Criptomoeda

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```
# inserindo os dados:
library(readxl)
litecoin <- read_excel("C:\\Users\\Daniel\\Documents\\MESTRADO\\II SEMESTRE\\FINANÇAS\\EXERCÍCIOS\\TRABA
```

Visualização das séries

```
# transformando em uma série de tempo:
library(timeSeries)
L <- timeSeries(litecoin)
L <- rev(L)
tail (L)
```

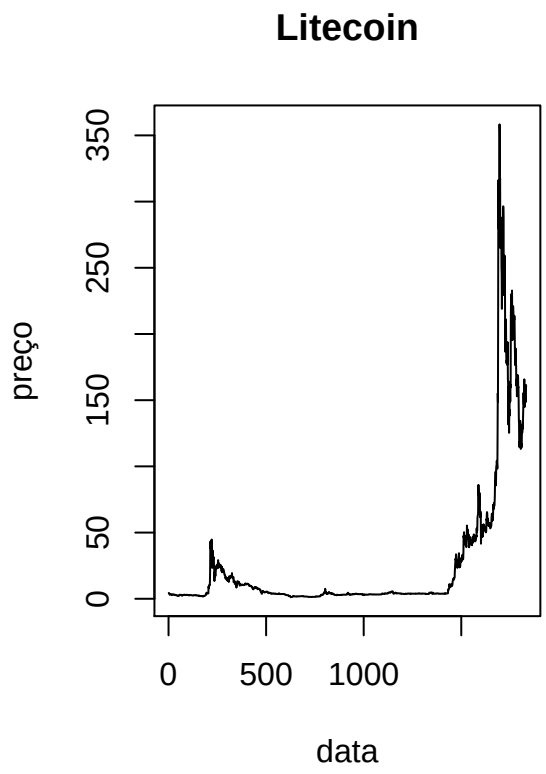
```
##
##      Date         Open   High   Low    Close  Volume      Market Cap
## [1,] Apr 28, 2018 145.74 153.33 145.74 152.30 337,117,000 8,202,220,000
## [2,] Apr 29, 2018 152.17 155.62 148.90 153.63 388,082,000 8,566,100,000
## [3,] Apr 30, 2018 153.65 154.08 147.87 148.48 341,397,000 8,651,810,000
## [4,] May 01, 2018 148.34 148.55 143.94 148.49 342,152,000 8,355,630,000
## [5,] May 02, 2018 148.45 152.89 146.98 151.58 354,657,000 8,363,530,000
## [6,] May 03, 2018 151.86 164.00 151.01 161.46 617,984,000 8,557,950,000
```

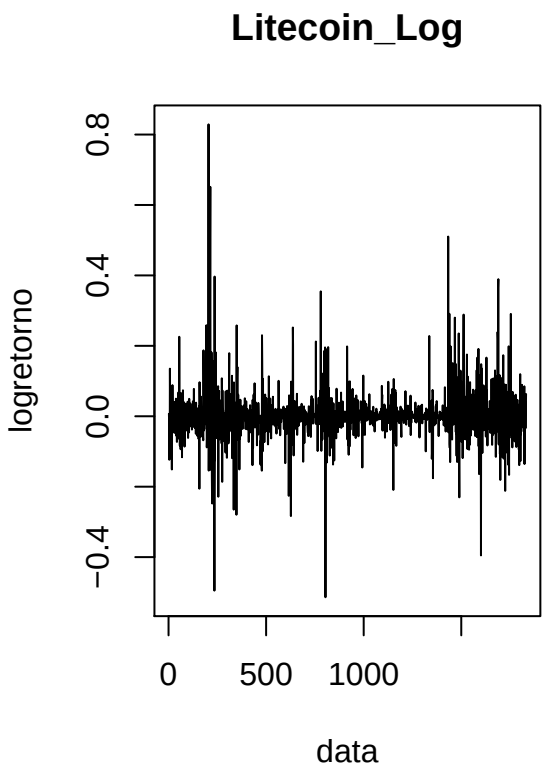
```
# para avaliar o logretorno, trabalharemos com o preço de fechamento:
preço <- as.numeric(L[,5])

