

GARCH parameters and quantiles estimation

Jose Augusto Fiorucci

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Input

```
symbol = "BAC"
from=as.Date('2000-01-01')
to=as.Date('2017-12-31')
C_Trend = 0.95
C_Reaction = 0.50
```

Data download

```
x <- getSymbols.yahoo(symbol,auto.assign = FALSE, from=from, to=to)
```

High and Low

```
H <- Hi(x)
L <- Lo(x)
C <- Cl(x)
plot(cbind(H,L))
```

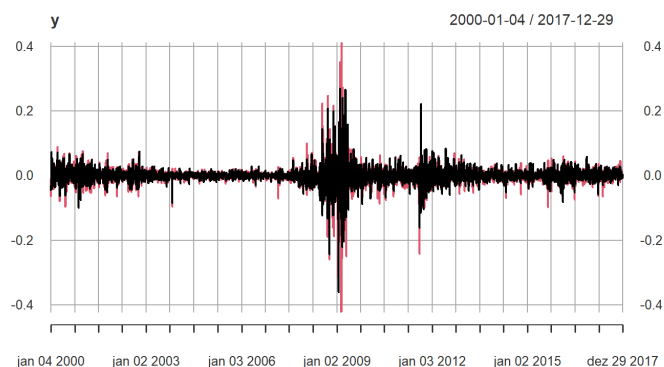


Returns

```
y <- cbind( diff(log(H)), diff(log(L)) )
y <- na.omit(y)
y %>% cor() # Returns correlation
```

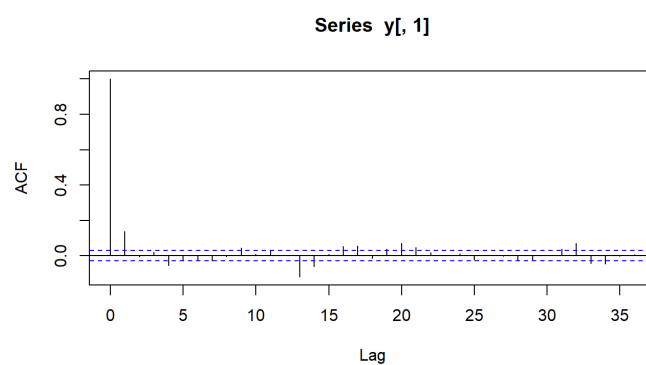
```
##          BAC.High  BAC.Low
## BAC.High 1.0000000 0.7829247
## BAC.Low  0.7829247 1.0000000
```

```
plot(y)
```

