

## tshw7

```
#1
x1=log(1+data_1$rtm)
t.test(x1)

##
## One Sample t-test
##
## data: x1
## t = 0.26515, df = 2534, p-value = 0.7909
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
## -0.0004633792 0.0006082874
## sample estimates:
## mean of x
## 7.24541e-05

Box.test(x1,lag=10)

##
## Box-Pierce test
##
## data: x1
## X-squared = 40.304, df = 10, p-value = 1.498e-05

xx1=x1-mean(x1)
source("archTest.R")
archTest(xx1,12)

##
## Call:
## lm(formula = atsq ~ x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.0050324 -0.0000996 -0.0000440  0.0000230  0.0153584
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  3.027e-05  1.242e-05   2.438 0.014855 *
## x1          -2.739e-02  1.996e-02  -1.372 0.170072
## x2           3.093e-01  1.957e-02  15.803 < 2e-16 ***
## x3          -4.084e-03  2.035e-02  -0.201 0.841000
## x4          -2.374e-02  2.032e-02  -1.168 0.242895
## x5           1.322e-01  2.030e-02   6.515 8.78e-11 ***
## x6           7.077e-02  2.044e-02   3.462 0.000545 ***
## x7           5.068e-02  2.037e-02   2.489 0.012892 *
## x8          -4.995e-02  2.023e-02  -2.469 0.013608 *
## x9           5.316e-02  2.024e-02   2.626 0.008693 **
## x10          1.329e-01  2.027e-02   6.558 6.60e-11 ***
## x11          1.965e-01  1.950e-02  10.076 < 2e-16 ***
## x12         -5.229e-03  1.988e-02  -0.263 0.792510
## ---
```

```

## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0005609 on 2510 degrees of freedom
## Multiple R-squared:  0.3112, Adjusted R-squared:  0.3079
## F-statistic: 94.5 on 12 and 2510 DF,  p-value: < 2.2e-16
model1 = garchFit(~garch(2,1), dta=x1)

##
## Series Initialization:
## ARMA Model:          arma
## Formula Mean:        ~ arma(0, 0)
## GARCH Model:         garch
## Formula Variance:    ~ garch(2, 1)
## ARMA Order:          0 0
## Max ARMA Order:      0
## GARCH Order:         2 1
## Max GARCH Order:     2
## Maximum Order:       2
## Conditional Dist:    norm
## h.start:             3
## llh.start:           1
## Length of Series:    1974
## Recursion Init:      mci
## Series Scale:        0.4702445
##
## Parameter Initialization:
## Initial Parameters:   $params
## Limits of Transformations: $U, $V
## Which Parameters are Fixed? $includes
## Parameter Matrix:
##           U          V      params includes
## mu      -0.34932441  0.3493244 -0.03493244    TRUE
## omega    0.00000100 100.0000000  0.10000000    TRUE
## alpha1   0.00000001  1.0000000  0.05000000    TRUE
## alpha2   0.00000001  1.0000000  0.05000000    TRUE
## gamma1  -0.99999999  1.0000000  0.10000000   FALSE
## gamma2  -0.99999999  1.0000000  0.10000000   FALSE
## beta1    0.00000001  1.0000000  0.80000000    TRUE
## delta    0.00000000  2.0000000  2.00000000   FALSE
## skew     0.10000000 10.0000000  1.00000000   FALSE
## shape    1.00000000 10.0000000  4.00000000   FALSE
## Index List of Parameters to be Optimized:
##   mu  omega alpha1 alpha2  beta1
##    1    2    3    4    7
## Persistence:          0.9
##
## --- START OF TRACE ---
## Selected Algorithm: nlminb
##
## R coded nlminb Solver:
##
## 0:      2634.4646: -0.0349324 0.100000 0.0500000 0.0500000 0.800000
## 1:      2624.7810: -0.0349307 0.0751698 0.0595825 0.0481232 0.786911