# calculando o log retorno:
L.ret <- returns(preço)
head(L.ret)
```

```
##              [,1]
## [1,]           NA
## [2,]  0.006872879
## [3,] -0.018433702
## [4,] -0.123613956
## [5,] -0.120088322
## [6,] -0.103055229
```

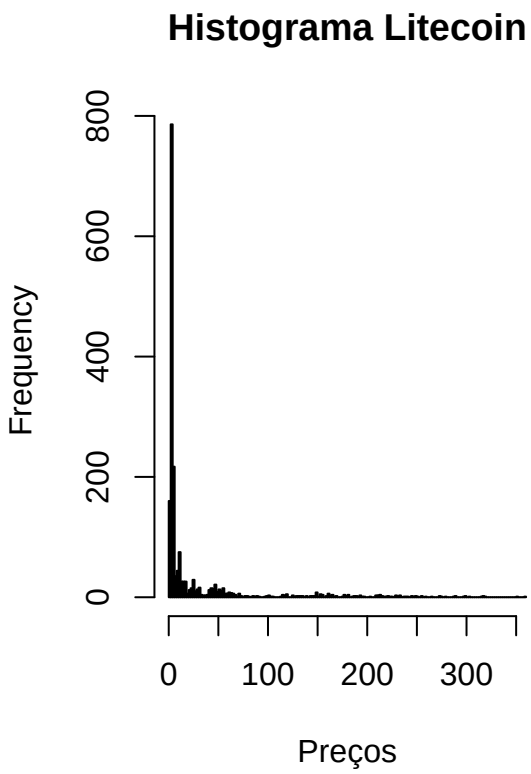
```
# visualização gráfica:
par(mfrow=c(1,2))
plot(preço, main="Litecoin", type="l", ylab="preço", xlab="data")
plot(L.ret, main="Litecoin_Log", type="l", ylab="logretorno", xlab="data")
```

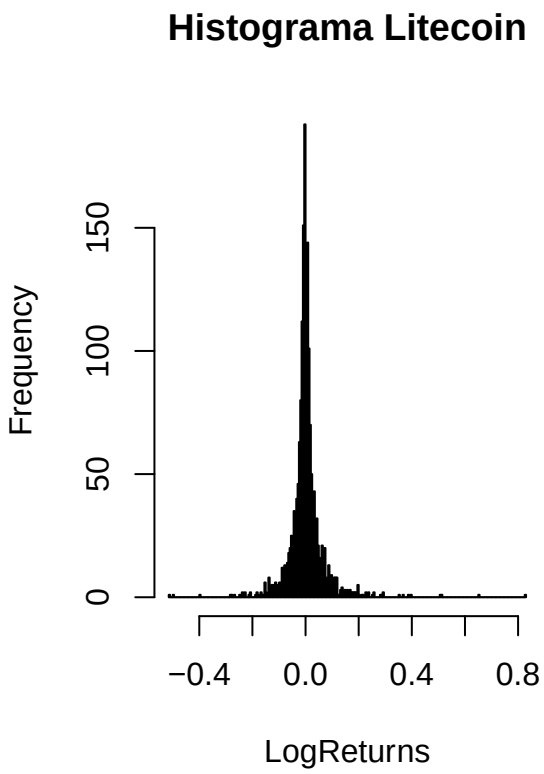




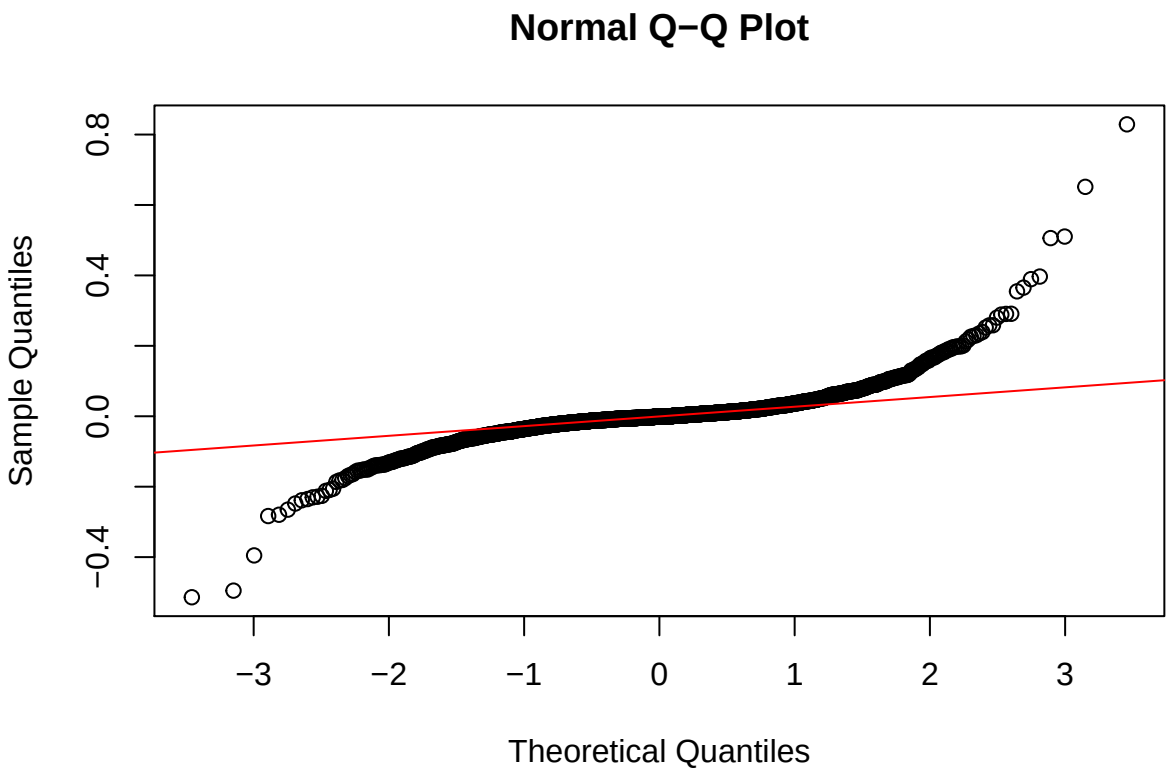

```
# histogramas:
par(mfrow=c(1,2))
hist(preço, breaks = "FD", col = "red", n=60,
     main = "Histograma Litecoin", xlab = "Preços")

hist(L.ret, breaks = "FD", col = "blue", n=60,
     main = "Histograma Litecoin", xlab = "LogReturns")
```






```
#qqplot
qqnorm(L.ret); qqline(L.ret, col="red")
```



Estatísticas das séries

```
# tabela com as principais estaísticas das séries de preços e retornos: média, min, max, desvio, variân

library(tseries)
library(fBasics)

options(digits=4)

#série de preços:
StatsPreço=as.matrix(basicStats(preço), 2,1)

#série de log retornos:
L.ret.NA <- removeNA(L.ret) #removendo o NA
StatsRet=as.matrix(basicStats(L.ret.NA), 2,1)