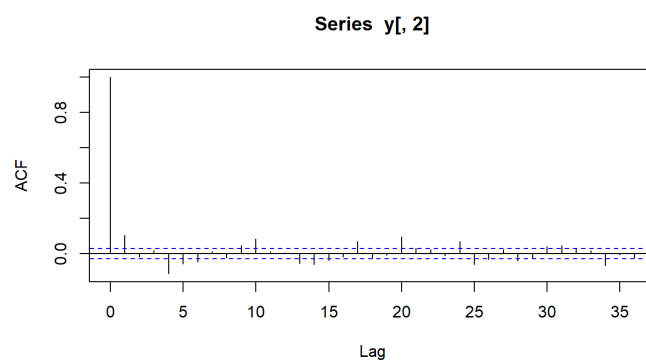


Autocorrelation

```
acf(y[,1])
```

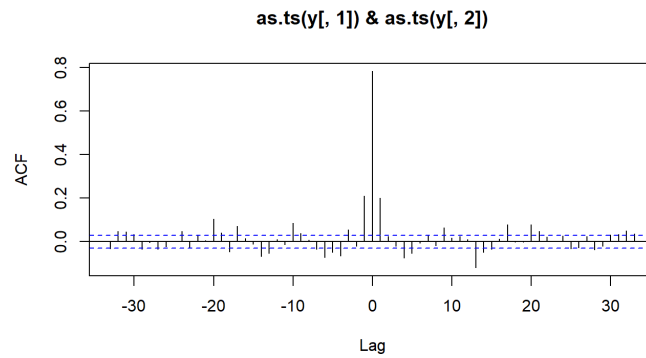


```
acf(y[,2])
```



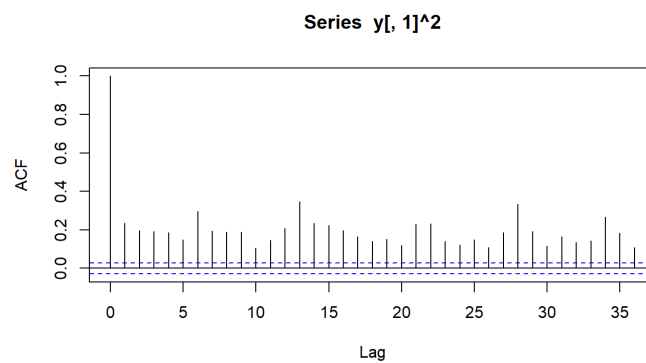
Cross correlation

```
ccf(as.ts(y[,1]),as.ts(y[,2]))
```