```

```

## 2:      2612.4005: -0.0349286 0.0739115 0.0857586 0.0607663 0.792960
## 3:      2607.8501: -0.0349245 0.0506952 0.101393 0.0581676 0.783316
## 4:      2602.2142: -0.0349117 0.0591997 0.126066 0.0441353 0.785573
## 5:      2599.4078: -0.0348915 0.0605683 0.138671 0.0173242 0.783761
## 6:      2597.3651: -0.0348575 0.0500013 0.152681 0.00315357 0.803088
## 7:      2597.2803: -0.0348556 0.0491545 0.152225 0.000675268 0.802486
## 8:      2597.1133: -0.0348534 0.0507231 0.153099 1.00000e-08 0.804252
## 9:      2597.0694: -0.0347348 0.0482147 0.152395 1.00000e-08 0.807231
## 10:     2597.0685: -0.0347279 0.0483317 0.151969 1.00000e-08 0.807035
## 11:     2597.0668: -0.0347118 0.0485186 0.152009 1.00000e-08 0.807182
## 12:     2597.0650: -0.0346940 0.0484377 0.151946 1.00000e-08 0.807149
## 13:     2597.0631: -0.0346585 0.0485660 0.151782 1.00000e-08 0.807258
## 14:     2596.4150: -0.0165921 0.0467419 0.146206 1.00000e-08 0.812834
## 15:     2596.3798: -0.0147908 0.0510631 0.155626 1.00000e-08 0.801251
## 16:     2596.3666: -0.0141823 0.0491926 0.155296 1.00000e-08 0.803472
## 17:     2596.3664: -0.0141852 0.0492922 0.155034 1.00000e-08 0.804246
## 18:     2596.3634: -0.0141737 0.0491189 0.154856 1.00000e-08 0.804197
## 19:     2596.3630: -0.0141672 0.0495782 0.154193 1.00000e-08 0.804189
## 20:     2596.3610: -0.0141197 0.0492087 0.153678 1.00000e-08 0.804885
## 21:     2596.3603: -0.0140076 0.0489705 0.153269 1.00000e-08 0.805540
## 22:     2596.3600: -0.0138920 0.0489204 0.153257 1.00000e-08 0.805539
## 23:     2596.3594: -0.0134296 0.0488433 0.153171 1.00000e-08 0.805729
## 24:     2596.3593: -0.0132952 0.0487750 0.153050 1.00000e-08 0.805906
## 25:     2596.3593: -0.0132943 0.0487792 0.153060 1.00000e-08 0.805894
##
## Final Estimate of the Negative LLH:
## LLH: 1106.971      norm LLH: 0.5607757
##      mu      omega      alpha1      alpha2      beta1
## -0.006251594 0.010786546 0.153060155 0.000000010 0.805893660
##
## R-optimhess Difference Approximated Hessian Matrix:
##      mu      omega      alpha1      alpha2      beta1
## mu      -14006.59547      509.0389      272.3188      -118.3307      31.17776
## omega      509.03892 -1454881.5267 -118725.0567 -122610.8489 -197352.46661
## alpha1      272.31877 -118725.0567 -18052.4055 -17403.6823 -22119.53130
## alpha2     -118.33070 -122610.8489 -17403.6823 -18466.2275 -23086.20359
## beta1       31.17776 -197352.4666 -22119.5313 -23086.2036 -31996.81719
## attr("time")
## Time difference of 0.03488612 secs
##
## --- END OF TRACE ---
##
## Time to Estimate Parameters:
## Time difference of 0.1286821 secs
summary(model1)

##
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~garch(2, 1), dta = x1)
##

```

```

## Mean and Variance Equation:
## data ~ garch(2, 1)
## <environment: 0x7ff140c3e2b0>
## [data = fGarch::dem2gbp]
##
## Conditional Distribution:
## norm
##
## Coefficient(s):
##      mu      omega      alpha1      alpha2      beta1
## -0.00625159  0.01078655  0.15306016  0.00000001  0.80589366
##
## Std. Errors:
## based on Hessian
##
## Error Analysis:
##      Estimate Std. Error t value Pr(>|t|)
## mu      -6.252e-03  8.488e-03  -0.737   0.461
## omega    1.079e-02  7.253e-03   1.487   0.137
## alpha1   1.531e-01  2.643e-02   5.792 6.97e-09 ***
## alpha2   1.000e-08  7.882e-02   0.000   1.000
## beta1    8.059e-01  1.045e-01   7.708 1.27e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
## -1106.971    normalized: -0.5607757
##
## Description:
## Sun Nov 19 22:06:22 2017 by user:
##
##
## Standardised Residuals Tests:
##
##      Statistic p-Value
## Jarque-Bera Test  R    Chi^2 1059.555 0
## Shapiro-Wilk Test  R    W    0.9622738 0
## Ljung-Box Test     R    Q(10) 10.13603 0.4286413
## Ljung-Box Test     R    Q(15) 17.06937 0.3147344
## Ljung-Box Test     R    Q(20) 19.32514 0.5007906
## Ljung-Box Test     R^2 Q(10) 9.048813 0.5274774
## Ljung-Box Test     R^2 Q(15) 16.06829 0.3775279
## Ljung-Box Test     R^2 Q(20) 17.49161 0.6208593
## LM Arch Test       R    TR^2  9.757674 0.6372103
##
## Information Criterion Statistics:
##      AIC      BIC      SIC      HQIC
## 1.126617 1.140771 1.126604 1.131818
res = residuals(model1, standardize=T)
vol = volatility(model1)
Box.test(res/vol, type='Ljung', lag=10)

##
## Box-Ljung test
##

