03    5.218 1.80e-07 ***
## b1 1.714e-01   2.096e-01    0.818   0.4136
## b2 2.000e-01   2.497e-01    0.801   0.4232
## b3 4.612e-15   2.401e-01    0.000   1.0000
## b4 5.432e-01   1.749e-01    3.106   0.0019 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Diagnostic Tests:
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 722.6, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 1.224, df = 1, p-value = 0.2686
```

##

```
EURUSDGARCHFit.41 = garch(DifflogEURUSDGarch,order=c(4,1),trace =FALSE)
summary(EURUSDGARCHFit.41)
```

```
##
```

```
## Call:
## garch(x = DifflogEURUSDGarch, order = c(4, 1), trace = FALSE)
##
## Model:
## GARCH(4,1)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -6.596524 -0.539787  0.005706  0.568154  5.450753
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 1.384e-03   3.568e-04    3.879 0.000105 ***
## a1 4.913e-02   1.104e-02    4.450  8.6e-06 ***
## b1 3.485e-01   1.690e-01    2.063 0.039152 *
## b2 4.094e-01   2.123e-01    1.928 0.053844 .
## b3 1.887e-01   2.516e-01    0.750 0.453159
## b4 1.374e-16   2.001e-01    0.000 1.000000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Diagnostic Tests:
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 761.49, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 3.4738, df = 1, p-value = 0.06235
```

Model Selection:

##Best possible model is selected by AIC scores of the models. From the below sort function, GARCH(3,1) would be the best model for the return series. From the p-value, 3.1 also has the lowest correlation

```
library(dLagM)
```

```
## Warning: package 'dLagM' was built under R version 4.0.5

## Loading required package: nardl

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

## Loading required package: dynlm

## Loading required package: zoo

##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
GARCHModelSelectionEURUSD = AIC(EURUSDGARCHFit.21,EURUSDGARCHFit.22 ,EURUSDGARCHFit.31,EURUSDGARCHFit.3
sortScore(GARCHModelSelectionEURUSD, score ="aic")
```

```
##                    df      AIC
## EURUSDGARCHFit.33   7 9807.682
## EURUSDGARCHFit.21   4 9828.115
## EURUSDGARCHFit.22   5 9828.458
## EURUSDGARCHFit.32   6 9831.225
## EURUSDGARCHFit.31   5 9831.402
## EURUSDGARCHFit.41   6 9834.134
## EURUSDGARCHFit.42   7 9834.283
```

Model Fitting:

```
library(rugarch)
```

```
## Warning: package 'rugarch' was built under R version 4.0.5
```

```
## Loading required package: parallel
```

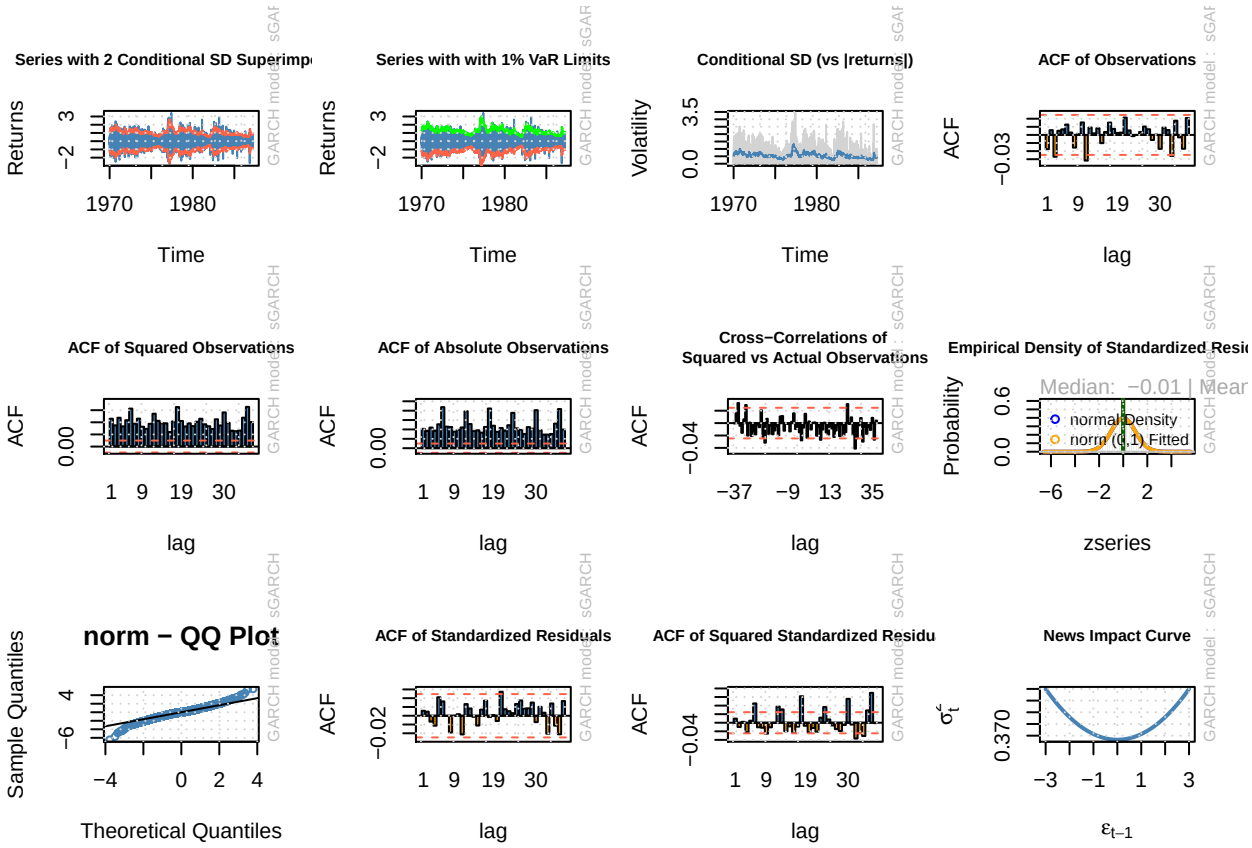
```
##
## Attaching package: 'rugarch'
```

