Envelope Simulado e Erro Quadrático Médio

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Envelope Simulado - Atividade 01

```
## Carregamento dos pacotes necessários

rm(list=ls(all=TRUE))
# install.packages("sn")
# install.packages("fGarch")
# install.packages("hnp")

require (sn)
```

```
## Carregando pacotes exigidos: sn
```

```
## Carregando pacotes exigidos: stats4
```

```
##
## Attaching package: 'sn'
```

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

```
require (fGarch)
```

```
## Carregando pacotes exigidos: fGarch
```

```
## Carregando pacotes exigidos: timeDate
```

```
## Carregando pacotes exigidos: timeSeries
```

```
## Carregando pacotes exigidos: fBasics
```

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

```
## The following objects are masked from 'package:sn':
##
##     tr, vech
```

```
require (hnp)
```

```
## Carregando pacotes exigidos: hnp
```

```
## Carregando pacotes exigidos: MASS
```

```
require(gamlss)
```

```
## Carregando pacotes exigidos: gamlss
```

```
## Carregando pacotes exigidos: splines
## Carregando pacotes exigidos: gamlss.data
##
## Attaching package: 'gamlss.data'
## The following object is masked from 'package:datasets':
##
##     sleep
## Carregando pacotes exigidos: gamlss.dist
## Carregando pacotes exigidos: nlme
## Carregando pacotes exigidos: parallel
##  **********   GAMLSS Version 5.3-4  **********
## For more on GAMLSS look at https://www.gamlss.com/
## Type gamlssNews() to see new features/changes/bug fixes.
```

```
## Definição do workdir e leitura dos dados de interesse
setwd("~/")
dados = read.table("~/apps/esquema_fatorial/A_FatCruz_ex2.txt", header = TRUE)
y = dados$Y
y
```

```
##  [1] 42.9 41.6 28.9 30.8 41.7 53.8 58.5 43.9 46.3 55.2 49.5 53.8 40.7 39.4 50.8
## [16] 53.3 65.6 45.4 35.1 51.4 57.6 69.6 42.4 51.9 56.3 59.8 65.8 41.4 45.4 60.0
## [31] 61.5 60.9 51.1 55.4 60.5 67.4 63.2 58.7 59.3 66.1
```

```
# Montagem do modelo
m1 = gamlss(y ~ 1, family = "NO", data = dados)
```

```
## GAMLSS-RS iteration 1: Global Deviance = 298.5526
## GAMLSS-RS iteration 2: Global Deviance = 298.5526
```

```
summary(m1)
```

```
## ******************************************************************
## Family:  c("NO", "Normal")
##
## Call:  gamlss(formula = y ~ 1, family = "NO", data = dados)
##
## Fitting method: RS()
##
## ------------------------------------------------------------------
## Mu link function:  identity
## Mu Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   52.073      1.598   32.59   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## ------------------------------------------------------------------
## Sigma link function:  log
## Sigma Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2.3130     0.1118   20.69   <2e-16 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## ------------------------------------------------------------------
## No. of observations in the fit:  40
## Degrees of Freedom for the fit:  2
##       Residual Deg. of Freedom:  38
##                       at cycle:  2
##
## Global Deviance:     298.5526
##             AIC:     302.5526
##             SBC:     305.9304
## ******************************************************************
```

```
# Captura dos residuos do modelo
r = residuals(m1)
shapiro.test(r)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  r
## W = 0.97008, p-value = 0.3621
```

```
res_quant <- function(obj){
  qnorm(pNO(q     = obj$y,
            mu    = obj$mu.fv,
            sigma = obj$sigma.fv))
}
```

```
d.fun <- function(obj) res_quant(obj) # this is the default if no
```

```
s.fun <- function(n, obj) {
  mu <- obj$mu.fv
  sig <- obj$sigma.fv
  rNO(n, mu=mu, sigma=sig)
}
```

```
my.data <- data.frame(y)
f.fun <- function(y.) gamlss(y. ~ 1, family= "NO", data=my.data)
```

```
# motagem do envelope simulado
my.hnp <- hnp(m1,newclass=TRUE, diagfun=d.fun, simfun=s.fun,
              fitfun=f.fun,halfnormal = F, print.on=TRUE, plot=FALSE, data=my.data)
```

```
## GAMLSS-RS iteration 1: Global Deviance = 302.4581
## GAMLSS-RS iteration 2: Global Deviance = 302.4581
## GAMLSS-RS iteration 1: Global Deviance = 288.1812
## GAMLSS-RS iteration 2: Global Deviance = 288.1812
## GAMLSS-RS iteration 1: Global Deviance = 302.9334
## GAMLSS-RS iteration 2: Global Deviance = 302.9334
## GAMLSS-RS iteration 1: Global Deviance = 291.3403
## GAMLSS-RS iteration 2: Global Deviance = 291.3403
## GAMLSS-RS iteration 1: Global Deviance = 295.3505
## GAMLSS-RS iteration 2: Global Deviance = 295.3505
## GAMLSS-RS iteration 1: Global Deviance = 280.6735
## GAMLSS-RS iteration 2: Global Deviance = 280.6735
```

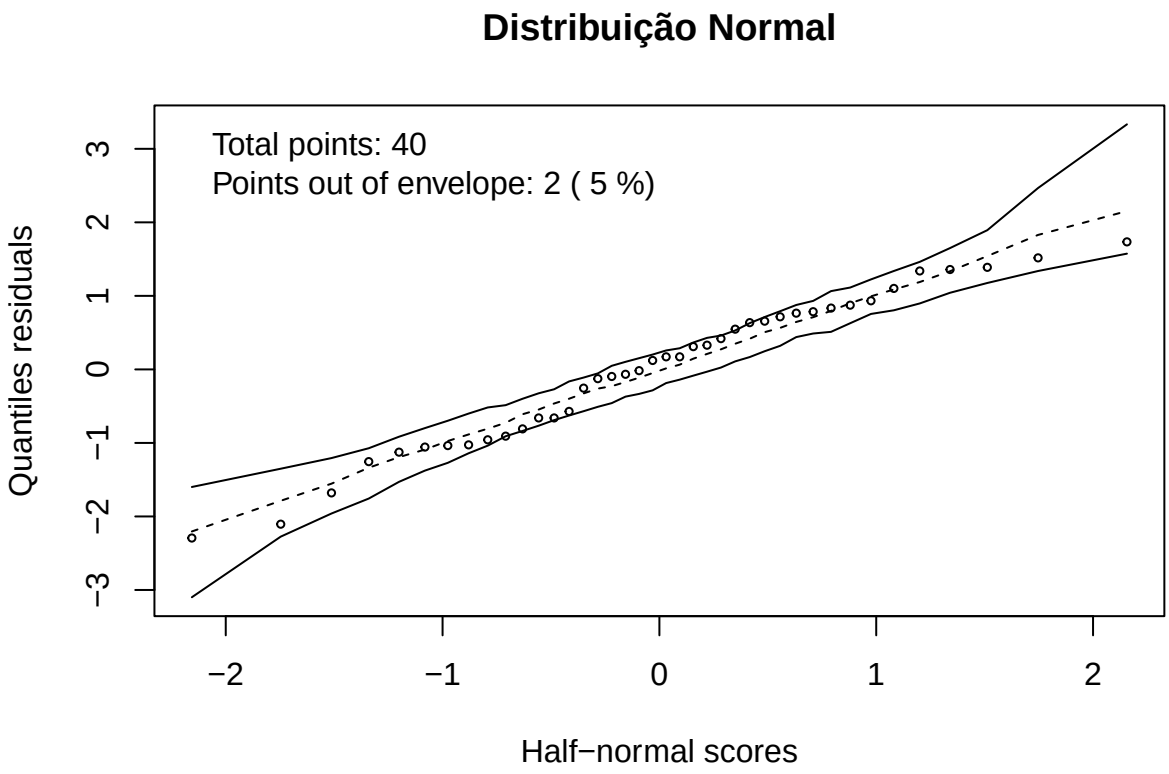
```
## GAMLSS-RS iteration 1: Global Deviance = 303.187
## GAMLSS-RS iteration 2: Global Deviance = 303.187
## GAMLSS-RS iteration 1: Global Deviance = 297.3623
## GAMLSS-RS iteration 2: Global Deviance = 297.3623
## GAMLSS-RS iteration 1: Global Deviance = 305.3065
## GAMLSS-RS iteration 2: Global Deviance = 305.3065
## GAMLSS-RS iteration 1: Global Deviance = 293.2618
## GAMLSS-RS iteration 2: Global Deviance = 293.2618
## GAMLSS-RS iteration 1: Global Deviance = 290.8647
## GAMLSS-RS iteration 2: Global Deviance = 290.8647
## GAMLSS-RS iteration 1: Global Deviance = 288.0745
## GAMLSS-RS iteration 2: Global Deviance = 288.0745
## GAMLSS-RS iteration 1: Global Deviance = 290.1778
## GAMLSS-RS iteration 2: Global Deviance = 290.1778
## GAMLSS-RS iteration 1: Global Deviance = 297.3815
## GAMLSS-RS iteration 2: Global Deviance = 297.3815
## GAMLSS-RS iteration 1: Global Deviance = 279.8533
## GAMLSS-RS iteration 2: Global Deviance = 279.8533
## GAMLSS-RS iteration 1: Global Deviance = 302.1837
## GAMLSS-RS iteration 2: Global Deviance = 302.1837
## GAMLSS-RS iteration 1: Global Deviance = 289.8833
## GAMLSS-RS iteration 2: Global Deviance = 289.8833
## GAMLSS-RS