```

```

## data: res/vol
## X-squared = 11.344, df = 10, p-value = 0.3313
qqnorm(res/vol)

model2 = garchFit(~garch(2,1), dta=x1,cond.dist="std")

##
## Series Initialization:
## ARMA Model: arma
## Formula Mean: ~ arma(0, 0)
## GARCH Model: garch
## Formula Variance: ~ garch(2, 1)
## ARMA Order: 0 0
## Max ARMA Order: 0
## GARCH Order: 2 1
## Max GARCH Order: 2
## Maximum Order: 2
## Conditional Dist: std
## h.start: 3
## llh.start: 1
## Length of Series: 1974
## Recursion Init: mci
## Series Scale: 0.4702445
##
## Parameter Initialization:
## Initial Parameters: $params
## Limits of Transformations: $U, $V
## Which Parameters are Fixed? $includes
## Parameter Matrix:
##      U      V      params includes
## mu    -0.34932441  0.3493244 -0.03493244  TRUE
## omega  0.00000100 100.0000000  0.10000000  TRUE
## alpha1 0.00000001  1.0000000  0.05000000  TRUE
## alpha2 0.00000001  1.0000000  0.05000000  TRUE
## gamma1 -0.99999999  1.0000000  0.10000000  FALSE
## gamma2 -0.99999999  1.0000000  0.10000000  FALSE
## beta1  0.00000001  1.0000000  0.80000000  TRUE
## delta  0.00000000  2.0000000  2.00000000  FALSE
## skew   0.10000000  10.0000000  1.00000000  FALSE
## shape  1.00000000  10.0000000  4.00000000  TRUE
## Index List of Parameters to be Optimized:
##      mu omega alpha1 alpha2 beta1 shape
##      1    2    3    4    7    10
## Persistence: 0.9
##
## --- START OF TRACE ---
## Selected Algorithm: nlminb
##
## R coded nlminb Solver:
##
## 0: 2528.2386: -0.0349324 0.100000 0.0500000 0.0500000 0.800000 4.00000
## 1: 2493.5144: -0.0348988 0.0348408 0.127359 0.105427 0.797787 4.00007
## 2: 2491.8697: -0.0348942 0.0268372 0.124766 0.101212 0.793104 3.99993

```

```

## 3:      2490.9029: -0.0348614 0.0285063 0.128715 0.0938872 0.799235 4.00001
## 4:      2487.2178: -0.0346597 0.0136882 0.143968 0.0444523 0.837844 4.00071
## 5:      2485.0012: -0.0344881 0.0222001 0.151758 1.00000e-08 0.860246 4.00097
## 6:      2483.8676: -0.0336184 0.0114934 0.113683 1.00000e-08 0.886508 4.00344
## 7:      2482.4168: -0.0320284 0.0130112 0.139403 1.00000e-08 0.874501 4.00346
## 8:      2482.2301: -0.0305008 0.00756205 0.118539 1.00000e-08 0.896381 4.00833
## 9:      2482.1527: -0.0304993 0.00743720 0.117908 1.00000e-08 0.895477 4.00833
## 10:     2482.1123: -0.0304905 0.00850985 0.117796 1.00000e-08 0.895405 4.00837
## 11:     2482.0556: -0.0304186 0.00812847 0.117352 1.00000e-08 0.894933 4.00873
## 12:     2482.0135: -0.0302676 0.00874282 0.117180 1.00000e-08 0.894853 4.00951
## 13:     2481.9494: -0.0299629 0.00851174 0.117023 1.00000e-08 0.894465 4.01112
## 14:     2480.7379: -0.0202098 0.00814769 0.127246 1.00000e-08 0.888389 4.06303
## 15:     2480.2537: -0.0104391 0.0111460 0.103837 1.00000e-08 0.897129 4.10684
## 16:     2479.8468: -0.000838615 0.00637044 0.102375 1.00000e-08 0.908778 4.03881
## 17:     2479.3353: -0.00147255 0.00893469 0.126220 1.00000e-08 0.889239 3.92158
## 18:     2479.1594: -0.000165037 0.00951133 0.125481 1.00000e-08 0.887029 4.03830
## 19:     2479.0832: 0.00405581 0.0103591 0.123711 1.00000e-08 0.886798 4.01764
## 20:     2479.0558: 0.00500670 0.0102913 0.123428 1.00000e-08 0.885162 4.13588
## 21:     2479.0519: 0.00479102 0.0104510 0.124250 1.00000e-08 0.884988 4.11039
## 22:     2479.0518: 0.00478913 0.0104148 0.124082 1.00000e-08 0.885120 4.10912
## 23:     2479.0518: 0.00479179 0.0104171 0.124090 1.00000e-08 0.885108 4.10948
## 24:     2479.0518: 0.00479159 0.0104173 0.124091 1.00000e-08 0.885107 4.10947
##
## Final Estimate of the Negative LLH:
## LLH: 989.6636      norm LLH: 0.5013494
##      mu      omega      alpha1      alpha2      beta1      shape
## 0.002253220 0.002303575 0.124090630 0.000000010 0.885106682 4.109469623
##
## R-optimhess Difference Approximated Hessian Matrix:
##      mu      omega      alpha1      alpha2      beta1
## mu      -20745.51284      -5075.782      -700.4511      -1091.8852      -1058.6902
## omega      -5075.78199 -3454852.057 -216250.4556 -217721.3747 -363008.5763
## alpha1      -700.45112 -216250.456 -27623.8488 -27314.5052 -37919.2822
## alpha2      -1091.88517 -217721.375 -27314.5052 -27986.8853 -38706.4987
## beta1      -1058.69017 -363008.576 -37919.2822 -38706.4987 -56405.8256
## shape      -33.11523      -4464.162      -539.7787      -554.9376      -761.5493
##
##      shape
## mu      -33.11523
## omega      -4464.16177
## alpha1      -539.77865
## alpha2      -554.93758
## beta1      -761.54927
## shape      -16.90880
## attr("time")
## Time difference of 0.0835278 secs
##
## --- END OF TRACE ---
##
##
## Time to Estimate Parameters:
## Time difference of 0.216527 secs
summary(model2)
##