STATS <- cbind(StatsRet, StatsPreço)
STATS
```

```
##                L.ret.NA     preço
## nobs         1.831e+03  1832.000
## NAs          0.000e+00     0.000
## Minimum     -5.139e-01     1.160
## Maximum      8.290e-01   358.340
## 1. Quartile -1.904e-02     3.147
## 3. Quartile  1.809e-02    16.277
## Mean         1.974e-03    25.924
## Median       0.000e+00     3.960
```

```
## Sum          3.614e+00 47493.390
## SE Mean      1.619e-03     1.258
## LCL Mean    -1.201e-03    23.458
## UCL Mean     5.148e-03    28.391
## Variance     4.797e-03  2897.497
## Stdev        6.926e-02    53.828
## Skewness     1.774e+00     3.158
## Kurtosis     2.495e+01    10.171
```

```
# estacionarieade série de preços
adf.test(preço)
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  preço
## Dickey-Fuller = -2.3, Lag order = 12, p-value = 0.4
## alternative hypothesis: stationary
```

```
kpss.test(preço)
```

```
## Warning in kpss.test(preço): p-value smaller than printed p-value
```

```
##
##  KPSS Test for Level Stationarity
##
## data:  preço
## KPSS Level = 7, Truncation lag parameter = 8, p-value = 0.01
```

```
# estacionarieade série de retorno
adf.test(L.ret.NA)
```

```
## Warning in adf.test(L.ret.NA): p-value smaller than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  L.ret.NA
## Dickey-Fuller = -11, Lag order = 12, p-value = 0.01
## alternative hypothesis: stationary
```

```
kpss.test(L.ret.NA, null="Trend")
```

```
## Warning in kpss.test(L.ret.NA, null = "Trend"): p-value greater than printed p-
## value
```

```
##
##  KPSS Test for Trend Stationarity
##
## data:  L.ret.NA
## KPSS Trend = 0.076, Truncation lag parameter = 8, p-value = 0.1
```

```
# teste de normalidade série de preços
jarque.bera.test(preço)
```

```
##
##  Jarque Bera Test
##
## data:  preço
```

```
## X-squared = 10968, df = 2, p-value <2e-16
```

```
# teste de normalidade série de retorno
jarque.bera.test(L.ret.NA)
```

```
##
##  Jarque Bera Test
##
## data:  L.ret.NA
## X-squared = 48565, df = 2, p-value <2e-16
```

```
# testes Box Pierce Ljung Box na série de retornos
Box.test(L.ret.NA, lag = 5)
```

```
##
##  Box-Pierce test
##
## data:  L.ret.NA
## X-squared = 8.8, df = 5, p-value = 0.1
```

```
Box.test(L.ret.NA, lag = 10)
```

```
##
##  Box-Pierce test
##
## data:  L.ret.NA
## X-squared = 38, df = 10, p-value = 4e-05
```

```
Box.test(L.ret.NA, lag = 30)
```

```
##
##  Box-Pierce test
##
## data:  L.ret.NA
## X-squared = 69, df = 30, p-value = 7e-05
```

```
# testes Box Pierce Ljung Box na série do quadrado dos retornos
Box.test(L.ret.NA^2, lag = 5)
```

```
##
##  Box-Pierce test
##
## data:  L.ret.NA^2
## X-squared = 82, df = 5, p-value = 2e-16
```

```
Box.test(L.ret.NA^2, lag = 10)
```

```
##
##  Box-Pierce test
##
## data:  L.ret.NA^2
## X-squared = 323, df = 10, p-value <2e-16
```

```
Box.test(L.ret.NA^2, lag = 30)
```

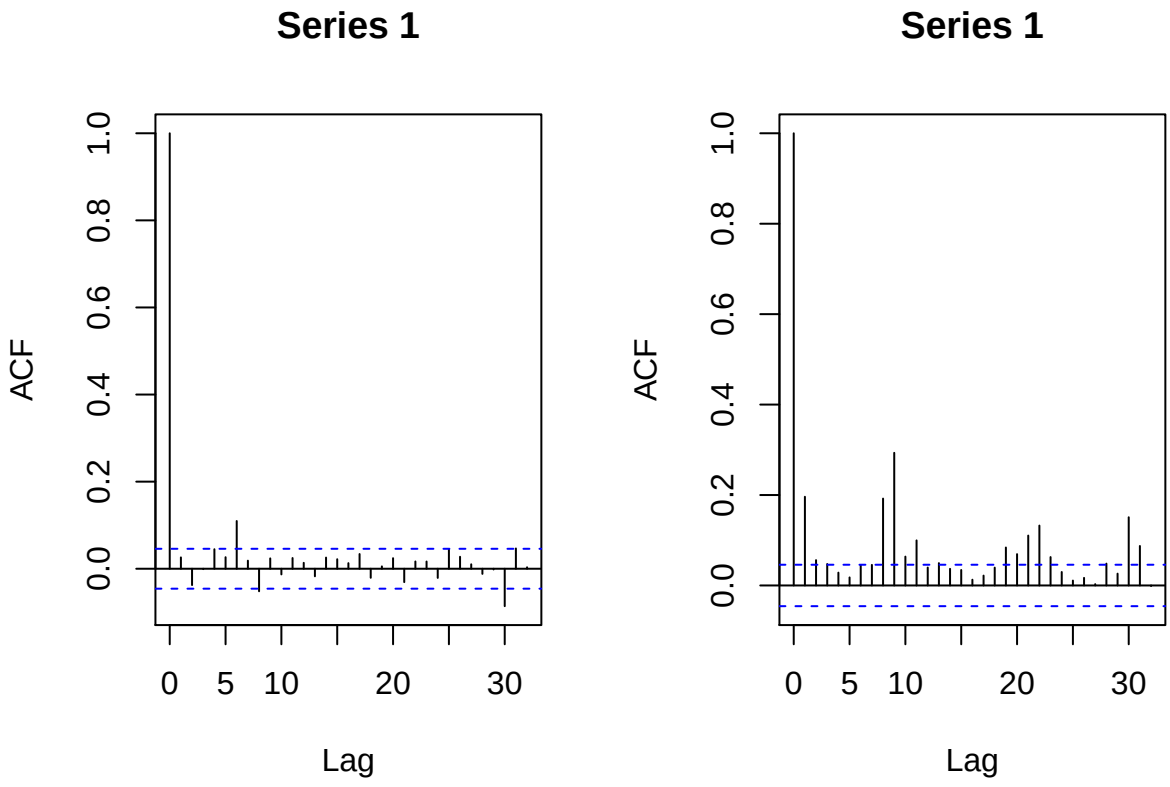
```
##
##  Box-Pierce test
##
## data:  L.ret.NA^2
```