iteration 1: Global Deviance = 285.4218
## GAMLSS-RS iteration 2: Global Deviance = 285.4218
## GAMLSS-RS iteration 1: Global Deviance = 317.5049
## GAMLSS-RS iteration 2: Global Deviance = 317.5049
## GAMLSS-RS iteration 1: Global Deviance = 288.7582
## GAMLSS-RS iteration 2: Global Deviance = 288.7582
## GAMLSS-RS iteration 1: Global Deviance = 298.869
## GAMLSS-RS iteration 2: Global Deviance = 298.869
## GAMLSS-RS iteration 1: Global Deviance = 301.2749
## GAMLSS-RS iteration 2: Global Deviance = 301.2749
## GAMLSS-RS iteration 1: Global Deviance = 304.5624
## GAMLSS-RS iteration 2: Global Deviance = 304.5624
## GAMLSS-RS iteration 1: Global Deviance = 296.613
## GAMLSS-RS iteration 2: Global Deviance = 296.613
## GAMLSS-RS iteration 1: Global Deviance = 299.3463
## GAMLSS-RS iteration 2: Global Deviance = 299.3463
## GAMLSS-RS iteration 1: Global Deviance = 296.7617
## GAMLSS-RS iteration 2: Global Deviance = 296.7617
## GAMLSS-RS iteration 1: Global Deviance = 297.6742
## GAMLSS-RS iteration 2: Global Deviance = 297.6742
## GAMLSS-RS iteration 1: Global Deviance = 295.5657
## GAMLSS-RS iteration 2: Global Deviance = 295.5657
## GAMLSS-RS iteration 1: Global Deviance = 296.0113
## GAMLSS-RS iteration 2: Global Deviance = 296.0113
## GAMLSS-RS iteration 1: Global Deviance = 291.2782
## GAMLSS-RS iteration 2: Global Deviance = 291.2782
## GAMLSS-RS iteration 1: Global Deviance = 293.0338
## GAMLSS-RS iteration 2: Global Deviance = 293.0338
## GAMLSS-RS iteration 1: Global Deviance = 277.9363
## GAMLSS-RS iteration 2: Global Deviance = 277.9363
## GAMLSS-RS iteration 1: Global Deviance = 298.2057
## GAMLSS-RS iteration 2: Global Deviance = 298.2057
```

```
## GAMLSS-RS iteration 1: Global Deviance = 292.6839
## GAMLSS-RS iteration 2: Global Deviance = 292.6839
## GAMLSS-RS iteration 1: Global Deviance = 291.7926
## GAMLSS-RS iteration 2: Global Deviance = 291.7926
## GAMLSS-RS iteration 1: Global Deviance = 288.3815
## GAMLSS-RS iteration 2: Global Deviance = 288.3815
## GAMLSS-RS iteration 1: Global Deviance = 308.5734
## GAMLSS-RS iteration 2: Global Deviance = 308.5734
## GAMLSS-RS iteration 1: Global Deviance = 282.5987
## GAMLSS-RS iteration 2: Global Deviance = 282.5987
## GAMLSS-RS iteration 1: Global Deviance = 303.3431
## GAMLSS-RS iteration 2: Global Deviance = 303.3431
## GAMLSS-RS iteration 1: Global Deviance = 299.1551
## GAMLSS-RS iteration 2: Global Deviance = 299.1551
## GAMLSS-RS iteration 1: Global Deviance = 300.0229
## GAMLSS-RS iteration 2: Global Deviance = 300.0229
## GAMLSS-RS iteration 1: Global Deviance = 294.1601
## GAMLSS-RS iteration 2: Global Deviance = 294.1601
## GAMLSS-RS iteration 1: Global Deviance = 292.1494
## GAMLSS-RS iteration 2: Global Deviance = 292.1494
## GAMLSS-RS iteration 1: Global Deviance = 294.6416
## GAMLSS-RS iteration 2: Global Deviance = 294.6416
## GAMLSS-RS iteration 1: Global Deviance = 295.0176
## GAMLSS-RS iteration 2: Global Deviance = 295.0176
## GAMLSS-RS iteration 1: Global Deviance = 321.4423
## GAMLSS-RS iteration 2: Global Deviance = 321.4423
## GAMLSS-RS iteration 1: Global Deviance = 297.0948
## GAMLSS-RS iteration 2: Global Deviance = 297.0948
## GAMLSS-RS iteration 1: Global Deviance = 291.09
## GAMLSS-RS iteration 2: Global Deviance = 291.09
## GAMLSS-RS iteration 1: Global Deviance = 285.5348
## GAMLSS-RS iteration 2: Global Deviance = 285.5348
## GAMLSS-RS iteration 1: Global Deviance = 290.3079
## GAMLSS-RS iteration 2: Global Deviance = 290.3079
## GAMLSS-RS iteration 1: Global Deviance = 292.0814
## GAMLSS-RS iteration 2: Global Deviance = 292.0814
## GAMLSS-RS iteration 1: Global Deviance = 306.2712
## GAMLSS-RS iteration 2: Global Deviance = 306.2712
## GAMLSS-RS iteration 1: Global Deviance = 306.2488
## GAMLSS-RS iteration 2: Global Deviance = 306.2488
## GAMLSS-RS iteration 1: Global Deviance = 282.7688
## GAMLSS-RS iteration 2: Global Deviance = 282.7688
## GAMLSS-RS iteration 1: Global Deviance = 304.4521
## GAMLSS-RS iteration 2: Global Deviance = 304.4521
## GAMLSS-RS iteration 1: Global Deviance = 293.3642
## GAMLSS-RS iteration 2: Global Deviance = 293.3642
## GAMLSS-RS iteration 1: Global Deviance = 294.1232
## GAMLSS-RS iteration 2: Global Deviance = 294.1232
## GAMLSS-RS iteration 1: Global Deviance = 306.9779
## GAMLSS-RS iteration 2: Global Deviance = 306.9779
## GAMLSS-RS iteration 1: Global Deviance = 304.7878
## GAMLSS-RS iteration 2: Global Deviance = 304.7878
## GAMLSS-RS iteration 1: Global Deviance = 307.0227
## GAMLSS-RS iteration 2: Global Deviance = 307.0227
```

```
## GAMLSS-RS iteration 1: Global Deviance = 284.9089
## GAMLSS-RS iteration 2: Global Deviance = 284.9089
## GAMLSS-RS iteration 1: Global Deviance = 295.205
## GAMLSS-RS iteration 2: Global Deviance = 295.205
## GAMLSS-RS iteration 1: Global Deviance = 313.6924
## GAMLSS-RS iteration 2: Global Deviance = 313.6924
## GAMLSS-RS iteration 1: Global Deviance = 294.6721
## GAMLSS-RS iteration 2: Global Deviance = 294.6721
## GAMLSS-RS iteration 1: Global Deviance = 296.8992
## GAMLSS-RS iteration 2: Global Deviance = 296.8992
## GAMLSS-RS iteration 1: Global Deviance = 284.1584
## GAMLSS-RS iteration 2: Global Deviance = 284.1584
## GAMLSS-RS iteration 1: Global Deviance = 302.3596
## GAMLSS-RS iteration 2: Global Deviance = 302.3596
## GAMLSS-RS iteration 1: Global Deviance = 305.7533
## GAMLSS-RS iteration 2: Global Deviance = 305.7533
## GAMLSS-RS iteration 1: Global Deviance = 301.1798
## GAMLSS-RS iteration 2: Global Deviance = 301.1798
## GAMLSS-RS iteration 1: Global Deviance = 301.5768
## GAMLSS-RS iteration 2: Global Deviance = 301.5768
## GAMLSS-RS iteration 1: Global Deviance = 278.1519
## GAMLSS-RS iteration 2: Global Deviance = 278.1519
## GAMLSS-RS iteration 1: Global Deviance = 295.9147
## GAMLSS-RS iteration 2: Global Deviance = 295.9147
## GAMLSS-RS iteration 1: Global Deviance = 297.7091
## GAMLSS-RS iteration 2: Global Deviance = 297.7091
## GAMLSS-RS iteration 1: Global Deviance = 305.9479
## GAMLSS-RS iteration 2: Global Deviance = 305.9479
## GAMLSS-RS iteration 1: Global Deviance = 314.4287
## GAMLSS-RS iteration 2: Global Deviance = 314.4287
## GAMLSS-RS iteration 1: Global Deviance = 299.4615
## GAMLSS-RS iteration 2: Global Deviance = 299.4615
## GAMLSS-RS iteration 1: Global Deviance = 294.0092
## GAMLSS-RS iteration 2: Global Deviance = 294.0092
## GAMLSS-RS iteration 1: Global Deviance = 299.5494
## GAMLSS-RS iteration 2: Global Deviance = 299.5494
## GAMLSS-RS iteration 1: Global Deviance = 292.6869
## GAMLSS-RS iteration 2: Global Deviance = 292.6869
## GAMLSS-RS iteration 1: Global Deviance = 283.8071
## GAMLSS-RS iteration 2: Global Deviance = 283.8071
## GAMLSS-RS iteration 1: Global Deviance = 297.4258
## GAMLSS-RS iteration 2: Global Deviance = 297.4258
## GAMLSS-RS iteration 1: Global Deviance = 298.9199
## GAMLSS-RS iteration 2: Global Deviance = 298.9199
## GAMLSS-RS iteration 1: Global Deviance = 288.4237
## GAMLSS-RS iteration 2: Global Deviance = 288.4237
## GAMLSS-RS iteration 1: Global Deviance = 306.9997
## GAMLSS-RS iteration 2: Global Deviance = 306.9997
## GAMLSS-RS iteration 1: Global Deviance = 278.949
## GAMLSS-RS iteration 2: Global Deviance = 278.949
## GAMLSS-RS iteration 1: Global Deviance = 295.7841
## GAMLSS-RS iteration 2: Global Deviance = 295.7841
## GAMLSS-RS iteration 1: Global Deviance = 305.1767
## GAMLSS-RS iteration 2: Global Deviance = 305.1767
```

```
## GAMLSS-RS iteration 1: Global Deviance = 301.7401
## GAMLSS-RS iteration 2: Global Deviance = 301.7401
## GAMLSS-RS iteration 1: Global Deviance = 277.1146
## GAMLSS-RS iteration 2: Global Deviance = 277.1146
## GAMLSS-RS iteration 1: Global Deviance = 298.2872
## GAMLSS-RS iteration 2: Global Deviance = 298.2872
## GAMLSS-RS iteration 1: Global Deviance = 288.9604
## GAMLSS-RS iteration 2: Global Deviance = 288.9604
## GAMLSS-RS iteration 1: Global Deviance = 282.317
## GAMLSS-RS iteration 2: Global Deviance = 282.317
## GAMLSS-RS iteration 1: Global Deviance = 303.5767
## GAMLSS-RS iteration 2: Global Deviance = 303.5767
## GAMLSS-RS iteration 1: Global Deviance = 305.507
## GAMLSS-RS iteration 2: Global Deviance = 305.507
## GAMLSS-RS iteration 1: Global Deviance = 276.3292
## GAMLSS-RS iteration 2: Global Deviance = 276.3292
## GAMLSS-RS iteration 1: Global Deviance = 290.1263
## GAMLSS-RS iteration 2: Global Deviance = 290.1263
## GAMLSS-RS iteration 1: Global Deviance = 281.6013
## GAMLSS-RS iteration 2: Global Deviance = 281.6013
## GAMLSS-RS iteration 1: Global Deviance = 300.1489
## GAMLSS-RS iteration 2: Global Deviance = 300.1489
## GAMLSS-RS iteration 1: Global Deviance = 295.094
## GAMLSS-RS iteration 2: Global Deviance = 295.094
```

```r
# motagem do envelope simulado
plot(my.hnp, main="Distribuição Normal", xlab="Half-normal scores",
     ylab="Quantiles residuals", legpos="topleft")
```



Erro Quadrático Médio - Atividade 02.1

```
## Carregamento dos pacotes necessários
rm(list=ls(all=TRUE))
# install.packages("sn")
# install.packages("fGarch")
# install.packages("hnp")

require (sn)
require (fGarch)
require (hnp)
```

```
## Seta o diretório do projeot "wordir"
setwd("~/")
dados = read.delim("~/apps/esquema_fatorial/A_FatCruz_ex2.txt", header = TRUE)
dados
```

```
##    A  B TR BL    Y
## 1  2  8  1  1 42.9
## 2  2  8  1  2 41.6
## 3  2  8  1  3 28.9
## 4  2  8  1  4 30.8
## 5  2  8  1  5 41.7
## 6  2 12  2  1 53.8
## 7  2 12  2  2 58.5
## 8  2 12  2  3 43.9
```

```
## 9  2 12  2  4 46.3
## 10 2 12  2  5 55.2
## 11 4  8  3  1 49.5
## 12 4  8  3  2 53.8
## 13 4  8  3  3 40.7
## 14 4  8  3  4 39.4
## 15 4  8  3  5 50.8
## 16 4 12  4  1 53.3
## 17 4 12  4  2 65.6
## 18 4 12  4  3 45.4
## 19 4 12  4  4 35.1
## 20 4 12  4  5 51.4
## 21 6  8  5  1 57.6
## 22 6  8  5  2 69.6
## 23 6  8  5  3 42.4
## 24 6  8  5  4 51.9
## 25 6  8  5  5 56.3
## 26 6 12  6  1 59.8
## 27 6 12  6  2 65.8
## 28 6 12  6  3 41.4
## 29 6 12  6  4 45.4
## 30 6 12  6  5 60.0
## 31 8  8  7  1 61.5
## 32 8  8  7  2 60.9
## 33 8  8  7  3 51.1
## 34 8  8  7  4 55.4
## 35 8  8  7  5 60.5
## 36 8 12  8  1 67.4
## 37 8 12  8  2 63.2
## 38 8 12  8  3 58.7
## 39 8 12  8  4 59.3
## 40 8 12  8  5 66.1
```

```
y <- dados$Y
y
```

```
##  [1] 42.9 41.6 28.9 30.8 41.7 53.8 58.5 43.9 46.3 55.2 49.5 53.8 40.7 39.4 50.8
## [16] 53.3 65.6 45.4 35.1 51.4 57.6 69.6 42.4 51.9 56.3 59.8 65.8 41.4 45.4 60.0
## [31] 61.5 60.9 51.1 55.4 60.5 67.4 63.2 58.7 59.3 66.1
```

```
n = 10
#n = 30
#n = 100
mu = mean(y)
mu
```

```
## [1] 52.0725
```

```
sigma = 40
```

```
y <- rnorm(n, mu, sigma)
y
```

```
##  [1]  54.9380234 -13.0769582  81.7148494  -8.5042171  63.3117812   2.2781676
##  [7]  52.4947484  29.7584740   0.4319739  48.8257182
```

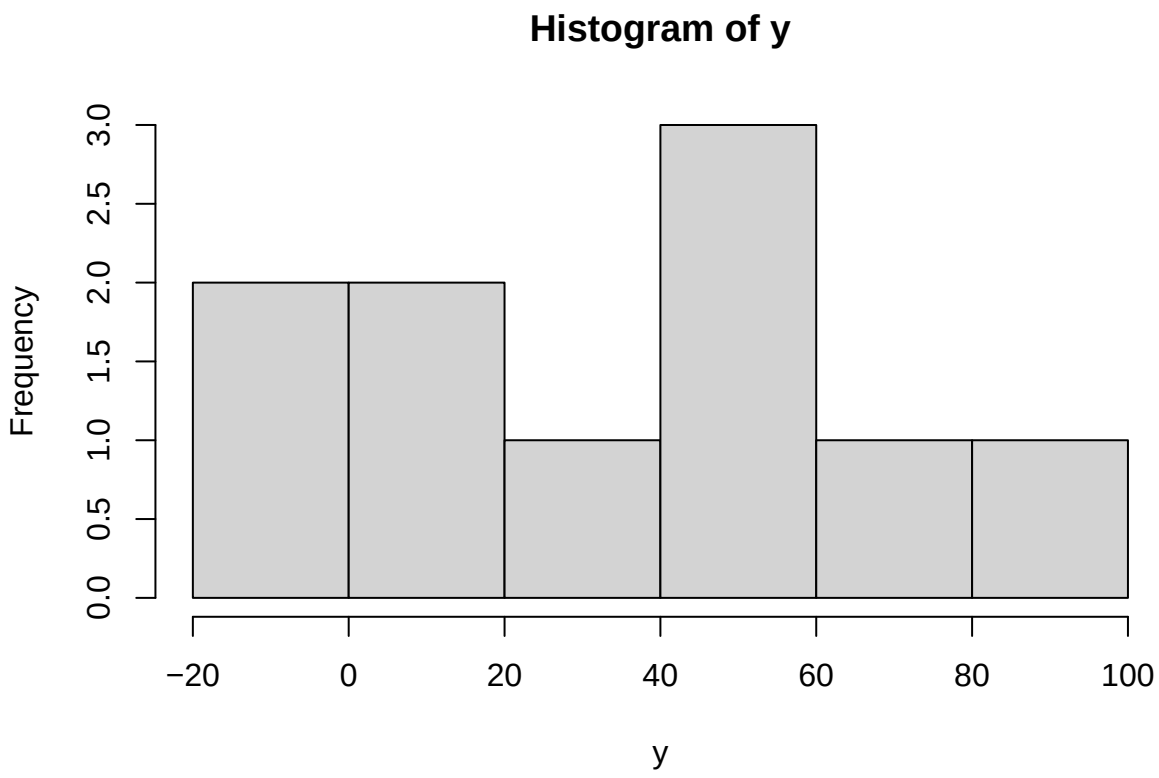
```
mean(y)
```

```
## [1] 31.21726
```

```
sd(y)
```

```
## [1] 33.71883
```

```
hist(y)
```




```
logvero <- function(param, y) {
  mu = param[1]
  sigma = param[2]
  lv = log((1/(sigma*sqrt(2*pi)))*exp(-0.5*((y - mu)/sigma)^2))
  soma = -sum(lv)
  return(soma)
}
```

```
N = 1000
T0 = NULL
T1 = NULL
```

```
for (i in 1:N){
  y = rnorm(n, mu, sigma)
  fit1 <- optim(par = c(mean(y),sd(y)),logvero,
                y = y,
                method = "BFGS",
                hessian = TRUE)
```

```
  T0[i] = fit1$par[1]
  T1[i] = fit1$par[2]
}
```

```
T0
```

```