```
## The following object is masked from 'package:stats':
##
##     sigma
```

```
EURUSDmodel4.1<-ugarchspec(variance.model = list(model = "sGARCH", garchOrder = c(4,1)),
                  mean.model = list(armaOrder = c(1, 1), include.mean = TRUE),
                  distribution.model = "norm")

EURUSDgarchMODEL4.1<-ugarchfit(spec=EURUSDmodel4.1,data=DifflogEURUSDGarch, out.sample = 100)
plot(EURUSDgarchMODEL4.1,which="all")
```

```
##
## please wait...calculating quantiles...
```



##Model Diagnostics

```
EURUSDgarchMODEL4.1
```

```
##
## *----------------------------------*
## *          GARCH Model Fit         *
## *----------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(4,1)
## Mean Model   : ARFIMA(1,0,1)
## Distribution : norm
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error     t value Pr(>|t|)
## mu      0.004940    0.005867    0.841942 0.399821
## ar1    -0.817712    0.166633   -4.907248 0.000001
## ma1     0.800469    0.173338    4.617955 0.000004
## omega   0.000977    0.000232    4.213379 0.000025
## alpha1  0.000965    0.009057    0.106565 0.915134
## alpha2  0.000008    0.014806    0.000555 0.999557
## alpha3  0.015250    0.015177    1.004770 0.315008
## alpha4  0.020400    0.009909    2.058689 0.039524
```

```
## beta1   0.960829    0.000960 1000.546864 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error     t value Pr(>|t|)
## mu      0.004940    0.005917    0.834840 0.403808
## ar1    -0.817712    0.189730   -4.309871 0.000016
## ma1     0.800469    0.197670    4.049515 0.000051
## omega   0.000977    0.000413    2.363011 0.018127
## alpha1  0.000965    0.010529    0.091670 0.926960
## alpha2  0.000008    0.024430    0.000336 0.999732
## alpha3  0.015250    0.023604    0.646049 0.518247
## alpha4  0.020400    0.011904    1.713615 0.086599
## beta1   0.960829    0.000365 2629.227416 0.000000
##
## LogLikelihood : -4863.539
##
## Information Criteria
## ------------------------------------
##
## Akaike       1.5468
## Bayes        1.5565
## Shibata      1.5468
## Hannan-Quinn 1.5502
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                     0.2027  0.6526
## Lag[2*(p+q)+(p+q)-1][5]    1.3714  0.9993
## Lag[4*(p+q)+(p+q)-1][9]    3.9153  0.7107
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                           statistic   p-value
## Lag[1]                       0.5887 4.429e-01
## Lag[2*(p+q)+(p+q)-1][14]   17.9515 6.035e-03
## Lag[4*(p+q)+(p+q)-1][24]   38.0186 1.173e-05
## d.o.f=5
##
## Weighted ARCH LM Tests
## ------------------------------------
##              Statistic Shape Scale   P-Value
## ARCH Lag[6]      12.80 0.500 2.000 0.0003463
## ARCH Lag[8]      14.08 1.480 1.774 0.0011491
## ARCH Lag[10]     17.46 2.424 1.650 0.0006601
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  2.0265
## Individual Statistics:
## mu     0.15926
## ar1    0.04308
```