```

```

## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~garch(2, 1), cond.dist = "std", dta = x1)
##
## Mean and Variance Equation:
## data ~ garch(2, 1)
## <environment: 0x7ff140d6a558>
## [data = fGarch::dem2gbp]
##
## Conditional Distribution:
## std
##
## Coefficient(s):
##      mu      omega    alpha1    alpha2    beta1    shape
## 0.00225322 0.00230357 0.12409063 0.00000001 0.88510668 4.10946962
##
## Std. Errors:
## based on Hessian
##
## Error Analysis:
##      Estimate Std. Error t value Pr(>|t|)
## mu      2.253e-03  7.001e-03   0.322  0.74757
## omega  2.304e-03  1.556e-03   1.480  0.13885
## alpha1 1.241e-01  3.243e-02   3.826  0.00013 ***
## alpha2 1.000e-08  5.534e-02   0.000  1.00000
## beta1  8.851e-01  3.855e-02  22.961 < 2e-16 ***
## shape  4.109e+00  4.185e-01   9.820 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
## -989.6636    normalized: -0.5013494
##
## Description:
## Sun Nov 19 22:06:23 2017 by user:
##
##
## Standardised Residuals Tests:
##
##      Statistic p-Value
## Jarque-Bera Test  R    Chi^2 1870.149 0
## Shapiro-Wilk Test  R    W    0.9504346 0
## Ljung-Box Test    R    Q(10) 9.732201 0.4642941
## Ljung-Box Test    R    Q(15) 15.45243 0.4193455
## Ljung-Box Test    R    Q(20) 17.72277 0.605665
## Ljung-Box Test    R^2 Q(10) 11.68919 0.306396
## Ljung-Box Test    R^2 Q(15) 18.10323 0.2572773
## Ljung-Box Test    R^2 Q(20) 22.34456 0.3221102
## LM Arch Test      R    TR^2 13.72064 0.3189022
##
## Information Criterion Statistics:
##      AIC      BIC      SIC      HQIC
## 1.008778 1.025762 1.008759 1.015018

```

```
res = residuals(model2, standardize=T)
vol = volatility(model2)
Box.test(res/vol, type='Ljung', lag=10)
```

```
##
## Box-Ljung test
##
## data: res/vol
## X-squared = 13.492, df = 10, p-value = 0.1975
```

```
#3
```

```
x3=log(1+data_3$rtm)
t.test(x3)
```

```
##
## One Sample t-test
##
## data: x3
## t = 1.2794, df = 2534, p-value = 0.2009
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
## -0.0001625660 0.0007728936
## sample estimates:
## mean of x
## 0.0003051638
```

```
Box.test(x1,lag=10)
```

```
##
## Box-Pierce test
##
## data: x1
## X-squared = 40.304, df = 10, p-value = 1.498e-05
```

```
xx3=x3-mean(x3)
archTest(xx3,12)
```

```
##
## Call:
## lm(formula = atsq ~ x)
##
## Residuals:
```

	Min	1Q	Median	3Q	Max
	-0.0017271	-0.0000933	-0.0000528	0.0000134	0.0076190

```
##
## Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	3.811e-05	8.897e-06	4.284	1.91e-05 ***
x1	8.295e-02	1.992e-02	4.165	3.23e-05 ***
x2	1.211e-01	1.981e-02	6.111	1.14e-09 ***
x3	1.843e-02	1.880e-02	0.981	0.326860
x4	1.120e-01	1.864e-02	6.010	2.12e-09 ***
x5	7.338e-02	1.874e-02	3.916	9.24e-05 ***
x6	6.304e-02	1.880e-02	3.354	0.000808 ***
x7	-8.840e-04	1.879e-02	-0.047	0.962486



```
## x8          -3.441e-02  1.873e-02  -1.837  0.066351 .
## x9           1.282e-01  1.863e-02   6.884  7.34e-12 ***
## x10         -1.985e-02  1.880e-02  -1.056  0.291297
## x11           1.184e-01  1.870e-02   6.329  2.90e-10 ***
## x12           5.516e-02  1.875e-02   2.942  0.003286 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0003721 on 2510 degrees of freedom
## Multiple R-squared:  0.1718, Adjusted R-squared:  0.1678
## F-statistic: 43.38 on 12 and 2510 DF,  p-value: < 2.2e-16
model3= garchFit(~garch(2,1), dta=x3)
```