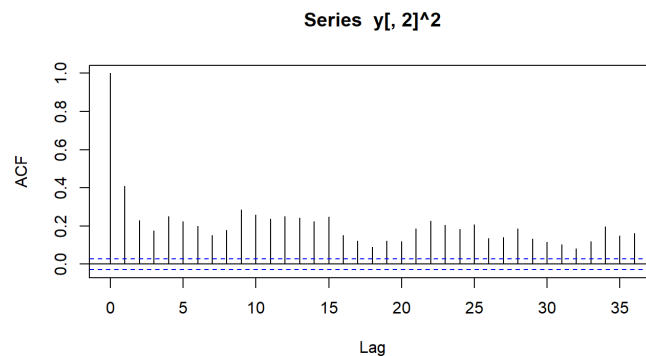


Volatility verification

```
acf(y[,1]^2)
```



```
acf(y[,2]^2)
```



Bivariate DCC-GARCH

We will consider the DCC-GARCH to model the volatility of $y = (r_H, r_L)'$, where r_H and r_L denote the $100 \times \log$ -returns from high's and low's observations.

```
# returns
mY <- 100*y

# generates the Markov Chain
start <- Sys.time()

out <- bayesDccGarch(mY, control=list(print=FALSE, nPilotSim=3000))
```

```
## Maximizing the log-posterior density function.
## Done.
## One approximation for covariance matrix of parameters cannot be directly computed through
the hessian matrix.
## Calibrating the standard deviations for simulation:
## Accept Rate:
##  phi_1  phi_2  phi_3  phi_4  phi_5  phi_6  phi_7  phi_8  phi_9  phi_10  phi_11
##   0.32   0.09   0.23   0.04   0.06   0.10   0.20   0.06   0.08   0.28   0.60
## Accept Rate:
##  phi_1  phi_2  phi_3  phi_4  phi_5  phi_6  phi_7  phi_8  phi_9  phi_10  phi_11
##   0.31   0.18   0.24   0.06   0.09   0.19   0.22   0.08   0.13   0.32   0.50
## Accept Rate:
##  phi_1  phi_2  phi_3  phi_4  phi_5  phi_6  phi_7  phi_8  phi_9  