```
## X-squared = 490, df = 30, p-value <2e-16
```

```
# teste ARCH-LM na série de retorno
library(FinTS)
ArchTest(L.ret.NA)
```

```
##
##  ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  L.ret.NA
## Chi-squared = 243, df = 12, p-value <2e-16
```

```
# ACF
par(mfrow=c(1,2))
acf(L.ret.NA)
acf(L.ret.NA^2)
```



Ajustando o modelor ARIMA

```
# ajustando o melhor modelo "familia GARCH"
library(forecast)
library(rugarch)
library(fGarch)
library(rmgarch)
library(quantmod)


# primeiro fazeos um FIT para ter uma idéia
fit <- auto.arima(L.ret.NA, seasonal=FALSE, stepwise=FALSE, approximation=FALSE)
```

```r
summary(fit)
```

```
## Series: L.ret.NA
## ARIMA(2,0,3) with zero mean
##
## Coefficients:
##         ar1     ar2     ma1    ma2    ma3
##       1.475  -0.854  -1.456  0.789  0.075
## s.e.  0.050   0.046   0.055  0.064  0.026
##
## sigma^2 estimated as 0.00474:  log likelihood=2303
## AIC=-4594   AICc=-4594   BIC=-4561
##
## Training set error measures:
##                       ME    RMSE     MAE MPE MAPE   MASE      ACF1
## Training set 0.001839 0.06878 0.03807 NaN  Inf 0.6776 -0.001263
```

Ajustando o modelo GARCH

```r
# modelos GARCH
garch_model <-  ugarchspec(mean.model = list(armaOrder=c(2,3)),
                           variance.model = list(garchOrder=c(1,1), model = "sGARCH"),
                           distribution.model = "sstd")

garch_model_1 <-  ugarchspec(mean.model = list(armaOrder=c(1,1)),
                           variance.model = list(garchOrder=c(1,1), model = "sGARCH"),
                           distribution.model = "std")
```

```r
garch <- ugarchfit(data = L.ret.NA, spec = garch_model)
print(garch)
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(1,1)
## Mean Model   : ARFIMA(2,0,3)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error    t value Pr(>|t|)
## mu     -0.000112    0.000567   -0.19695 0.843870
## ar1     1.493662    0.010543  141.66717 0.000000
## ar2    -0.929453    0.007649 -121.52063 0.000000
## ma1    -1.587060    0.009860 -160.95606 0.000000
## ma2     1.048025    0.000408 2568.85987 0.000000
## ma3    -0.063834    0.000629 -101.48543 0.000000
## omega   0.000018    0.000008    2.27105 0.023144
## alpha1  0.110106    0.015566    7.07350 0.000000
## beta1   0.888894    0.015734   56.49401 0.000000
```

```
## skew    1.034550    0.025977   39.82616 0.000000
## shape   2.791510    0.114966   24.28124 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error    t value Pr(>|t|)
## mu     -0.000112    0.000535   -0.20871  0.83467
## ar1     1.493662    0.007830  190.75218  0.00000
## ar2    -0.929453    0.005907 -157.34258  0.00000
## ma1    -1.587060    0.007257 -218.70639  0.00000
## ma2     1.048025    0.000455 2301.20521  0.00000
## ma3    -0.063834    0.000622 -102.63230  0.00000
## omega   0.000018    0.000015    1.23280  0.21765
## alpha1  0.110106    0.021476    5.12690  0.00000
## beta1   0.888894    0.028964   30.68949  0.00000
## skew    1.034550    0.024750   41.79958  0.00000
## shape   2.791510    0.114771   24.32238  0.00000
##
## LogLikelihood : 3255
##
## Information Criteria
## ------------------------------------
##
## Akaike       -3.5434
## Bayes        -3.5103
## Shibata      -3.5435
## Hannan-Quinn -3.5312
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                            statistic  p-value
## Lag[1]                         6.623 0.010068
## Lag[2*(p+q)+(p+q)-1][14]    14.449 0.000000
## Lag[4*(p+q)+(p+q)-1][24]    20.097 0.006191
## d.o.f=5
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                           statistic p-value
## Lag[1]                      0.07444  0.7850
## Lag[2*(p+q)+(p+q)-1][5]   0.31551  0.9821
## Lag[4*(p+q)+(p+q)-1][9]   0.47468  0.9987
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]    0.1247 0.500 2.000  0.7240
## ARCH Lag[5]    0.3142 1.440 1.667  0.9365
## ARCH Lag[7]    0.3800 2.315 1.543  0.9879
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  10.76
```