```
##
## Series Initialization:
## ARMA Model:          arma
## Formula Mean:        ~ arma(0, 0)
## GARCH Model:         garch
## Formula Variance:    ~ garch(2, 1)
## ARMA Order:          0 0
## Max ARMA Order:      0
## GARCH Order:         2 1
## Max GARCH Order:     2
## Maximum Order:       2
## Conditional Dist:    norm
## h.start:             3
## llh.start:           1
## Length of Series:    1974
## Recursion Init:      mci
## Series Scale:        0.4702445
##
## Parameter Initialization:
## Initial Parameters:   $params
## Limits of Transformations: $U, $V
## Which Parameters are Fixed? $includes
## Parameter Matrix:
##           U          V      params includes
## mu      -0.34932441  0.3493244 -0.03493244    TRUE
## omega    0.00000100 100.0000000  0.10000000    TRUE
## alpha1   0.00000001  1.0000000  0.05000000    TRUE
## alpha2   0.00000001  1.0000000  0.05000000    TRUE
## gamma1  -0.99999999  1.0000000  0.10000000    FALSE
## gamma2  -0.99999999  1.0000000  0.10000000    FALSE
## beta1    0.00000001  1.0000000  0.80000000    TRUE
## delta    0.00000000  2.0000000  2.00000000    FALSE
## skew     0.10000000 10.0000000  1.00000000    FALSE
## shape    1.00000000 10.0000000  4.00000000    FALSE
## Index List of Parameters to be Optimized:
## mu omega alpha1 alpha2 beta1
## 1   2       3     4     7
## Persistence:          0.9
##
##
## --- START OF TRACE ---
```

```

## Selected Algorithm: nlminb
##
## R coded nlminb Solver:
##
## 0:      2634.4646: -0.0349324 0.100000 0.0500000 0.0500000 0.800000
## 1:      2624.7810: -0.0349307 0.0751698 0.0595825 0.0481232 0.786911
## 2:      2612.4005: -0.0349286 0.0739115 0.0857586 0.0607663 0.792960
## 3:      2607.8501: -0.0349245 0.0506952 0.101393 0.0581676 0.783316
## 4:      2602.2142: -0.0349117 0.0591997 0.126066 0.0441353 0.785573
## 5:      2599.4078: -0.0348915 0.0605683 0.138671 0.0173242 0.783761
## 6:      2597.3651: -0.0348575 0.0500013 0.152681 0.00315357 0.803088
## 7:      2597.2803: -0.0348556 0.0491545 0.152225 0.000675268 0.802486
## 8:      2597.1133: -0.0348534 0.0507231 0.153099 1.00000e-08 0.804252
## 9:      2597.0694: -0.0347348 0.0482147 0.152395 1.00000e-08 0.807231
## 10:     2597.0685: -0.0347279 0.0483317 0.151969 1.00000e-08 0.807035
## 11:     2597.0668: -0.0347118 0.0485186 0.152009 1.00000e-08 0.807182
## 12:     2597.0650: -0.0346940 0.0484377 0.151946 1.00000e-08 0.807149
## 13:     2597.0631: -0.0346585 0.0485660 0.151782 1.00000e-08 0.807258
## 14:     2596.4150: -0.0165921 0.0467419 0.146206 1.00000e-08 0.812834
## 15:     2596.3798: -0.0147908 0.0510631 0.155626 1.00000e-08 0.801251
## 16:     2596.3666: -0.0141823 0.0491926 0.155296 1.00000e-08 0.803472
## 17:     2596.3664: -0.0141852 0.0492922 0.155034 1.00000e-08 0.804246
## 18:     2596.3634: -0.0141737 0.0491189 0.154856 1.00000e-08 0.804197
## 19:     2596.3630: -0.0141672 0.0495782 0.154193 1.00000e-08 0.804189
## 20:     2596.3610: -0.0141197 0.0492087 0.153678 1.00000e-08 0.804885
## 21:     2596.3603: -0.0140076 0.0489705 0.153269 1.00000e-08 0.805540
## 22:     2596.3600: -0.0138920 0.0489204 0.153257 1.00000e-08 0.805539
## 23:     2596.3594: -0.0134296 0.0488433 0.153171 1.00000e-08 0.805729
## 24:     2596.3593: -0.0132952 0.0487750 0.153050 1.00000e-08 0.805906
## 25:     2596.3593: -0.0132943 0.0487792 0.153060 1.00000e-08 0.805894
##
## Final Estimate of the Negative LLH:
## LLH: 1106.971      norm LLH: 0.5607757
##      mu      omega      alpha1      alpha2      beta1
## -0.006251594 0.010786546 0.153060155 0.000000010 0.805893660
##
## R-optimhess Difference Approximated Hessian Matrix:
##      mu      omega      alpha1      alpha2      beta1
## mu      -14006.59547      509.0389      272.3188      -118.3307      31.17776
## omega      509.03892 -1454881.5267 -118725.0567 -122610.8489 -197352.46661
## alpha1      272.31877 -118725.0567 -18052.4055 -17403.6823 -22119.53130
## alpha2      -118.33070 -122610.8489 -17403.6823 -18466.2275 -23086.20359
## beta1       31.17776 -197352.4666 -22119.5313 -23086.2036 -31996.81719
## attr("time")
## Time difference of 0.03805017 secs
##
## --- END OF TRACE ---
##
##
## Time to Estimate Parameters:
## Time difference of 0.130964 secs
summary(model3)
##

```