phi_10  phi_11
##   0.31   0.16   0.23   0.08   0.13   0.18   0.23   0.14   0.22   0.32   0.40
## Accept Rate:
##  phi_1  phi_2  phi_3  phi_4  phi_5  phi_6  phi_7  phi_8  phi_9  phi_10  phi_11
##   0.31   0.17   0.23   0.14   0.23   0.19   0.21   0.23   0.22   0.32   0.41
## Accept Rate:
##  phi_1  phi_2  phi_3  phi_4  phi_5  phi_6  phi_7  phi_8  phi_9  phi_10  phi_11
##   0.33   0.16   0.26   0.25   0.23   0.16   0.24   0.23   0.22   0.32   0.41
## Computing the covariance matrix of pilot sample.
```

```
## Warning in if (class(control$cholCov) != "try-error") {: a condição tem
## comprimento > 1 e somente o primeiro elemento será usado
```

```
## Done.
## Calibrating the Lambda coefficient:
## lambda: 0.4
## Accept Rate: 0.45
## Done.
## Starting the simulation by one-block random walk Metropolis-Hasting algorithm.
## Done.
```

```
out2 <- increaseSim(out, nSim=50000)
```

```
## Calibrating the Lambda coefficient:
## lambda: 0.4
## Accept Rate: 0.46
## Done.
## Starting the simulation by one-block random walk Metropolis-Hasting algorithm.
## Done.
```

```
out <- window(out2, start=20000, thin=10)