```
## Individual Statistics:
## mu     0.45477
## ar1    0.02664
## ar2    0.04446
## ma1    0.01984
## ma2    0.08710
## ma3    0.23755
## omega  0.57550
## alpha1 1.05199
## beta1  0.76915
## skew   0.09177
## shape  0.91898
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          2.49 2.75 3.27
## Individual Statistic:     0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value   prob sig
## Sign Bias           1.2492 0.2118
## Negative Sign Bias  0.1391 0.8894
## Positive Sign Bias  0.8991 0.3687
## Joint Effect        2.2038 0.5312
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     44.51    0.0008022
## 2    30     48.02    0.0146195
## 3    40     66.21    0.0042043
## 4    50     70.94    0.0218557
##
##
## Elapsed time : 0.9485
```

```
garch_1 <- ugarchfit(data = L.ret.NA, spec = garch_model_1)
print(garch_1)
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(1,1)
## Mean Model   : ARFIMA(1,0,1)
## Distribution : std
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     -0.000598    0.000426  -1.4035 0.160465
```

```
## ar1     0.417623    0.109821   3.8027 0.000143
## ma1    -0.512906    0.102203  -5.0185 0.000001
## omega   0.000019    0.000009   2.1820 0.029109
## alpha1  0.110623    0.016192   6.8320 0.000000
## beta1   0.888377    0.016957  52.3901 0.000000
## shape   2.779880    0.114359  24.3084 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     -0.000598    0.000366  -1.6353 0.101978
## ar1     0.417623    0.085329   4.8942 0.000001
## ma1    -0.512906    0.079305  -6.4675 0.000000
## omega   0.000019    0.000017   1.1264 0.260008
## alpha1  0.110623    0.024222   4.5671 0.000005
## beta1   0.888377    0.033231  26.7336 0.000000
## shape   2.779880    0.117564  23.6457 0.000000
##
## LogLikelihood : 3248
##
## Information Criteria
## ------------------------------------
##
## Akaike       -3.5399
## Bayes        -3.5189
## Shibata      -3.5400
## Hannan-Quinn -3.5322
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic   p-value
## Lag[1]                      8.618 3.329e-03
## Lag[2*(p+q)+(p+q)-1][5]    12.127 0.000e+00
## Lag[4*(p+q)+(p+q)-1][9]    17.745 1.325e-06
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                    0.06936  0.7923
## Lag[2*(p+q)+(p+q)-1][5]   0.29922  0.9838
## Lag[4*(p+q)+(p+q)-1][9]   0.45860  0.9988
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]    0.1244 0.500 2.000  0.7243
## ARCH Lag[5]    0.3084 1.440 1.667  0.9380
## ARCH Lag[7]    0.3760 2.315 1.543  0.9882
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  10.15
```

```
## Individual Statistics:
## mu     0.6220
## ar1    0.1787
## ma1    0.1499
## omega  0.5854
## alpha1 1.1371
## beta1  0.8363
## shape  0.9461
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          1.69 1.9 2.35
## Individual Statistic:     0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value   prob sig
## Sign Bias           1.1221 0.2620
## Negative Sign Bias  0.1417 0.8873
## Positive Sign Bias  0.7739 0.4391
## Joint Effect        1.7904 0.6170
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     42.74    0.0014062
## 2    30     52.64    0.0046179
## 3    40     73.12    0.0007608
## 4    50     78.48    0.0047431
##
##
## Elapsed time : 0.3381
```

Exponencial GARCH

```
# modelos EGARCH
egarch_model <-  ugarchspec(mean.model = list(armaOrder=c(2,3), include.mean=FALSE),
                            variance.model = list(garchOrder=c(1,1), model = "eGARCH"),
                            distribution.model = "sstd")

egarch_model_1 <-  ugarchspec(mean.model = list(armaOrder=c(1,1), include.mean=FALSE),
                            variance.model = list(garchOrder=c(1,1), model = "eGARCH"),
                            distribution.model = "std")
```

```
egarch <- ugarchfit(data = L.ret.NA, spec = egarch_model)
print(egarch)
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## ---------------------------------
```

```
## GARCH Model  : eGARCH(1,1)
## Mean Model   : ARFIMA(2,0,3)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error   t value Pr(>|t|)
## ar1     1.093229    0.052514  20.81800 0.000000
## ar2    -0.594734    0.057622 -10.32136 0.000000
## ma1    -1.190092    0.055136 -21.58470 0.000000
## ma2     0.646880    0.055009  11.75952 0.000000
## ma3    -0.022182    0.009438  -2.35026 0.018760
## omega  -0.050616    0.012757  -3.96778 0.000073
## alpha1  0.021231    0.030537   0.69526 0.486895
## beta1   0.989755    0.001749 565.92523 0.000000
## gamma1  0.477235    0.144280   3.30769 0.000941
## skew    1.038213    0.018638  55.70430 0.000000
## shape   2.133296    0.083319  25.60391 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error    t value Pr(>|t|)
## ar1     1.093229    0.015147   72.17511 0.000000
## ar2    -0.594734    0.034430  -17.27387 0.000000
## ma1    -1.190092    0.021365  -55.70217 0.000000
## ma2     0.646880    0.025863   25.01211 0.000000
## ma3    -0.022182    0.003112   -7.12724 0.000000
## omega  -0.050616    0.011039   -4.58536 0.000005
## alpha1  0.021231    0.035074    0.60533 0.544962
## beta1   0.989755    0.000927 1067.22699 0.000000
## gamma1  0.477235    0.153064    3.11787 0.001822
## skew    1.038213    0.015416   67.34845 0.000000
## shape   2.133296    0.089188   23.91911 0.000000
##
## LogLikelihood : 3276
##
## Information Criteria
## ------------------------------------
##
## Akaike       -3.5665
## Bayes        -3.5334
## Shibata      -3.5666
## Hannan-Quinn -3.5543
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                             statistic   p-value
## Lag[1]                          9.945 0.0016127
## Lag[2*(p+q)+(p+q)-1][14]    17.765 0.0000000
## Lag[4*(p+q)+(p+q)-1][24]    22.843 0.0006195
## d.o.f=5
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
```