```

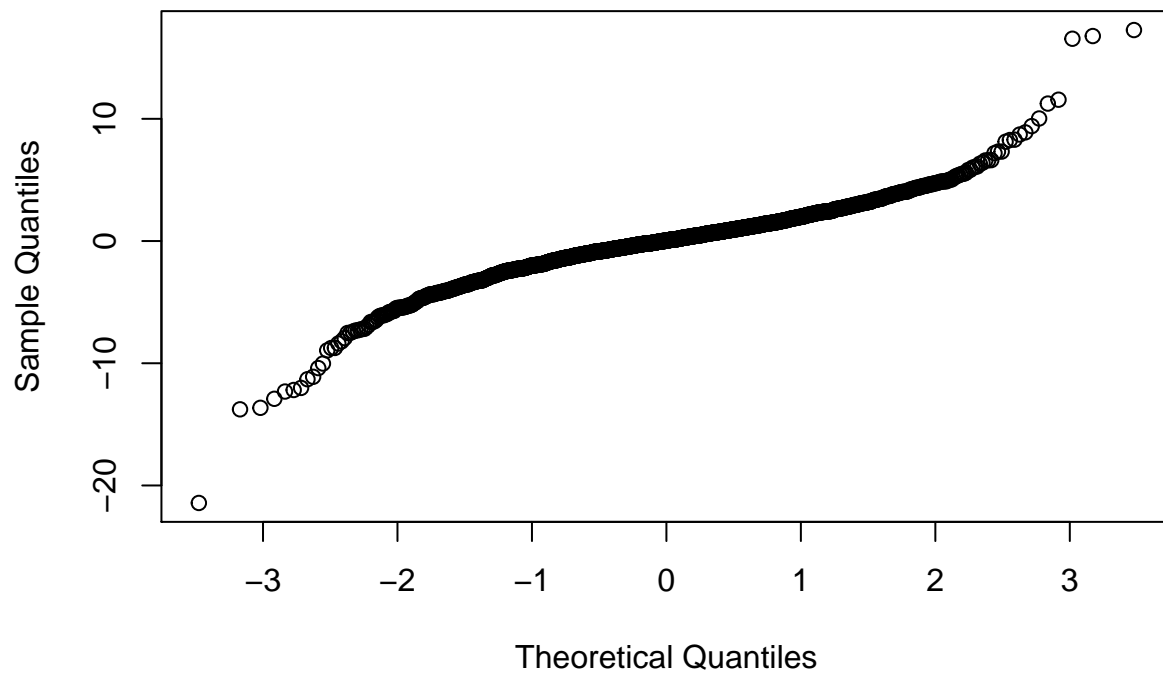
## Title:
## GARCH Modelling
##
## Call:
## garchFit(formula = ~garch(2, 1), dta = x3)
##
## Mean and Variance Equation:
## data ~ garch(2, 1)
## <environment: 0x7ff13f3ba548>
## [data = fGarch::dem2gbp]
##
## Conditional Distribution:
## norm
##
## Coefficient(s):
##      mu      omega      alpha1      alpha2      beta1
## -0.00625159  0.01078655  0.15306016  0.00000001  0.80589366
##
## Std. Errors:
## based on Hessian
##
## Error Analysis:
##      Estimate Std. Error t value Pr(>|t|)
## mu      -6.252e-03  8.488e-03  -0.737   0.461
## omega   1.079e-02  7.253e-03   1.487   0.137
## alpha1  1.531e-01  2.643e-02   5.792 6.97e-09 ***
## alpha2  1.000e-08  7.882e-02   0.000   1.000
## beta1   8.059e-01  1.045e-01   7.708 1.27e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
## -1106.971    normalized: -0.5607757
##
## Description:
## Sun Nov 19 22:06:23 2017 by user:
##
##
## Standardised Residuals Tests:
##
##      Statistic p-Value
## Jarque-Bera Test  R    Chi^2 1059.555 0
## Shapiro-Wilk Test  R    W    0.9622738 0
## Ljung-Box Test     R    Q(10) 10.13603 0.4286413
## Ljung-Box Test     R    Q(15) 17.06937 0.3147344
## Ljung-Box Test     R    Q(20) 19.32514 0.5007906
## Ljung-Box Test     R^2 Q(10) 9.048813 0.5274774
## Ljung-Box Test     R^2 Q(15) 16.06829 0.3775279
## Ljung-Box Test     R^2 Q(20) 17.49161 0.6208593
## LM Arch Test       R    TR^2  9.757674 0.6372103
##
## Information Criterion Statistics:
##      AIC      BIC      SIC      HQIC
## 1.126617 1.140771 1.126604 1.131818

```