rm(out2)

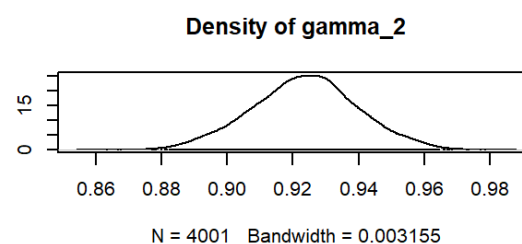
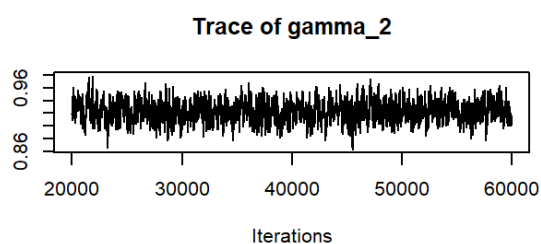
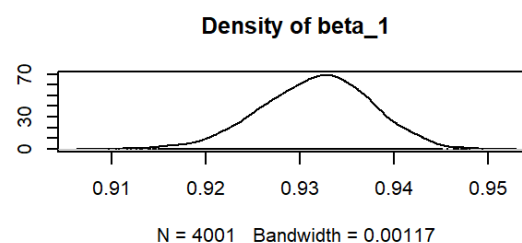
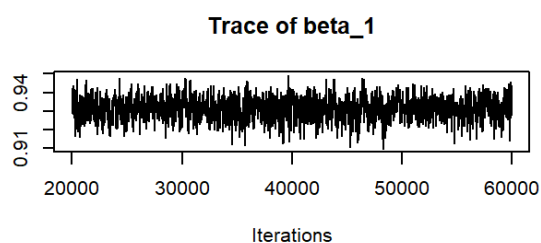
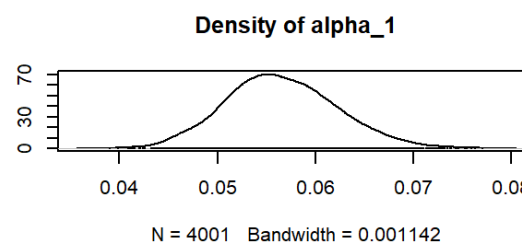
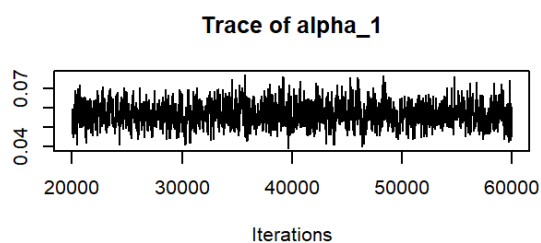
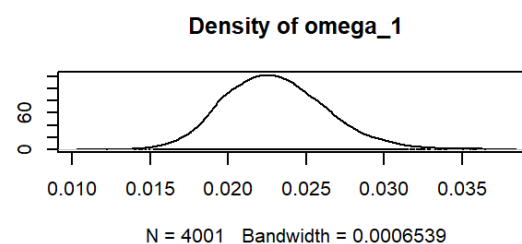
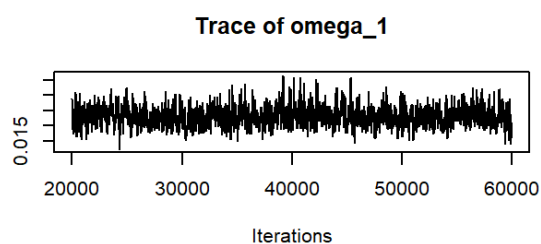
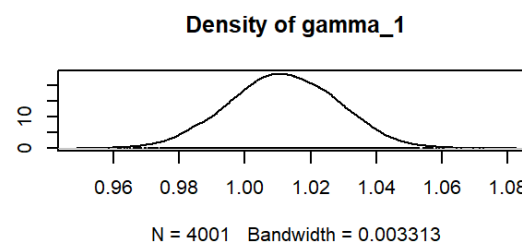
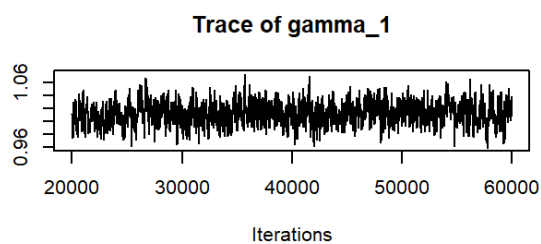
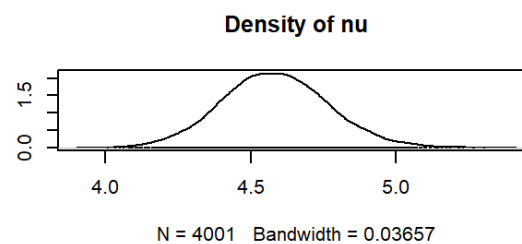
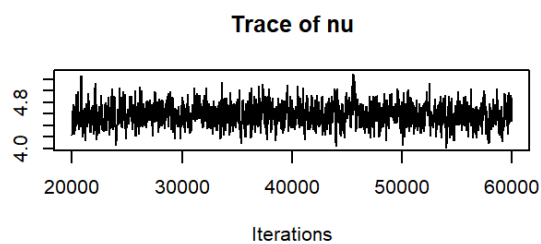
end <- Sys.time()

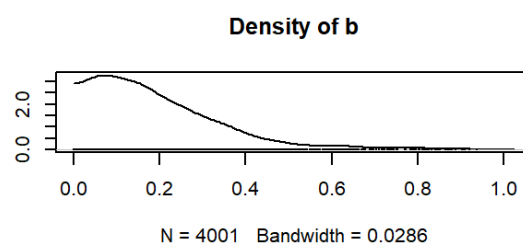
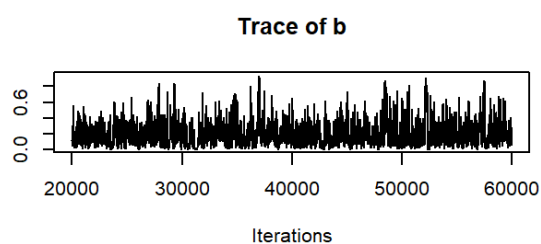
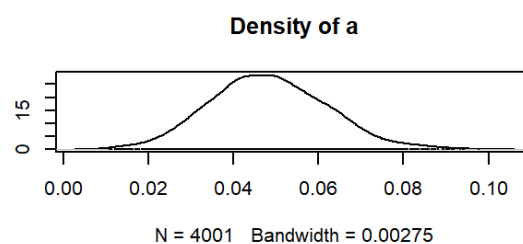
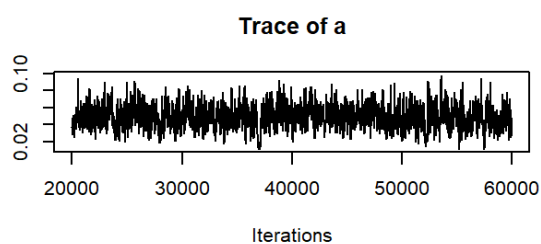
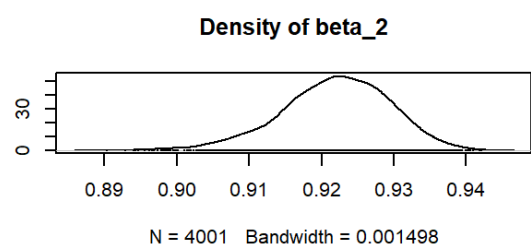
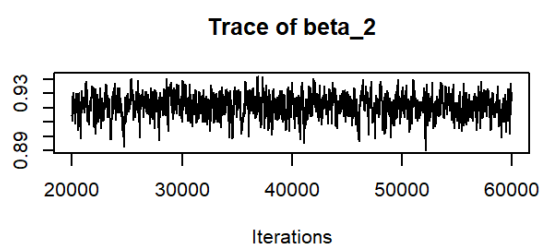
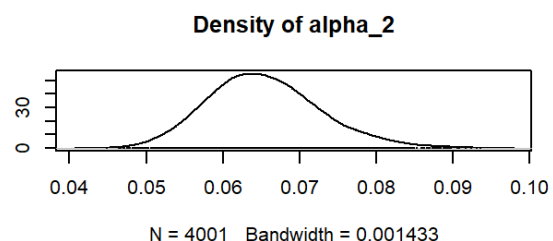
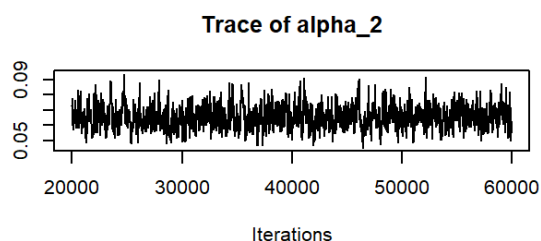
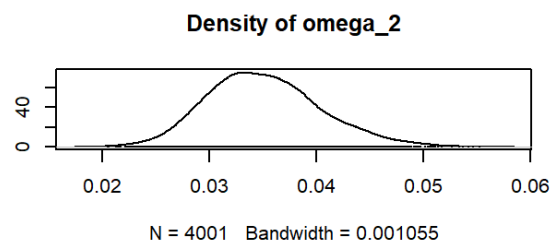
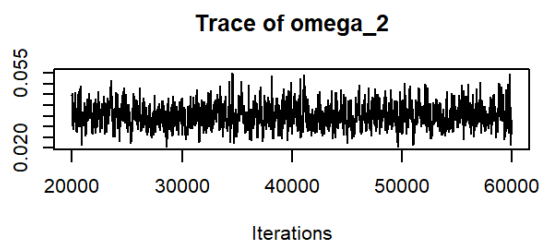
# elapsed time
end-start
```

```
## Time difference of 10.52597 mins
```

```
## Estimative of parameters
parEst <- summary(out)$statistics[, 'Mean']

# plot Markov Chain
plot(out$MC)
```