```
##                         statistic p-value
## Lag[1]                    0.05165  0.8202
## Lag[2*(p+q)+(p+q)-1][5]   0.34069  0.9793
## Lag[4*(p+q)+(p+q)-1][9]   0.56118  0.9978
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]    0.1586 0.500 2.000  0.6905
## ARCH Lag[5]    0.3912 1.440 1.667  0.9152
## ARCH Lag[7]    0.5003 2.315 1.543  0.9784
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  2.822
## Individual Statistics:
## ar1    0.03724
## ar2    0.10641
## ma1    0.03997
## ma2    0.07425
## ma3    0.05495
## omega  0.49198
## alpha1 0.44894
## beta1  0.46660
## gamma1 0.17413
## skew   0.02746
## shape  0.29907
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          2.49 2.75 3.27
## Individual Statistic:     0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value   prob sig
## Sign Bias          1.40751 0.1594
## Negative Sign Bias 0.07262 0.9421
## Positive Sign Bias 0.94794 0.3433
## Joint Effect       2.61246 0.4553
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     22.03       0.2827
## 2    30     30.03       0.4124
## 3    40     34.58       0.6716
## 4    50     45.76       0.6052
##
##
## Elapsed time : 2.235
```

```r
egarch_1 <- ugarchfit(data = L.ret.NA, spec = egarch_model_1)
print(egarch_1)
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : eGARCH(1,1)
## Mean Model   : ARFIMA(1,0,1)
## Distribution : std
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error   t value Pr(>|t|)
## ar1     0.409123    0.046538   8.79121 0.000000
## ma1    -0.511154    0.044402 -11.51198 0.000000
## omega  -0.049404    0.013878  -3.55976 0.000371
## alpha1  0.024709    0.031375   0.78754 0.430968
## beta1   0.989647    0.001771 558.78039 0.000000
## gamma1  0.501016    0.166799   3.00371 0.002667
## shape   2.122821    0.084405  25.15041 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error   t value Pr(>|t|)
## ar1     0.409123    0.017544   23.3198 0.000000
## ma1    -0.511154    0.019834  -25.7716 0.000000
## omega  -0.049404    0.012059   -4.0969 0.000042
## alpha1  0.024709    0.035862    0.6890 0.490822
## beta1   0.989647    0.000946 1046.1061 0.000000
## gamma1  0.501016    0.167521    2.9908 0.002783
## shape   2.122821    0.084519   25.1164 0.000000
##
## LogLikelihood : 3271
##
## Information Criteria
## ------------------------------------
##
## Akaike       -3.5655
## Bayes        -3.5444
## Shibata      -3.5655
## Hannan-Quinn -3.5577
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic   p-value
## Lag[1]                      11.22 8.076e-04
## Lag[2*(p+q)+(p+q)-1][5]     14.12 0.000e+00
## Lag[4*(p+q)+(p+q)-1][9]     18.47 5.318e-07
## d.o.f=2
## H0 : No serial correlation
##
```

```
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                    0.04778  0.8270
## Lag[2*(p+q)+(p+q)-1][5]   0.32993  0.9805
## Lag[4*(p+q)+(p+q)-1][9]   0.54598  0.9980
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]    0.1580 0.500 2.000  0.6910
## ARCH Lag[5]    0.3792 1.440 1.667  0.9186
## ARCH Lag[7]    0.4877 2.315 1.543  0.9795
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  2.237
## Individual Statistics:
## ar1    0.1651
## ma1    0.1429
## omega  0.4991
## alpha1 0.4149
## beta1  0.4704
## gamma1 0.1772
## shape  0.2939
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          1.69 1.9 2.35
## Individual Statistic:     0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value   prob sig
## Sign Bias          1.31103 0.1900
## Negative Sign Bias 0.08813 0.9298
## Positive Sign Bias 0.90581 0.3652
## Joint Effect       2.30012 0.5125
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     23.67       0.2091
## 2    30     28.10       0.5126
## 3    40     34.23       0.6869
## 4    50     46.47       0.5762
##
##
## Elapsed time : 0.8089
```

APARCH

```
# modelos APARCH
aparch_model <-  ugarchspec(mean.model = list(armaOrder=c(2,3), include.mean=FALSE),
                            variance.model = list(garchOrder=c(1,1), model = "apARCH"),
                            distribution.model = "sstd")

aparch_model_1 <-  ugarchspec(mean.model = list(armaOrder=c(1,1), include.mean=FALSE),
                            variance.model = list(garchOrder=c(1,1), model = "apARCH"),
                            distribution.model = "std")
```

```
aparch <- ugarchfit(data = L.ret.NA, spec = aparch_model)
print(aparch)
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : apARCH(1,1)
## Mean Model   : ARFIMA(2,0,3)
## Distribution : sstd
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error   t value Pr(>|t|)
## ar1     1.490045    0.010041  148.4021 0.000000
## ar2    -0.925236    0.006802 -136.0180 0.000000
## ma1    -1.587411    0.009702 -163.6122 0.000000
## ma2     1.050190    0.000903 1162.8049 0.000000
## ma3    -0.068835    0.000471 -146.1374 0.000000
## omega   0.000810    0.000625    1.2946 0.195443
## alpha1  0.369318    0.079327    4.6556 0.000003
## beta1   0.870284    0.017085   50.9396 0.000000
## gamma1 -0.086774    0.070295   -1.2344 0.217046
## delta   1.064638    0.177068    6.0126 0.000000
## skew    1.036420    0.018746   55.2872 0.000000
## shape   2.155017    0.055971   38.5023 0.000000
##
## Robust Standard Errors:
##         Estimate  Std. Error   t value Pr(>|t|)
## ar1     1.490045    0.006674  223.2668 0.000000
## ar2    -0.925236    0.004219 -219.3119 0.000000
## ma1    -1.587411    0.006180 -256.8725 0.000000
## ma2     1.050190    0.000532 1975.6355 0.000000
## ma3    -0.068835    0.000493 -139.7105 0.000000
## omega   0.000810    0.000787    1.0289 0.303549
## alpha1  0.369318    0.062446    5.9142 0.000000
## beta1   0.870284    0.021934   39.6779 0.000000
## gamma1 -0.086774    0.078401   -1.1068 0.268381
## delta   1.064638    0.236897    4.4941 0.000007
## skew    1.036420    0.015650   66.2265 0.000000
```