```
res = residuals(model3, standardize=T)
vol = volatility(model3)
Box.test(res/vol, type='Ljung', lag=10)
```

```
##
## Box-Ljung test
##
## data: res/vol
## X-squared = 11.344, df = 10, p-value = 0.3313
qqnorm(res/vol)
```

Normal Q-Q Plot



```
#5
x5=log(1+data_5$ko)
t.test(x5)
```

```
##
## One Sample t-test
##
## data: x5
## t = 4.2198, df = 608, p-value = 2.819e-05
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
## 0.005655242 0.015501584
## sample estimates:
## mean of x
## 0.01057841
```

```
Box.test(x5,lag=10)
```

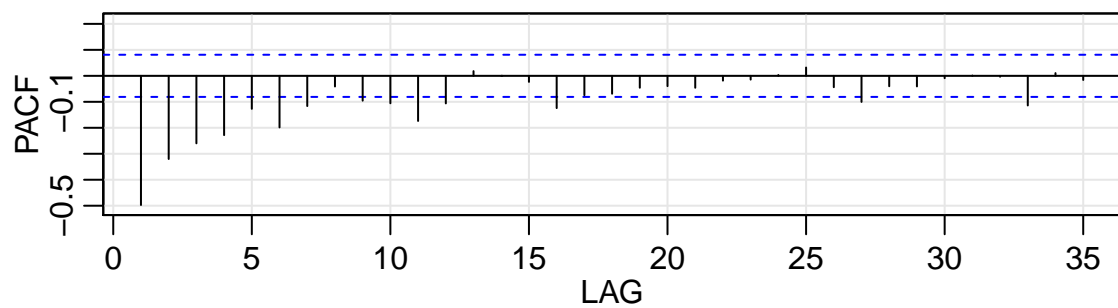
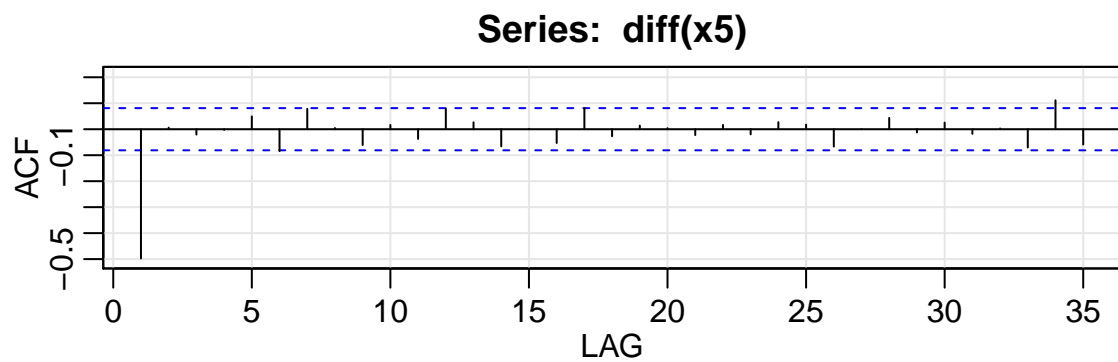
```
##
```

```
## Box-Pierce test
##
## data:  x5
## X-squared = 6.67, df = 10, p-value = 0.7562

xx5=x5-mean(x5)
archTest(xx5,12)

##
## Call:
## lm(formula = atsq ~ x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.020771 -0.002807 -0.001545  0.000666  0.099244
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.0015671  0.0004379   3.578 0.000374 ***
## x1           0.2056943  0.0413608   4.973 8.67e-07 ***
## x2           0.2481802  0.0421593   5.887 6.65e-09 ***
## x3          -0.0263466  0.0432095  -0.610 0.542271
## x4           0.0781499  0.0432051   1.809 0.070995 .
## x5          -0.0262333  0.0433213  -0.606 0.545048
## x6           0.0631800  0.0432992   1.459 0.145062
## x7          -0.0381006  0.0432942  -0.880 0.379200
## x8          -0.0101886  0.0433062  -0.235 0.814083
## x9          -0.0276711  0.0431917  -0.641 0.521997
## x10          0.0968461  0.0431845   2.243 0.025296 *
## x11          0.0086381  0.0421235   0.205 0.837592
## x12          0.0180950  0.0412754   0.438 0.661262
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.007753 on 584 degrees of freedom
## Multiple R-squared:  0.1723, Adjusted R-squared:  0.1553
## F-statistic: 10.13 on 12 and 584 DF,  p-value: < 2.2e-16