##    [1] 39.912701 62.145805 31.869974 54.930843 52.673039 61.833217 69.272878
##    [8] 52.618761 62.167863 35.892891  8.550981 41.542021 37.181478 51.072486
##   [15] 40.890883 45.674588 46.554303 18.605240 54.153815 51.021539 55.945285
##   [22] 50.716875 43.923573 54.346422 38.256074 60.745339 68.288849 43.782102
##   [29] 73.615725 65.723707 48.407603 76.691573 60.002001 32.603105 51.717003
##   [36] 34.390390 72.857008 44.936640 45.876915 60.599060 47.159824 61.883235
##   [43] 48.641841 70.334631 46.953188 57.707464 40.168101 56.303280 65.359849
##   [50] 52.658076 44.236241 69.746354 65.554950 43.659890 19.177276 53.041666
##   [57] 60.019772 45.867226 80.111935 72.393101 57.695473 63.256252 84.761571
##   [64] 58.550265 42.832233 50.979429 32.923413 86.246520 46.986565 63.893906
##   [71] 43.465525 47.830235 48.465329 49.855838 43.180775 26.522112 76.664533
##   [78] 56.560989 45.362524 43.128474 51.024074 45.484909 43.858005 51.055641
##   [85] 32.056726 45.195482 56.112135 29.522504 48.520720 66.373220 65.116026
##   [92] 62.936665 64.668186 47.464219 65.654874 65.536326 49.286545 44.956930
##   [99] 45.715477 28.969396 57.593254 48.479347 55.537206 52.042422 35.160431
##  [106] 47.835374 71.453004 34.494476 61.626129 36.575943 31.962898 29.675580
##  [113] 47.731348 36.865949 42.637048 48.471879 47.321646 62.605772 45.210117
##  [120] 45.748276 89.958612 43.561450 45.994931 65.540922 49.978527 54.451859
##  [127] 60.630235 56.325248 48.618215 41.619233 49.687435 42.306312 46.021349
##  [134] 58.926413 58.683827 45.306214 59.306898 45.873835 49.621526 63.154991
##  [141] 49.432795 49.127571 45.664385 58.836098 42.130244 59.044146 52.387247
##  [148] 77.214976 54.423251 53.172213 60.813199 27.365872 50.862747 51.101062
##  [155] 62.990231 55.792279 45.592790 43.888190 56.593777 59.177400 67.650344
##  [162] 39.634097 42.211476 54.313197 64.644805 49.150608 61.447203 64.811663
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##  [689] 31.37568 23.08261 42.14541 21.43292 53.61291 31.69357 27.99352 28.61166
##  [697] 44.46933 49.87899 31.18427 27.57694 27.62722 28.22969 29.94026 37.20419
##  [705] 43.21991 46.82880 28.66032 31.79642 42.35443 37.13441 31.09078 28.93894
##  [713] 31.25819 26.06062 31.02882 33.41992 33.67378 34.40588 53.09189 48.72368
##  [721] 48.55864 56.10203 34.21379 27.16814 43.94111 37.56855 32.50098 41.04026
##  [729] 57.65107 37.05253 48.54318 48.38440 31.68193 49.20621 51.43304 27.75013
##  [737] 39.09301 44.14818 35.59547 46.20461 40.31572 27.65532 52.83088 34.50123
##  [745] 29.96789 38.47646 43.17812 41.92584 51.83575 46.00814 32.71948 29.64374
##  [753] 50.68863 36.51147 38.02261 35.08331 24.30906 42.52158 33.55773 34.52499
##  [761] 26.03747 40.11076 38.22169 44.50923 31.10755 40.17260 35.59341 36.93123
##  [769] 43.76864 53.48649 38.59614 36.52736 38.72475 35.74107 43.75655 39.84546
##  [777] 42.63822 38.29960 33.44853 37.33117 27.26607 32.52268 32.41916 35.39069
##  [785] 37.33769 25.53942 41.75476 26.77038 38.45632 34.41048 32.98419 44.43120
##  [793] 33.14865 46.90483 34.72260 35.05873 43.70450 35.75396 31.71487 40.76254
##  [801] 53.24450 29.53521 27.67097 24.24149 33.22742 25.98640 28.96755 30.84603
##  [809] 35.61406 50.50892 45.21703 42.53072 26.51594 30.82420 32.59655 49.16408
##  [817] 35.52325 37.00455 43.89817 37.35250 24.20218 31.44938 24.90180 25.01709
##  [825] 35.52854 22.48197 36.66707 51.57456 53.08581 47.85205 50.96680 33.73230
##  [833] 42.40628 55.59280 29.65563 42.91372 38.87570 33.46723 29.18158 31.07755
##  [841] 38.46148 50.33265 27.64128 31.78251 46.80871 61.09007 33.72685 48.12142
##  [849] 44.46769 42.25842 39.00952 38.09748 32.90452 42.42216 43.60582 45.13564
##  [857] 15.99315 40.82807 41.40858 31.08525 26.05436 40.88312 43.17188 30.61124
##  [865] 54.10024 19.39615 28.14457 29.80967 45.14638 28.65779 24.10865 25.58310
##  [873] 51.41821 32.65102 25.91730 48.35716 37.58337 33.77962 38.22694 58.13345
##  [881] 45.62587 26.57777 38.06631 26.12217 26.48956 41.25176 27.71655 33.65175
##  [889] 38.79847 42.54082 43.20370 41.16792 30.81853 30.10259 27.56650 42.26483
##  [897] 39.34305 41.96028 38.50814 34.61006 37.48856 31.63606 33.59255 26.90422
##  [905] 25.19137 32.61811 37.27859 33.29924 27.90328 40.86463 41.06563 41.14084
##  [913] 42.90241 20.74285 27.69297 35.75715 26.85953 49.06121 35.81788 26.74381
##  [921] 44.56580 44.98888 44.97331 27.98360 41.22012 44.16700 57.48418 39.85440
##  [929] 34.19991 27.89559 26.86440 33.34602 45.38718 27.97889 37.44687 31.06857
##  [937] 43.99372 32.82134 31.22177 25.02320 44.77930 32.23375 43.42098 44.70578
##  [945] 21.33426 20.49803 46.26252 36.08536 28.89443 50.61068 26.89402 46.31173
```

```
##  [953] 36.53952 21.14375 32.41354 26.78890 43.12121 28.41818 40.03369 25.63977
##  [961] 27.69257 23.85928 31.52585 40.65557 40.06582 37.55069 38.30764 30.41433
##  [969] 42.66020 27.34587 42.93997 39.78130 48.86631 34.76262 43.36419 45.86204
##  [977] 30.75362 20.45207 38.39488 23.56766 40.54350 33.55939 24.42274 33.71922
##  [985] 41.74925 44.24380 45.05496 51.59051 48.85893 42.12388 36.44006 36.14761
##  [993] 36.20940 29.61016 49.13020 35.83807 35.54039 27.97991 49.77814 39.02948
```

```
vicio_l = mean(T0) - mu;
mean(T0)
```

```
## [1] 52.94334
```

```
vicio_l
```

```
## [1] 0.8708444
```

```
EQM_l = var(T0) + vicio_l^2; EQM_l
```

```
## [1] 163.6928
```

```
vicio_s = mean(T1) - sigma
EQM_s = var(T1) + vicio_s^2
```

```
Tabela <- data.frame("Vícios" = c(vicio_l, vicio_s),
                     "EQMs" = c(EQM_l, EQM_s),
                     "Estimativa" = c(mean(T0), mean(T1)),
                     "Verdadeiro" = c(mu, sigma),
                     row.names = c("mu", "Sigma"))
```

```
Tabela
```

```
##           Vícios      EQMs Estimativa Verdadeiro
## mu     0.8708444 163.69279   52.94334    52.0725
## Sigma -3.2892915  88.53778   36.71071    40.0000
```

```
#n = 10
n = 30
#n = 100
mu = mean(y)
mu
```

```
## [1] 54.17822
```

```
sigma = 40
```

```
y <- rnorm(n, mu, sigma)
y
```

```
##  [1]  27.620633  82.541538 122.671679  63.141613  22.942312  54.909835
##  [7]  12.632636  55.059983  25.487555  28.422420  80.128537  65.801740
## [13]  50.878069  75.683513  69.361823  24.313886  82.568469  53.056429
## [19]  62.391916  68.339239  54.958288 134.574733  78.179716  30.070304
## [25] 110.411112  -4.272511  60.010322  67.349640  51.955887   5.621479
```