```
## shape   2.155017    0.044922   47.9723 0.000000
##
## LogLikelihood : 3281
##
## Information Criteria
## ------------------------------------
##
## Akaike       -3.5703
## Bayes        -3.5342
## Shibata      -3.5704
## Hannan-Quinn -3.5570
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                           statistic  p-value
## Lag[1]                        9.921 0.001634
## Lag[2*(p+q)+(p+q)-1][14]     17.280 0.000000
## Lag[4*(p+q)+(p+q)-1][24]     21.551 0.001900
## d.o.f=5
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                          statistic p-value
## Lag[1]                     0.04334  0.8351
## Lag[2*(p+q)+(p+q)-1][5]    0.30455  0.9832
## Lag[4*(p+q)+(p+q)-1][9]    0.46369  0.9988
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]    0.1194 0.500 2.000  0.7297
## ARCH Lag[5]    0.3273 1.440 1.667  0.9329
## ARCH Lag[7]    0.3872 2.315 1.543  0.9874
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  3.413
## Individual Statistics:
## ar1    0.03886
## ar2    0.07093
## ma1    0.02641
## ma2    0.14153
## ma3    0.35497
## omega  0.35903
## alpha1 0.30880
## beta1  0.35009
## gamma1 0.83875
## delta  0.36986
## skew   0.03924
## shape  0.39200
##
## Asymptotic Critical Values (10% 5% 1%)
```

```
## Joint Statistic:          2.69 2.96 3.51
## Individual Statistic:     0.35 0.47 0.75
##
## Sign Bias Test
## -----------------------------------
##                    t-value   prob sig
## Sign Bias           1.2350 0.2170
## Negative Sign Bias  0.3101 0.7565
## Positive Sign Bias  1.1607 0.2459
## Joint Effect        2.7027 0.4398
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     17.88       0.5304
## 2    30     28.33       0.5004
## 3    40     33.18       0.7317
## 4    50     42.59       0.7289
##
##
## Elapsed time : 38.45
```

```r
aparch_1 <- ugarchfit(data = L.ret.NA, spec = aparch_model_1)
print(aparch_1)
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : apARCH(1,1)
## Mean Model   : ARFIMA(1,0,1)
## Distribution : std
##
## Optimal Parameters
## ------------------------------------
##         Estimate  Std. Error  t value Pr(>|t|)
## ar1     0.423658    0.033768  12.5463  0.00000
## ma1    -0.519937    0.031749 -16.3766  0.00000
## omega   0.001214    0.000814   1.4918  0.13576
## alpha1  0.461968    0.077530   5.9586  0.00000
## beta1   0.864629    0.018410  46.9644  0.00000
## gamma1 -0.080628    0.067559  -1.1934  0.23270
## delta   1.033309    0.163287   6.3282  0.00000
## shape   2.100000    0.005459 384.6814  0.00000
##
## Robust Standard Errors:
##         Estimate  Std. Error   t value Pr(>|t|)
## ar1     0.423658    0.011573   36.6080 0.000000
## ma1    -0.519937    0.011978  -43.4064 0.000000
## omega   0.001214    0.000937    1.2961 0.194951
## alpha1  0.461968    0.092072    5.0175 0.000001
```