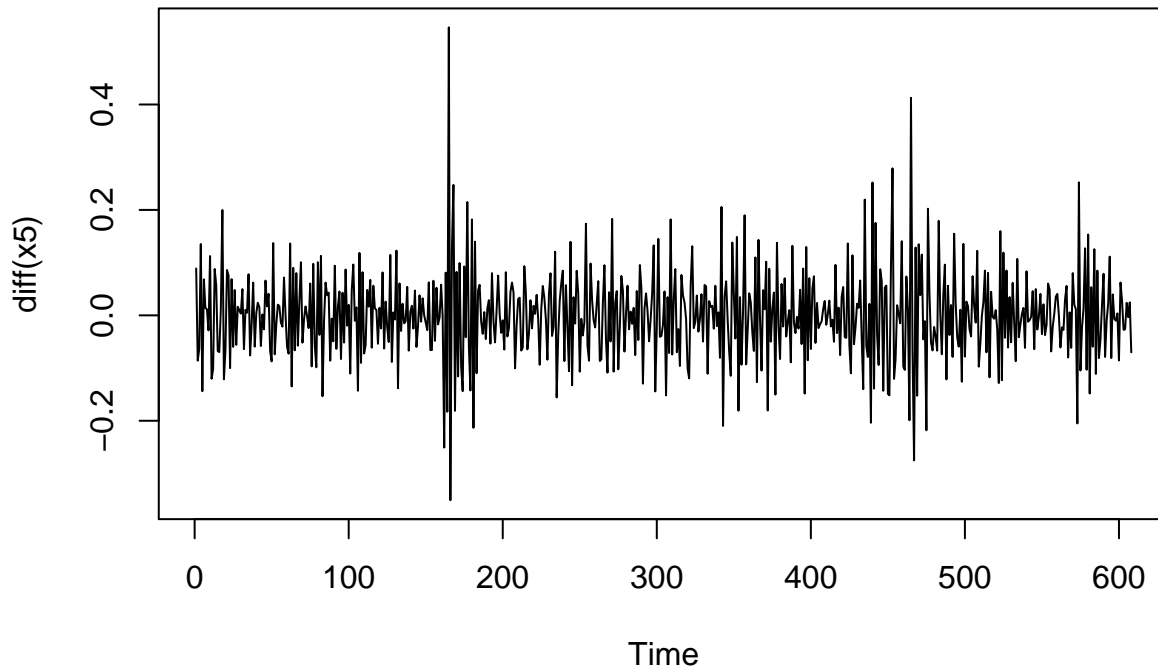
acf2(diff(x5))
```



##		ACF	PACF
##	[1,]	-0.50	-0.50
##	[2,]	0.01	-0.32
##	[3,]	-0.02	-0.26
##	[4,]	0.00	-0.23
##	[5,]	0.05	-0.13
##	[6,]	-0.08	-0.20
##	[7,]	0.08	-0.12
##	[8,]	0.00	-0.04
##	[9,]	-0.06	-0.10
##	[10,]	0.02	-0.11
##	[11,]	-0.04	-0.17
##	[12,]	0.08	-0.11
##	[13,]	0.03	0.02
##	[14,]	-0.07	0.00
##	[15,]	0.00	-0.02
##	[16,]	-0.05	-0.12
##	[17,]	0.08	-0.07
##	[18,]	-0.03	-0.07
##	[19,]	0.01	-0.05
##	[20,]	0.00	-0.04
##	[21,]	-0.02	-0.05
##	[22,]	0.02	-0.02
##	[23,]	-0.02	-0.01
##	[24,]	0.03	0.00
##	[25,]	0.02	0.03
##	[26,]	-0.07	-0.04
##	[27,]	0.00	-0.10
##	[28,]	0.04	-0.04
##	[29,]	-0.01	-0.04

```
## [30,] 0.03 -0.01
## [31,] -0.02 0.00
## [32,] 0.00 0.00
## [33,] -0.07 -0.11
## [34,] 0.11 0.01
## [35,] -0.06 -0.02
```

```
ts.plot(diff(x5))
```



```
model5=arima(x5,order = c(6,1,1))
archTest(model5$residuals*100)
```

```
##
## Call:
## lm(formula = atsq ~ x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -201.01  -28.13  -16.72    3.89   948.97
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 16.442175   4.298279   3.825 0.000145 ***
## x1           0.199966   0.041041   4.872 1.42e-06 ***
## x2           0.229692   0.041846   5.489 6.02e-08 ***
## x3          -0.004802   0.042901  -0.112 0.910914
## x4           0.077831   0.042860   1.816 0.069886 .
## x5          -0.019918   0.042881  -0.465 0.642459
## x6           0.067403   0.042881   1.572 0.116520
## x7          -0.044617   0.042849  -1.041 0.298179
## x8          -0.002564   0.042887  -0.060 0.952346
## x9          -0.026981   0.041830  -0.645 0.519167
## x10          0.097025   0.041024   2.365 0.018351 *
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 78.33 on 588 degrees of freedom
## Multiple R-squared:  0.1604, Adjusted R-squared:  0.1461
## F-statistic: 11.23 on 10 and 588 DF,  p-value: < 2.2e-16
```