```
## ma1    0.04612
## omega  0.10336
## alpha1 0.11696
## alpha2 0.10910
## alpha3 0.14217
## alpha4 0.11403
## beta1  0.17892
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          2.1 2.32 2.82
## Individual Statistic:     0.35 0.47 0.75
##
## Sign Bias Test
## -----------------------------------
##                    t-value   prob sig
## Sign Bias           0.3522 0.7247
## Negative Sign Bias  1.3843 0.1663
## Positive Sign Bias  0.4110 0.6811
## Joint Effect        5.3284 0.1493
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     322.0    6.110e-57
## 2    30     351.7    4.062e-57
## 3    40     372.0    6.487e-56
## 4    50     396.4    7.136e-56
##
##
## Elapsed time : 0.781878
```

Forecasting

```
forcgarchEURUSD= ugarchforecast(EURUSDgarchMODEL4.1, data = DiffEURUSDLogTran, n.ahead = 100)
print(forcgarchEURUSD)
```

```
##
## *----------------------------------*
## *       GARCH Model Forecast       *
## *----------------------------------*
## Model: sGARCH
## Horizon: 100
## Roll Steps: 0
## Out of Sample: 100
##
## 0-roll forecast [T0=1987-04-02 03:00:00]:
##         Series  Sigma
## T+1   0.001633 0.4287
## T+2   0.007644 0.4217
## T+3   0.002729 0.4148
## T+4   0.006748 0.4114
```

```
## T+5   0.003462 0.4126
## T+6   0.006149 0.4135
## T+7   0.003951 0.4141
## T+8   0.005748 0.4147
## T+9   0.004279 0.4153
## T+10  0.005480 0.4159
## T+11  0.004498 0.4165
## T+12  0.005301 0.4171
## T+13  0.004644 0.4177
## T+14  0.005182 0.4182
## T+15  0.004742 0.4188
## T+16  0.005102 0.4194
## T+17  0.004808 0.4200
## T+18  0.005048 0.4206
## T+19  0.004852 0.4211
## T+20  0.005012 0.4217
## T+21  0.004881 0.4223
## T+22  0.004988 0.4228
## T+23  0.004900 0.4234
## T+24  0.004972 0.4240
## T+25  0.004914 0.4245
## T+26  0.004962 0.4251
## T+27  0.004922 0.4256
## T+28  0.004954 0.4262
## T+29  0.004928 0.4267
## T+30  0.004950 0.4273
## T+31  0.004932 0.4278
## T+32  0.004946 0.4284
## T+33  0.004935 0.4289
## T+34  0.004944 0.4295
## T+35  0.004936 0.4300
## T+36  0.004943 0.4305
## T+37  0.004938 0.4311
## T+38  0.004942 0.4316
## T+39  0.004938 0.4322
## T+40  0.004941 0.4327
## T+41  0.004939 0.4332
## T+42  0.004941 0.4337
## T+43  0.004939 0.4343
## T+44  0.004941 0.4348
## T+45  0.004940 0.4353
## T+46  0.004940 0.4358
## T+47  0.004940 0.4363
## T+48  0.004940 0.4369
## T+49  0.004940 0.4374
## T+50  0.004940 0.4379
## T+51  0.004940 0.4384
## T+52  0.004940 0.4389
## T+53  0.004940 0.4394
## T+54  0.004940 0.4399
## T+55  0.004940 0.4404
## T+56  0.004940 0.4409
## T+57  0.004940 0.4414
## T+58  0.004940 0.4419
```