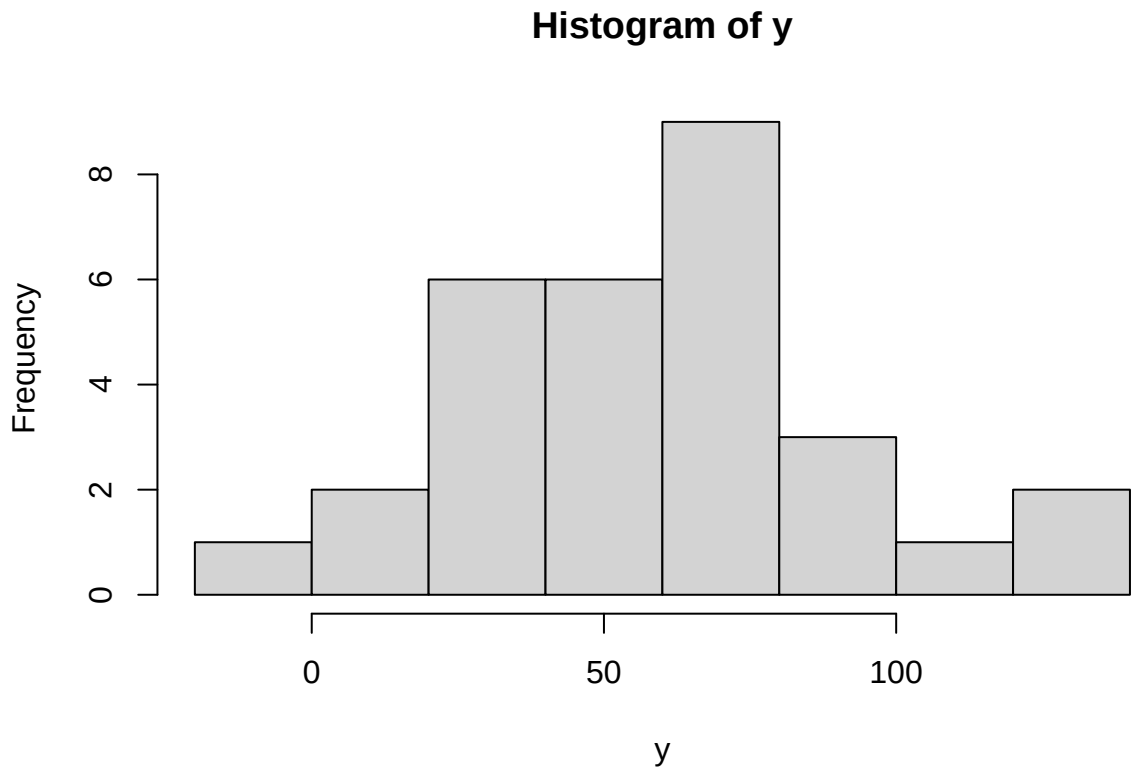
```
mean(y)
```

```
## [1] 57.22709
```

```
sd(y)
```

```
## [1] 32.39946
```

```
hist(y)
```




```
logvero <- function(param, y) {
  mu = param[1]
  sigma = param[2]
  lv = log((1/(sigma*sqrt(2*pi)))*exp(-0.5*((y - mu)/sigma)^2))
  soma = -sum(lv)
  return(soma)
}
```

```
N = 1000
T0 = NULL
T1 = NULL
```

```
for (i in 1:N){
  y = rnorm(n, mu, sigma)
  fit1 <- optim(par = c(mean(y),sd(y)),logvero,
                y = y,
                method = "BFGS",
                hessian = TRUE)

  T0[i] = fit1$par[1]
  T1[i] = fit1$par[2]
}
```

```
T0
```

```
##    [1] 39.09522 54.35292 52.79519 52.98785 45.00327 65.27844 56.03492 58.10176
```

```
##    [9] 55.65975 51.44180 57.31103 53.12820 49.12385 53.73037 43.16312 55.50047
##   [17] 66.77843 57.26145 57.27159 61.13854 49.40797 60.82365 50.32170 49.24174
##   [25] 53.77465 47.09529 54.38123 51.07136 48.32344 66.82312 46.77791 48.26728
##   [33] 70.36003 55.51194 51.37923 60.76125 59.75944 59.45158 46.19007 45.15328
##   [41] 46.68497 47.26007 64.79238 41.05690 57.33582 45.41862 63.28319 55.24534
##   [49] 32.89138 47.62966 58.72006 46.75243 68.45307 46.56970 62.58408 56.40312
##   [57] 53.50116 71.74398 67.44212 51.20739 57.96284 50.64262 62.92902 53.23694
##   [65] 62.50226 54.98910 66.20507 48.90917 55.50380 51.90293 65.31136 44.04705
##   [73] 57.74199 63.75498 45.88828 59.60243 36.09962 58.40474 49.53270 34.14417
##   [81] 69.27130 60.19131 44.91858 43.43998 55.72876 59.32769 56.27245 42.85532
##   [89] 56.33156 57.10573 63.06150 59.51952 54.40147 50.97710 52.64767 46.87297
##   [97] 61.71010 63.95440 60.07297 50.04701 54.28261 56.08224 48.05708 52.68816
##  [105] 57.23472 60.72973 60.34195 55.87314 56.87827 58.34997 58.28272 53.10120
##  [113] 55.74074 36.66827 53.14659 46.88131 56.61702 53.40018 57.94362 57.90621
##  [121] 63.16655 54.50081 53.83166 43.90227 60.09207 65.15453 60.15177 56.09971
##  [129] 65.01329 53.64300 55.21617 43.42831 57.11365 60.19752 55.36750 67.68267
##  [137] 51.42770 42.61609 55.04530 52.19060 56.41381 44.21724 55.33644 73.14271
##  [145] 59.35781 52.63487 62.29592 50.07072 59.98347 65.42481 58.51791 63.69196
##  [153] 53.52320 57.86643 51.37652 51.40462 41.99316 55.18462 45.25250 44.41520
##  [161] 63.38218 40.71695 53.14171 45.86404 71.19855 56.53304 42.87735 53.98915
##  [169] 62.45264 48.68596 46.64330 60.80168 48.91904 47.00903 46.55513 52.76062
##  [177] 50.28261 59.47590 58.48672 61.78277 58.83223 56.57302 53.16747 54.94612
##  [185] 48.43186 61.64344 51.12795 48.36921 53.02640 52.72812 54.17201 51.96458
##  [193] 60.07417 61.71218 62.25354 49.88782 48.16627 67.50976 62.47274 58.56855
##  [201] 54.60819 56.71983 63.38634 49.02515 59.92376 52.56726 58.20186 64.76886
##  [209] 65.77035 51.17853 67.28782 57.14441 66.69148 54.55691 47.78848 53.19656
##  [217] 68.37089 58.90286 41.48859 42.11505 74.18999 59.22141 49.08134 50.84445
##  [225] 55.52763 56.12487 46.42078 54.84435 66.02493 35.53519 55.49516 58.29439
##  [233] 53.86334 55.17929 45.21088 43.14580 60.91013 48.16176 50.94046 41.93226
##  [241] 44.07108 64.85357 69.88707 63.12579 40.16251 44.75256 64.79845 50.07972
##  [249] 48.66364 54.00275 49.09424 59.11062 57.16262 40.77815 55.76256 62.84063
##  [257] 54.10689 56.34457 47.52735 49.63446 49.80411 55.32224 61.07482 71.77358
##  [265] 62.12165 39.70182 67.44273 47.92421 60.77687 59.46384 61.48829 67.48936
##  [273] 46.26174 64.10363 47.43024 60.35779 43.76457 57.00078 44.76320 54.33214
##  [281] 53.00096 48.42583 48.10483 49.54895 47.81212 48.82556 53.60227 48.65689
##  [289] 55.65404 59.72482 47.40396 57.63889 63.97673 64.07278 64.33862 55.46066
##  [297] 50.08881 52.57027 57.91056 42.97579 52.70982 56.04454 39.26349 45.61028
##  [305] 60.83786 61.95715 61.82712 50.92224 63.27902 59.90500 47.65732 52.74981
##  [313] 40.36556 59.96844 46.59181 54.49570 58.12830 46.69939 62.51699 51.39216
##  [321] 53.47529 52.12800 55.81263 54.33180 54.58363 54.11761 64.43727 62.98476
##  [329] 62.45592 58.30614 45.71308 52.75215 59.95871 46.07722 60.63292 57.07814
##  [337] 56.29316 53.75699 48.27242 60.24852 44.17963 58.89605 57.43757 56.88888
##  [345] 53.65487 58.86763 43.47596 65.01303 45.99132 59.52659 43.34189 51.83422
##  [353] 55.93603 57.08400 46.65593 60.86987 46.19430 54.03600 64.88768 35.24742
##  [361] 46.85336 51.89657 49.53493 51.59403 45.20577 46.46165 51.43931 42.34715
##  [369] 61.11802 52.84074 63.29716 57.30752 56.10175 48.46645 53.91772 43.10010
##  [377] 50.19512 48.83397 56.77113 49.76806 53.70272 52.64975 59.47875 40.44703
##  [385] 58.78576 42.43140 50.70355 51.94402 51.07555 46.23722 51.56042 59.28761
##  [393] 56.45672 51.11069 45.68991 56.12000 53.49867 49.09107 47.02464 49.99799
##  [401] 55.43846 64.47164 56.64692 47.90180 54.52942 53.95416 58.59226 55.96284
##  [409] 36.18370 61.97524 47.91231 45.95210 58.44174 46.23787 59.88866 44.45502
##  [417] 53.02113 71.41691 63.60070 45.62765 60.28916 55.71203 53.59926 51.26018
##  [425] 52.80856 60.58408 58.91362 42.68146 42.73156 58.92719 60.85426 60.38797
##  [433] 45.36230 61.08854 47.45620 54.45298 56.25649 32.31194 59.86558 53.31905
```

```