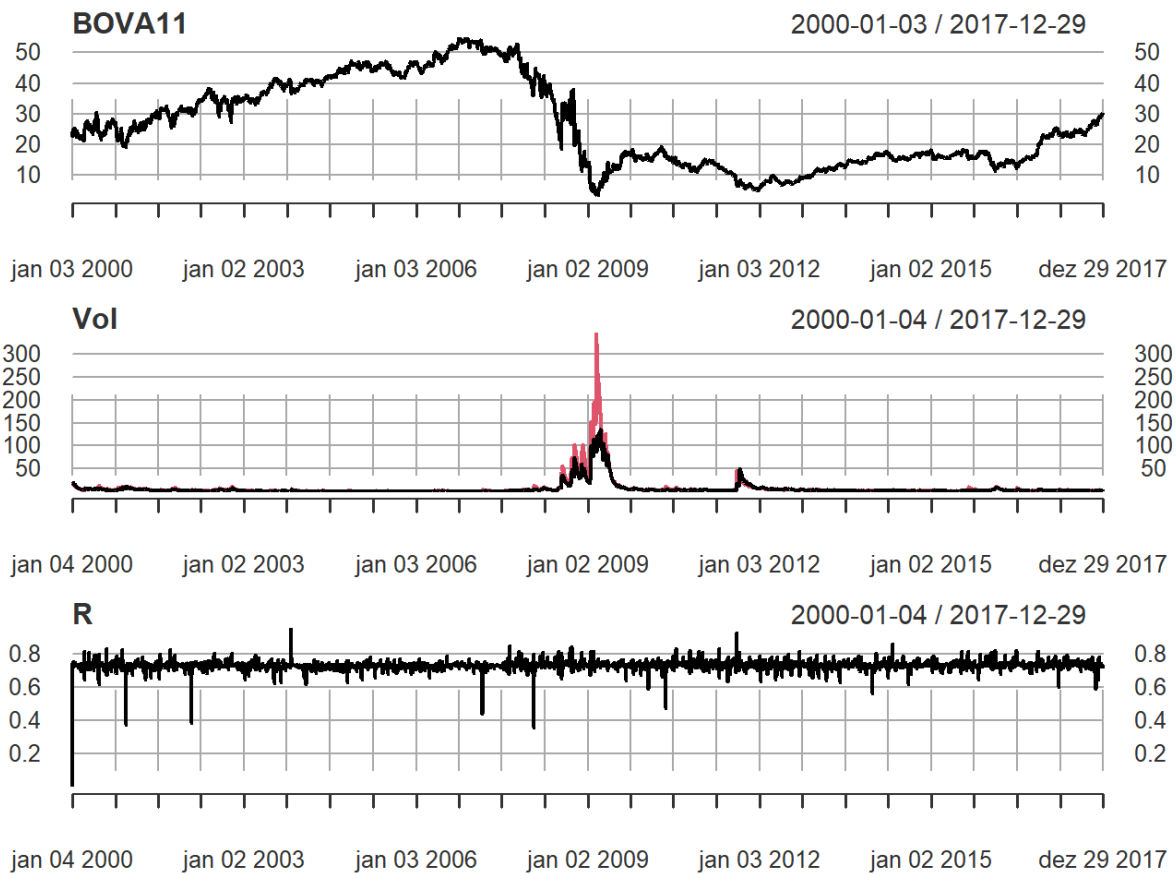
```
## Estimative of parameters
out$MC %>% summary()
```

```
##
## Iterations = 20000:60000
## Thinning interval = 10
## Number of chains = 1
## Sample size per chain = 4001
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##          Mean          SD Naive SE Time-series SE
## nu      4.58306 0.182681 2.888e-03    0.0075954
## gamma_1 1.01167 0.016418 2.596e-04    0.0006886
## omega_1 0.02303 0.003244 5.129e-05    0.0001350
## alpha_1 0.05652 0.005660 8.948e-05    0.0002192
## beta_1  0.93165 0.005798 9.166e-05    0.0002082
## gamma_2 0.92355 0.016016 2.532e-04    0.0006423
## omega_2 0.03508 0.005228 8.264e-05    0.0002346
## alpha_2 0.06536 0.007312 1.156e-04    0.0003176
## beta_2  0.92187 0.007504 1.186e-04    0.0003525
## a       0.04823 0.013645 2.157e-04    0.0005587
## b       0.19433 0.153402 2.425e-03    0.0063016
##
## 2. Quantiles for each variable:
##
##          2.5%      25%      50%      75%      97.5%
## nu      4.23631 4.46055 4.57974 4.70340 4.95607
## gamma_1 0.97994 1.00069 1.01163 1.02308 1.04322
## omega_1 0.01732 0.02075 0.02284 0.02509 0.02999
## alpha_1 0.04607 0.05259 0.05619 0.06018 0.06843
## beta_1  0.91979 0.92783 0.93190 0.93569 0.94249
## gamma_2 0.89143 0.91308 0.92382 0.93404 0.95508
## omega_2 0.02584 0.03136 0.03475 0.03838 0.04648
## alpha_2 0.05229 0.06034 0.06487 0.06985 0.08123
## beta_2  0.90551 0.91721 0.92235 0.92716 0.93535
## a       0.02296 0.03902 0.04772 0.05728 0.07641
## b       0.01096 0.07964 0.15989 0.26957 0.60568
```

```
## Conditional Correlation
R <- xts(out$R[,2], order.by=index(y))

## Volatility
Vol <- xts(out$H[,c("H_1,1", "H_2,2")], order.by=index(y))

par(mfrow=c(3,1))
plot(C, main="BOVA11")
plot(Vol)
plot(R, main="R")
```



```
## Standard Residuals
```

```
r <- mY / sqrt(Vol)
```

```
par(mfrow=c(3,2))
```

```
plot(r[,1], main="e_H")
```

```
plot(r[,2], main="e_L")
```

```
acf(r[,1]^2, main="e_H^2")
```

```
acf(r[,2]^2, main="e_L^2")
```

```
r1 <- as.numeric(r[,1])
```

```
x <- rsstd(2000, mean = 0, sd = 1, nu = parEst['nu'], xi =parEst['gamma_1'])
```

```
qqplot(x=x, y=r1, xlim=c(-5, 5), ylim=c(-5, 5), ylab="e_H",xlab="sstd")
```