```
## beta1   0.864629    0.024993   34.5955 0.000000
## gamma1 -0.080628    0.075025   -1.0747 0.282518
## delta   1.033309    0.187213    5.5194 0.000000
## shape   2.100000    0.000781 2687.5415 0.000000
##
## LogLikelihood : 3274
##
## Information Criteria
## ------------------------------------
##
## Akaike       -3.5677
## Bayes        -3.5436
## Shibata      -3.5678
## Hannan-Quinn -3.5588
##
## Weighted Ljung-Box Test on Standardized Residuals
## ------------------------------------
##                         statistic   p-value
## Lag[1]                      12.17 4.863e-04
## Lag[2*(p+q)+(p+q)-1][5]     15.46 0.000e+00
## Lag[4*(p+q)+(p+q)-1][9]     20.60 3.423e-08
## d.o.f=2
## H0 : No serial correlation
##
## Weighted Ljung-Box Test on Standardized Squared Residuals
## ------------------------------------
##                         statistic p-value
## Lag[1]                    0.03741  0.8466
## Lag[2*(p+q)+(p+q)-1][5]   0.30139  0.9836
## Lag[4*(p+q)+(p+q)-1][9]   0.47158  0.9987
## d.o.f=2
##
## Weighted ARCH LM Tests
## ------------------------------------
##             Statistic Shape Scale P-Value
## ARCH Lag[3]    0.1264 0.500 2.000  0.7222
## ARCH Lag[5]    0.3432 1.440 1.667  0.9286
## ARCH Lag[7]    0.4099 2.315 1.543  0.9858
##
## Nyblom stability test
## ------------------------------------
## Joint Statistic:  2.903
## Individual Statistics:
## ar1    0.09294
## ma1    0.08483
## omega  0.38196
## alpha1 0.31939
## beta1  0.34788
## gamma1 0.80636
## delta  0.28197
## shape  0.38697
##
## Asymptotic Critical Values (10% 5% 1%)
## Joint Statistic:          1.89 2.11 2.59
```

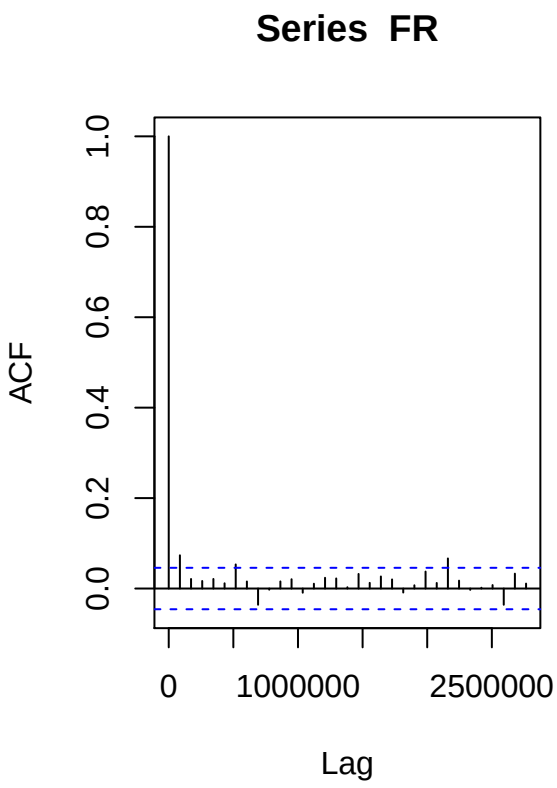
```
## Individual Statistic:     0.35 0.47 0.75
##
## Sign Bias Test
## ------------------------------------
##                    t-value   prob sig
## Sign Bias           1.2368 0.2163
## Negative Sign Bias  0.2973 0.7663
## Positive Sign Bias  1.1315 0.2580
## Joint Effect        2.6342 0.4515
##
##
## Adjusted Pearson Goodness-of-Fit Test:
## ------------------------------------
##   group statistic p-value(g-1)
## 1    20     30.44      0.04644
## 2    30     35.28      0.19564
## 3    40     56.12      0.03721
## 4    50     51.33      0.38244
##
##
## Elapsed time : 15.06
```

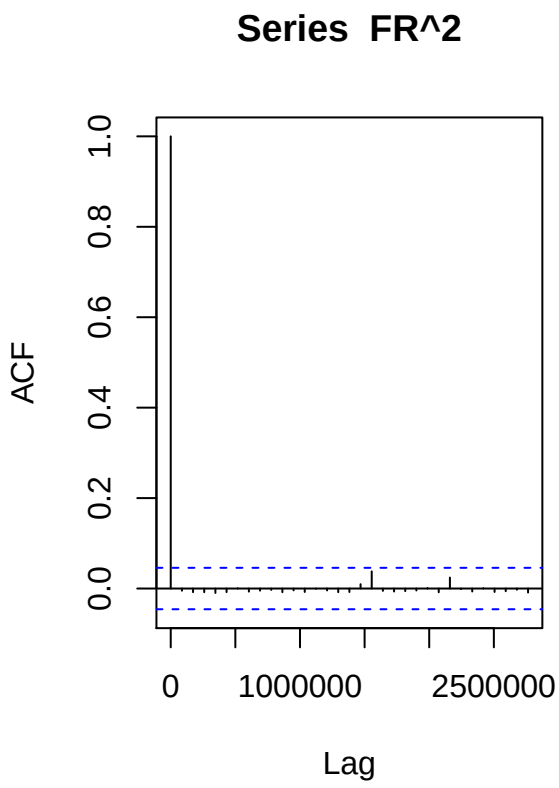
Melhor modelo pelo critério AKAIKE ARMA (2,3) APARCH (1,1)

Avaliando o modelo

```
FR=residuals(aparch, standardize=TRUE)

# ACF
par(mfrow=c(1,2))
acf(FR)
acf(FR^2)
```






```
# estacionáridade dos resíduos
adf.test(FR)
```

```
## Warning in adf.test(FR): p-value smaller than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  FR
## Dickey-Fuller = -11, Lag order = 12, p-value = 0.01
## alternative hypothesis: stationary
```

```
kpss.test(FR, null="Trend")
```

```
## Warning in kpss.test(FR, null = "Trend"): p-value greater than printed p-value
```

```
##
##  KPSS Test for Trend Stationarity
##
## data:  FR
## KPSS Trend = 0.078, Truncation lag parameter = 8, p-value = 0.1
```

```
# normalidade dos resíduos
jarque.bera.test(FR)
```

```
##
##  Jarque Bera Test
##
## data:  FR
```

```
## X-squared = 329372, df = 2, p-value <2e-16
```

```
#testes Box Pierce Ljung Box nos resíduos
Box.test(FR, lag = 5)
```

```
##
##  Box-Pierce test
##
## data:  FR
## X-squared = 12, df = 5, p-value = 0.03
```

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

```
##
##  Box-Pierce test
##
## data:  FR
## X-squared = 21, df = 10, p-value = 0.02
```

```
Box.test(FR, lag = 50)
```

```
##
##  Box-Pierce test
##
## data:  FR
## X-squared = 53, df = 50, p-value = 0.3
```

```
# qq plot dos resíduos
qqnorm(FR); qqline(FR, col="red")
```