##  [441] 64.26133 58.87348 40.08677 48.40556 60.79235 38.17708 46.05712 45.54397
##  [449] 46.22485 64.41135 50.57302 46.46218 54.62175 54.25656 50.10901 45.36695
##  [457] 62.56928 61.26079 55.47263 53.20628 51.75918 55.58298 48.69078 45.70114
##  [465] 56.16350 69.16271 53.00665 63.68446 61.06546 46.27243 60.56336 50.64818
##  [473] 57.13730 55.74767 44.78155 45.90257 50.01019 63.91103 57.10468 64.31656
##  [481] 52.24720 46.30617 49.65407 61.31137 45.56243 56.83312 50.42778 56.39028
##  [489] 46.35682 54.55615 49.32206 48.84620 39.13458 50.94608 68.08142 43.32624
##  [497] 53.26641 40.71171 55.24103 71.35149 61.03913 63.76451 62.40073 65.43433
##  [505] 54.40186 52.58105 44.51433 64.08135 58.28509 61.96653 59.08557 58.12574
##  [513] 66.05820 55.62379 61.67661 46.77946 69.33716 42.80966 66.82767 77.41572
##  [521] 38.92349 61.76134 46.22334 50.17954 56.43251 41.83046 63.94766 56.47469
##  [529] 72.79703 60.69782 51.23044 50.24626 55.55156 53.41783 56.29340 44.21594
##  [537] 44.89906 64.92013 56.58291 52.41635 67.80412 66.05610 36.69395 62.60676
##  [545] 47.76437 61.74465 53.74266 64.24824 56.96857 50.62963 50.59517 57.16532
##  [553] 57.81293 64.15551 50.87016 54.21782 49.91146 48.87990 59.86764 55.03693
##  [561] 57.17911 56.67180 55.12659 42.79459 61.84529 59.67649 53.50886 62.90344
##  [569] 43.77817 49.23119 59.98535 54.61117 48.83967 63.67162 51.09942 57.87841
##  [577] 51.75600 43.82197 56.95271 51.53692 50.08396 57.89846 64.27260 53.58407
##  [585] 50.27777 72.89454 51.62191 53.18039 54.62666 51.22219 37.59728 50.48206
##  [593] 58.23907 60.00009 54.87140 69.08119 51.53959 58.28144 48.86095 46.13912
##  [601] 47.32360 39.33692 46.93393 53.04286 52.61065 58.75973 46.69540 54.00402
##  [609] 58.57186 49.90470 65.56785 57.01526 51.14860 49.08306 61.18937 71.08419
##  [617] 54.98991 56.35409 47.06308 58.08209 61.64017 66.64259 47.16270 63.97816
##  [625] 60.16788 49.40482 50.95050 53.27445 51.96413 59.72517 74.81666 66.82646
##  [633] 57.05008 53.04353 49.23718 59.63651 46.53475 61.76213 44.00968 51.43998
##  [641] 58.45643 50.72836 59.46009 45.00351 63.05908 58.08332 58.37670 44.21513
##  [649] 44.73898 45.58990 55.46349 64.38761 41.59062 63.68886 63.34244 57.67959
##  [657] 52.17234 51.89614 55.22352 48.67550 60.97682 55.49689 49.43417 64.41528
##  [665] 57.01860 64.00885 51.20564 52.00008 51.97213 47.00153 65.13463 66.34516
##  [673] 54.88025 52.57339 58.12815 49.86205 71.07234 62.85474 67.97061 53.37213
##  [681] 63.09439 46.50755 46.90917 49.91905 52.26084 55.21672 54.43117 45.37265
##  [689] 56.08897 45.95583 54.37674 42.47299 56.79125 63.63928 48.14283 68.79086
##  [697] 59.91417 51.98056 53.71654 45.65189 59.51480 42.87224 50.69456 59.59304
##  [705] 65.43145 60.70055 54.95055 51.47261 48.67868 50.00914 52.17314 45.95180
##  [713] 52.09722 48.55448 66.06600 60.04545 55.78405 56.94195 59.97885 68.20394
##  [721] 64.82707 39.37110 53.68239 57.64693 59.20166 56.35666 57.42609 55.21712
##  [729] 51.90478 47.85621 63.77452 46.54966 45.85712 48.11522 64.56723 48.75574
##  [737] 53.22517 53.27882 62.97413 53.94919 58.70679 56.84426 44.40726 53.98571
##  [745] 44.96385 51.78815 52.81590 52.63241 39.28830 65.61900 48.12150 56.34322
##  [753] 55.04174 52.26652 49.65066 48.14628 48.16746 49.42003 76.97430 58.14036
##  [761] 52.00400 47.18759 47.48496 48.72479 50.31833 71.41193 52.18224 50.72912
##  [769] 59.86606 57.33423 43.08810 63.23270 48.75050 58.05368 62.96114 45.48907
##  [777] 45.51429 56.42318 45.72058 60.97625 50.09856 59.04614 52.75145 49.45184
##  [785] 57.15980 63.41707 53.36351 49.52051 50.69734 62.44362 48.28560 41.62855
##  [793] 50.08018 51.90904 48.73363 60.35393 44.53926 47.57474 65.61230 54.70158
##  [801] 59.68492 56.14758 41.71062 50.38736 49.96570 48.51377 57.71498 42.70747
##  [809] 56.85215 62.69268 58.58782 58.25130 37.12145 49.16657 43.33232 49.77388
##  [817] 45.10385 64.06957 52.99870 54.93469 54.21513 50.41346 53.84527 60.55480
##  [825] 55.62319 61.71062 48.37775 60.75160 53.66277 50.50435 66.13524 50.29044
##  [833] 63.38046 60.10751 52.20716 57.50363 66.56001 63.01308 67.80293 43.38573
##  [841] 56.77826 53.62144 62.81589 54.08748 55.22228 41.72577 45.23728 42.08028
##  [849] 53.42274 54.14753 56.67457 56.17011 49.50219 57.09422 52.05903 60.31872
##  [857] 52.72927 57.64750 55.66548 57.99140 58.63540 69.14096 52.88452 38.71457
##  [865] 54.97111 60.99558 58.58255 56.65144 45.35627 34.63530 59.45577 44.02165
```

```
##  [873] 48.30584 56.02317 66.86827 54.34286 68.88132 42.40641 44.31667 45.46377
##  [881] 57.28355 51.38660 52.19274 51.36744 59.91597 48.38405 66.77096 55.97520
##  [889] 63.71795 55.25560 59.47608 50.08877 57.61241 52.60636 57.45036 45.65031
##  [897] 57.25690 67.46319 60.23204 57.37971 52.11170 58.18766 59.98060 60.72971
##  [905] 60.39922 53.46579 43.83518 51.25865 42.08364 67.67049 52.37668 66.08433
##  [913] 49.44582 43.21173 57.82562 51.36875 54.86284 66.51567 53.92934 62.54763
##  [921] 62.94771 54.94989 46.83442 51.58056 63.10640 58.89599 63.22574 49.99578
##  [929] 49.58301 59.99597 55.72710 53.80936 48.00736 49.61419 43.14162 55.73739
##  [937] 65.42743 55.91438 56.63000 55.18448 52.23073 46.14764 56.38864 65.35534
##  [945] 60.16170 71.07086 45.48742 57.41450 60.15201 52.13189 53.57991 54.37440
##  [953] 51.27973 53.72962 57.85407 49.88099 59.45867 46.45836 51.08135 59.77930
##  [961] 59.97794 36.69971 49.49745 61.55450 65.31615 63.11459 48.27815 55.23783
##  [969] 62.59966 48.56049 50.97400 37.24512 57.77968 51.41711 61.53352 49.42942
##  [977] 63.17376 54.73751 63.81196 50.27506 57.11819 50.39718 57.68275 36.17883
##  [985] 60.58747 49.83325 57.12736 61.79846 48.41916 67.79355 42.29932 39.40152
##  [993] 48.00974 55.13672 46.81335 60.63092 47.24372 61.90838 53.22653 51.11086
```

```
T1
```

```