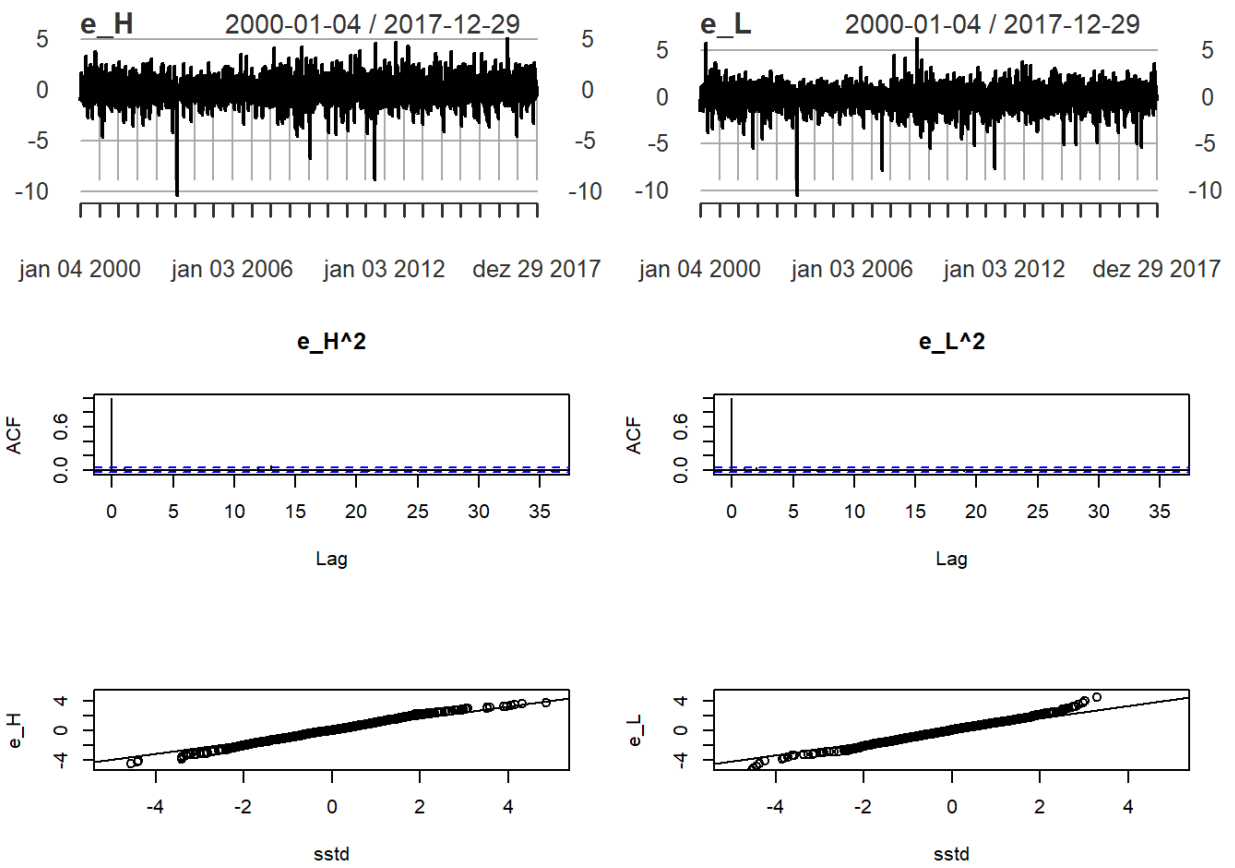
```
qqline(r1)
```

```
r2 <- as.numeric(r[,2])
```

```
x <- rsstd(2000, mean = 0, sd = 1, nu = parEst['nu'], xi =parEst['gamma_2'])
```

```
qqplot(x=x, y=r2 , xlim=c(-5, 5), ylim=c(-5, 5), ylab="e_L",xlab="sstd" )
```

```
qqline(r2)
```

```

# Prepare input for the expert advisor

## High
#HBOP
High_UB_HBOP = qstd(p=1-(1-C_Trend)/2, mean = 0, sd = 1, nu = parEst['nu'], xi = parEst['gamma_1'])
#S1
High_UB_S1 = qstd(p=1-(1-C_Reaction)/2, mean = 0, sd = 1, nu = parEst['nu'], xi = parEst['gamma_1'])

## Low
#B1
Low_LB_B1 = qstd(p=(1-C_Reaction)/2, mean = 0, sd = 1, nu = parEst['nu'], xi = parEst['gamma_2'])
#LBOP
Low_LB_LBOP = qstd(p=(1-C_Trend)/2, mean = 0, sd = 1, nu = parEst['nu'], xi = parEst['gamma_2'])

pH <- c(0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 0.975, 0.99, 0.995)
qH <- round(qstd(p=pH, mean = 0, sd = 1, nu = parEst['nu'], xi = parEst['gamma_1']),3)
names(qH) <- paste0(100*pH,"%")
pL <- 1 - pH
qL <- round(qstd(p=pL, mean = 0, sd = 1, nu = parEst['nu'], xi = parEst['gamma_2']),3)
names(qL) <- paste0(100*pL,"%")

qC <- rbind(qH, qL)