```
## T+59  0.004940 0.4424
## T+60  0.004940 0.4429
## T+61  0.004940 0.4434
## T+62  0.004940 0.4439
## T+63  0.004940 0.4444
## T+64  0.004940 0.4449
## T+65  0.004940 0.4454
## T+66  0.004940 0.4458
## T+67  0.004940 0.4463
## T+68  0.004940 0.4468
## T+69  0.004940 0.4473
## T+70  0.004940 0.4478
## T+71  0.004940 0.4482
## T+72  0.004940 0.4487
## T+73  0.004940 0.4492
## T+74  0.004940 0.4497
## T+75  0.004940 0.4501
## T+76  0.004940 0.4506
## T+77  0.004940 0.4511
## T+78  0.004940 0.4515
## T+79  0.004940 0.4520
## T+80  0.004940 0.4524
## T+81  0.004940 0.4529
## T+82  0.004940 0.4534
## T+83  0.004940 0.4538
## T+84  0.004940 0.4543
## T+85  0.004940 0.4547
## T+86  0.004940 0.4552
## T+87  0.004940 0.4556
## T+88  0.004940 0.4561
## T+89  0.004940 0.4565
## T+90  0.004940 0.4570
## T+91  0.004940 0.4574
## T+92  0.004940 0.4579
## T+93  0.004940 0.4583
## T+94  0.004940 0.4588
## T+95  0.004940 0.4592
## T+96  0.004940 0.4596
## T+97  0.004940 0.4601
## T+98  0.004940 0.4605
## T+99  0.004940 0.4609
## T+100 0.004940 0.4614
```

Forecasting the rate

```
p.t_1 = 1.22141
  R_t <- c( 0.001633, 0.007644, 0.002729, 0.006748, 0.003462, 0.006149, 0.003951, 0.005748, 0.004279, 0
0.004498, 0.005301, 0.004644, 0.005182, 0.004742, 0.005102, 0.004808, 0.005048, 0.004852, 0.005012, 0.0
```

```
)
  p_t= 0
  for (i in 1:100){
    p_t =  p.t_1  *((2.71828)^(R_t[i]/100))
   print(p_t)
    p.t_1=p_t
  }
```

```
## [1] 1.22143
## [1] 1.221523
## [1] 1.221557
## [1] 1.221639
## [1] 1.221681
## [1] 1.221757
## [1] 1.221805
## [1] 1.221875
## [1] 1.221927
## [1] 1.221994
## [1] 1.222049
## [1] 1.222114
## [1] 1.222171
## [1] 1.222234
## [1] 1.222292
## [1] 1.222354
## [1] 1.222413
## [1] 1.222475
## [1] 1.222534
## [1] 1.222595
## [1] 1.222655
## [1] 1.222716
## [1] 1.222776
## [1] 1.222837
## [1] 1.222897
## [1] 1.222958
## [1] 1.223018
## [1] 1.223078
## [1] 1.223139
## [1] 1.223199
## [1] 1.22326
## [1] 1.22332
## [1] 1.22338
## [1] 1.223441
## [1] 1.223501
## [1] 1.223562
## [1] 1.223622
## [1] 1.223683
## [1] 1.223743
## [1] 1.223804
## [1] 1.223864
## [1] 1.223925
## [1] 1.223985
## [1] 1.224045
## [1] 1.224106
```

```
## [1] 1.224166
## [1] 1.224227
## [1] 1.224287
## [1] 1.224348
## [1] 1.224408
## [1] 1.224469
## [1] 1.224529
## [1] 1.22459
## [1] 1.22465
## [1] 1.224711
## [1] 1.224771
## [1] 1.224832
## [1] 1.224892
## [1] 1.224953
## [1] 1.225013
## [1] 1.225074
## [1] 1.225134
## [1] 1.225195
## [1] 1.225255
## [1] 1.225316
## [1] 1.225376
## [1] 1.225437
## [1] 1.225498
## [1] 1.225558
## [1] 1.225619
## [1] 1.225679
## [1] 1.22574
## [1] 1.2258
## [1] 1.225861
## [1] 1.225921
## [1] 1.225982
## [1] 1.226043
## [1] 1.226103
## [1] 1.226164
## [1] 1.226224
## [1] 1.226285
## [1] 1.226345
## [1] 1.226406
## [1] 1.226467
## [1] 1.226527
## [1] 1.226588
## [1] 1.226648
## [1] 1.226709
## [1] 1.22677
## [1] 1.22683
## [1] 1.226891
## [1] 1.226951
## [1] 1.227012
## [1] 1.227073
## [1] 1.227133
## [1] 1.227194
## [1] 1.227254
## [1] 1.227315
## [1] 1.227376
```

```
## [1] 1.227436
```