##    [1] 42.89912 34.20152 35.62988 37.46663 36.24391 45.18607 37.95208 34.78520
##    [9] 34.41816 43.26479 40.37640 46.07895 39.27449 38.21065 32.42449 42.94873
##   [17] 45.64888 43.65933 38.22819 44.17719 33.67215 35.38728 39.86614 40.95206
##   [25] 32.23162 39.49322 45.18934 35.62059 39.49627 44.04240 37.46075 42.71301
##   [33] 38.84085 40.57020 40.01882 38.39934 38.77639 40.06095 38.61650 44.81754
##   [41] 34.74833 34.30921 32.24183 39.51522 44.14475 38.86130 37.31017 45.42095
##   [49] 42.58835 47.52004 42.16992 43.81387 40.11255 38.18146 42.21114 37.73263
##   [57] 41.21494 40.36025 36.87401 42.39424 31.55873 34.42180 38.71155 34.29387
##   [65] 32.06025 31.49401 39.27963 41.17593 39.12392 31.51995 46.51902 35.33489
##   [73] 35.97407 33.42634 44.34913 30.98618 48.34084 30.11223 34.86897 41.31149
##   [81] 37.47686 41.76736 42.70098 39.90252 49.37104 44.06691 43.89409 40.03175
##   [89] 39.74946 34.77116 37.00786 34.08411 38.81768 41.91719 39.00159 42.93561
##   [97] 36.20220 51.48715 36.39344 45.43247 41.39597 35.81918 43.38440 39.96614
##  [105] 36.66196 40.11973 42.70075 39.51941 47.45926 45.23983 33.50329 36.67603
##  [113] 38.46210 39.31427 37.16256 38.55458 35.46940 35.79086 45.16648 41.70175
##  [121] 40.13175 33.36939 36.83929 39.98754 39.45097 45.92356 40.18430 29.97798
##  [129] 35.04829 35.24080 38.66850 45.45289 31.42445 48.16491 36.86656 45.20549
##  [137] 36.85617 42.94492 45.16179 36.87072 31.59558 29.38964 41.91880 35.00300
##  [145] 39.03902 44.77296 44.31491 39.54787 35.29028 38.82516 37.84809 44.04610
##  [153] 38.68766 41.22679 48.64745 36.53763 35.58164 41.33190 29.63755 39.41376
##  [161] 43.32473 35.12581 34.99485 38.96811 39.99567 35.55780 38.68587 34.71811
##  [169] 39.44961 41.86046 46.65223 35.38478 32.68407 37.61305 35.19080 29.68557
##  [177] 39.88085 43.53872 39.77681 42.68056 38.77034 36.20903 39.06423 42.01344
##  [185] 39.49252 42.21840 32.48861 37.54831 53.70175 39.05429 41.96521 37.94008
##  [193] 28.59292 36.51579 43.97611 35.68884 25.99740 37.94975 37.01530 39.17425
##  [201] 41.11721 34.50602 39.50686 38.37071 44.22219 39.76851 43.62739 41.08791
##  [209] 43.42953 40.11637 36.62096 42.30139 40.09945 42.35884 38.01615 32.32110
##  [217] 51.12324 39.72047 41.92665 36.11858 39.49864 36.66388 33.68484 39.16193
##  [225] 44.65507 40.34944 46.65051 34.13316 31.26976 40.02333 33.09624 35.90257
##  [233] 41.55616 32.09100 47.28099 33.96677 36.17941 33.26532 44.03350 44.68004
##  [241] 41.76181 38.11748 38.91056 34.07990 39.29631 45.80828 50.50181 33.15475
##  [249] 34.30764 46.70194 44.45424 42.44809 32.45722 31.61196 37.27209 31.42519
##  [257] 39.84799 40.40980 37.31241 39.64476 32.39045 35.65189 50.90599 40.68773
##  [265] 41.79366 44.60679 33.64328 32.53157 37.23263 38.06164 33.44910 29.93280
##  [273] 48.53744 42.47960 39.27360 31.38270 39.62222 34.66336 41.60848 34.09317
##  [281] 40.30277 47.89530 32.78164 36.40586 48.79618 37.41380 33.43664 42.10642
```

```
##  [289] 39.09541 42.51042 36.58353 40.53416 27.89090 42.72587 41.71419 41.32260
##  [297] 41.17367 42.01116 44.13129 43.08701 31.10643 38.14943 36.40415 39.30641
##  [305] 38.86535 41.44096 37.68490 41.62521 38.06710 40.13500 40.21927 32.88396
##  [313] 45.59984 42.34745 36.69659 33.15988 41.40086 33.52408 44.20654 41.65292
##  [321] 41.38283 44.25712 48.05506 40.77520 44.71702 41.09021 48.36477 41.47293
##  [329] 40.13185 53.10639 26.89199 34.98962 43.31085 48.65507 32.73923 39.71268
##  [337] 41.35702 37.21510 40.92089 33.97681 34.81410 39.92410 39.55665 41.64202
##  [345] 38.83280 41.39961 38.88383 41.04941 37.68213 39.04574 35.65596 30.40493
##  [353] 33.99471 40.26260 39.39507 39.89209 48.53058 41.84964 32.69240 37.82263
##  [361] 36.90575 41.27354 34.46758 42.49624 44.22096 43.36239 38.97495 36.66900
##  [369] 37.16410 40.95422 38.45311 40.77733 40.44570 34.89550 42.63220 44.24322
##  [377] 30.97755 34.01136 40.60135 45.50046 32.06957 36.93132 41.39658 32.46084
##  [385] 43.53474 39.00750 40.54276 30.19702 36.08334 39.44359 43.22085 31.96243
##  [393] 37.81731 29.60774 40.81162 35.50231 41.24435 34.86353 38.13736 30.40523
##  [401] 39.53406 49.33416 39.47970 41.22149 36.47875 40.36385 35.02680 48.03881
##  [409] 35.23185 39.90545 44.15986 38.72858 40.66411 41.04436 29.11288 40.47200
##  [417] 47.94742 40.86463 37.75138 52.26926 47.84922 33.42844 37.40716 41.41289
##  [425] 39.09496 33.94230 42.10959 48.63356 45.63979 46.97833 42.69694 40.76193
##  [433] 34.64246 46.87525 42.04168 47.87829 34.41813 42.77952 36.60706 33.13226
##  [441] 36.35243 30.38340 40.55760 33.19379 49.76600 34.89386 38.73368 40.92193
##  [449] 41.27229 30.11635 44.49992 40.76846 41.35416 37.09284 47.60458 42.85602
##  [457] 41.53122 40.59649 41.36809 45.15471 38.96945 42.94706 31.03998 45.92216
##  [465] 51.00955 40.34938 36.73637 38.49075 33.46449 39.71216 38.15730 43.69015
##  [473] 31.20244 28.35652 28.24670 43.65217 40.98585 47.37842 29.83298 41.22202
##  [481] 38.92150 28.69473 41.36665 41.50028 39.52643 43.39412 37.11447 41.25998
##  [489] 30.21254 50.54354 44.52878 41.96916 48.52756 37.81178 37.04614 37.14258
##  [497] 40.40883 43.02775 42.28783 41.73502 40.16232 29.92269 39.77003 44.45327
##  [505] 41.08877 38.91164 45.19524 32.23490 38.27303 40.30087 41.44626 37.82006
##  [513] 39.61496 45.85487 35.07560 34.41532 33.56287 39.40279 43.76990 33.83956
##  [521] 44.79879 39.99049 33.97095 39.37327 40.53667 41.43481 44.98038 34.98357
##  [529] 44.86889 39.81479 33.28047 42.55018 33.78510 36.38109 44.89661 34.50793
##  [537] 44.60057 36.62967 39.60426 45.78582 40.80220 41.73588 37.61296 38.23249
##  [545] 39.28920 40.15164 30.89687 38.37520 34.10469 31.51142 42.58162 38.90991
##  [553] 41.89752 41.03655 35.96096 33.51287 42.74457 47.13412 43.87862 41.00333
##  [561] 43.84383 43.63964 42.35192 53.55992 39.46785 43.40069 38.16713 35.39072
##  [569] 29.54601 40.53743 35.84301 33.96707 33.51970 47.64970 29.81256 31.29447
##  [577] 44.31145 47.82034 36.53506 38.73537 41.63989 43.02694 47.23371 34.67425
##  [585] 49.22277 24.44551 31.29477 41.33798 37.09247 34.52601 49.45879 40.08552
##  [593] 36.07614 49.86247 54.82718 41.36963 39.32212 35.32925 44.06300 31.31162
##  [601] 38.39972 36.73898 37.43110 47.31381 35.56815 36.35918 45.70579 35.74645
##  [609] 37.25454 35.94757 41.80678 39.50735 43.94273 36.22672 38.45377 29.18572
##  [617] 32.62291 42.70304 39.00874 32.97704 31.34676 39.81303 51.33748 44.97918
##  [625] 38.33507 39.94490 53.31278 39.47827 38.04224 32.06263 43.57378 39.09408
##  [633] 44.64399 32.00563 37.40017 43.87152 38.69117 42.49164 44.01483 39.45251
##  [641] 32.61369 35.40844 41.25884 32.68387 43.03921 40.05308 35.26142 40.49844
##  [649] 38.93630 40.86255 34.55944 46.60981 52.86250 38.66209 41.08785 39.61395
##  [657] 40.64636 43.92271 32.12702 38.38535 42.72844 38.48169 42.07471 39.30659
##  [665] 32.74085 40.58283 34.44468 45.37399 40.39615 45.45362 45.47963 40.30057
##  [673] 40.56161 29.44874 39.70393 37.76626 32.73342 39.92158 48.27644 33.66644
##  [681] 39.90836 38.78304 37.66088 36.98127 33.71313 38.28832 36.74968 32.40222
##  [689] 29.46684 42.70660 43.19042 32.70778 33.44795 39.56218 41.76689 42.95905
##  [697] 43.70177 37.44284 32.01852 45.40856 42.56947 29.39809 48.28168 32.86740
##  [705] 35.28869 46.43162 37.73446 47.65497 34.82183 32.32468 41.87712 36.58242
##  [713] 30.06974 36.84593 38.27506 36.71079 45.15803 38.87495 39.96584 49.02824
```