rownames(qC) <- c("High_UB", "Low_LB")
colnames(qC) <- paste0(100*pL,"%")

m = matrix(NA,nrow=10,ncol=1)
rownames(m) = c("High_UB_HBOP","High_UB_S1","Low_LB_B1","Low_LB_LBOP",
               "High_omega", "High_alpha","High_beta",
               "Low_omega", "Low_alpha", "Low_beta" )
colnames(m) = 'Value'

m["High_UB_HBOP",1] = High_UB_HBOP
m["High_UB_S1",1] = High_UB_S1
m["Low_LB_B1",1] = Low_LB_B1
m["Low_LB_LBOP",1] = Low_LB_LBOP

m["High_omega",1] = parEst["omega_1"]
m["High_alpha",1] = parEst["alpha_1"]
m["High_beta",1] = parEst["beta_1"]

m["Low_omega",1] = parEst["omega_2"]
m["Low_alpha",1] = parEst["alpha_2"]
m["Low_beta",1] = parEst["beta_2"]

# Input for expert advisor
print(qC)

```

	40%	35%	30%	25%	20%	15%	10%	5%	2.5%	1%
High_UB	0.197	0.304	0.419	0.547	0.695	0.877	1.126	1.552	1.998	2.647
Low_LB	-0.169	-0.279	-0.398	-0.531	-0.687	-0.879	-1.144	-1.597	-2.075	-2.773
	0.5%									
High_UB	3.203									
Low_LB	-3.371									

```
print(round(m,3))
```

	Value
High_UB_HBOP	1.998
High_UB_S1	0.547
Low_LB_B1	-0.531
Low_LB_LBOP	-2.075
High_omega	0.023
High_alpha	0.057
High_beta	0.932
Low_omega	0.035
Low_alpha	0.065
Low_beta	0.922