```
##  [721] 33.47909 32.24157 34.70554 35.99946 36.49767 26.80215 40.38017 42.60202
##  [729] 33.37356 28.63542 39.33202 45.61264 50.41623 46.78056 41.06011 45.73448
##  [737] 49.90853 38.24189 38.70115 36.40192 31.72797 45.24571 39.65856 42.21279
##  [745] 45.23685 43.44338 38.00400 42.73796 35.78336 33.44404 42.68972 34.49047
##  [753] 44.23302 32.12932 35.87840 31.25338 38.74965 42.79527 42.97538 33.17163
##  [761] 41.13036 38.02160 41.26479 35.63610 46.69508 36.19247 39.63390 44.57417
##  [769] 40.02788 45.97354 36.92772 46.34025 31.39257 36.92227 37.62200 41.43204
##  [777] 38.69052 45.67364 43.03190 39.97971 39.82496 39.60690 27.53184 35.42114
##  [785] 36.08826 38.53223 36.81486 38.62425 47.73881 45.43811 39.13314 39.36256
##  [793] 40.71999 38.89039 33.82302 47.14512 50.87437 39.36927 28.74365 34.45794
##  [801] 32.64925 39.27001 31.70942 43.46607 36.44043 29.16773 43.48782 36.99027
##  [809] 40.79789 45.74684 36.44313 43.36335 43.83672 26.95805 44.53594 48.25539
##  [817] 36.90163 40.29725 33.17515 26.80762 40.11305 38.46797 38.99769 42.15719
##  [825] 44.29697 37.84322 38.43248 36.91651 35.16071 39.14976 43.08621 43.90575
##  [833] 34.82467 42.14471 53.15418 35.62408 38.00015 39.42259 40.14663 44.85357
##  [841] 42.53956 35.50310 38.53007 40.37381 41.53228 44.14092 50.58284 28.20129
##  [849] 31.61817 39.09399 42.27544 34.46739 35.77262 32.71468 38.48621 31.00632
##  [857] 43.91969 45.35456 32.89902 31.57086 39.64013 40.41611 34.09023 38.15909
##  [865] 38.95958 35.90721 39.61645 40.82193 47.80368 39.77145 47.42125 41.26604
##  [873] 34.40858 37.31925 34.73178 40.95665 41.30705 40.24987 37.70490 39.79256
##  [881] 40.31201 42.06998 31.55675 40.02766 34.25439 43.55567 41.06393 39.80117
##  [889] 28.38112 38.17689 34.98413 41.92662 48.54365 36.33097 45.11204 50.44200
##  [897] 43.69292 30.16941 42.36625 36.17536 33.81223 35.29527 37.67751 39.88470
##  [905] 43.34465 40.04635 32.54709 36.30164 38.57083 40.40174 45.90388 45.81850
##  [913] 32.42074 36.02935 41.53810 34.17836 51.52395 32.85121 46.34117 41.68281
##  [921] 36.32977 40.07988 38.30491 35.15482 34.62520 38.75865 38.48629 35.33646
##  [929] 32.48914 32.34378 34.17849 46.81026 32.76901 28.51419 38.06180 48.35278
##  [937] 43.13566 47.82170 43.87652 44.97439 36.66135 38.03682 38.18623 47.15965
##  [945] 38.71998 40.69695 36.61307 38.45170 39.12257 38.18207 37.19811 37.14836
##  [953] 41.54202 39.93591 37.75112 47.46125 49.91662 36.10504 37.37422 37.22150
##  [961] 38.11532 35.67241 39.71466 44.03406 38.41703 36.09232 29.78199 38.15964
##  [969] 36.63945 35.66124 30.65900 42.36710 35.04351 36.24703 40.69868 36.61926
##  [977] 39.76654 33.88692 36.94801 27.87888 36.62097 44.18726 30.95480 38.53789
##  [985] 37.18770 38.91599 47.47248 41.99003 49.75864 39.47757 44.68070 49.02757
##  [993] 44.29687 31.84685 32.50794 32.58093 45.63679 38.15102 42.38091 47.75253
```

```
vicio_l = mean(T0) - mu;
mean(T0)
```

```
## [1] 54.38943
```

```
vicio_l
```

```
## [1] 0.2112059
```

```
EQM_l = var(T0) + vicio_l^2; EQM_l
```

```
## [1] 55.6645
```

```
vicio_s = mean(T1) - sigma
EQM_s = var(T1) + vicio_s^2
```

```
Tabela <- data.frame("Vícios" = c(vicio_l, vicio_s),
                     "EQMs" = c(EQM_l, EQM_s),
                     "Estimativa" = c(mean(T0), mean(T1)),
                     "Verdadeiro" = c(mu, sigma),
                     row.names = c("mu", "Sigma"))
```

```
Tabela
```

```
##            Vícios     EQMs Estimativa Verdadeiro
## mu     0.2112059 55.66450   54.38943   54.17822
## Sigma -0.7732346 26.25845   39.22677   40.00000
```

```
#n = 10
#n = 30
n = 100
mu = mean(y)
mu
```

```
## [1] 51.11086
```

```
sigma = 40
```

```
y <- rnorm(n, mu, sigma)
y
```

```
##   [1] 111.8455813  35.2997546  57.4731099  79.1794869 -23.3881517 106.4237286
##   [7]  71.1878776  45.6472852 103.5079801  28.8469970   9.6258625  19.7531063
##  [13]  69.3296537 104.6371616  60.6015510  95.2757903   1.7958085  57.7936090
##  [19]  56.2828240 106.9931143  51.8465701 -55.4423221  33.8456416  62.3636948
##  [25]  52.1944779  54.1112133 132.4322544  -0.9970426  66.3236438 -28.9847531
##  [31] -30.6794628 -18.8573920  22.0366199  59.1125474  97.1543718 120.2541849
##  [37]  43.5622798  22.5352812 -21.7651601   7.5996852 118.9689286  54.5511978
##  [43] -20.0183057  27.4124797  51.5524361  86.5067420  13.8175078   5.5376764
##  [49]  -8.4266321 100.5820014  96.3304442  63.2826513  54.9711726  59.6643415
##  [55]  78.5988981  52.4181858  66.6701078  18.8474136  68.4605094  73.7177924
##  [61]  24.8109491  94.8425226  79.6391969 108.5703320  -3.0456379  34.2897975
##  [67] 119.1357946  92.7320102  63.3264623  80.9629582  54.3003874  69.4020113
##  [73]  60.9505143  66.7452337  32.0258939 -38.2469426  21.8745431  43.7891183
##  [79]  27.1757336  19.6565462  23.4882619  61.0613036 149.7376039  25.6560098
##  [85]  85.7296984  35.5126611 102.9917572   4.3237243  31.7695909  11.6057676
##  [91] 155.3981587 170.5650385  35.1678148  22.5394495 -18.1047863  66.1394182
##  [97]  40.6498025  36.3860394  61.5073174  58.9533380
```

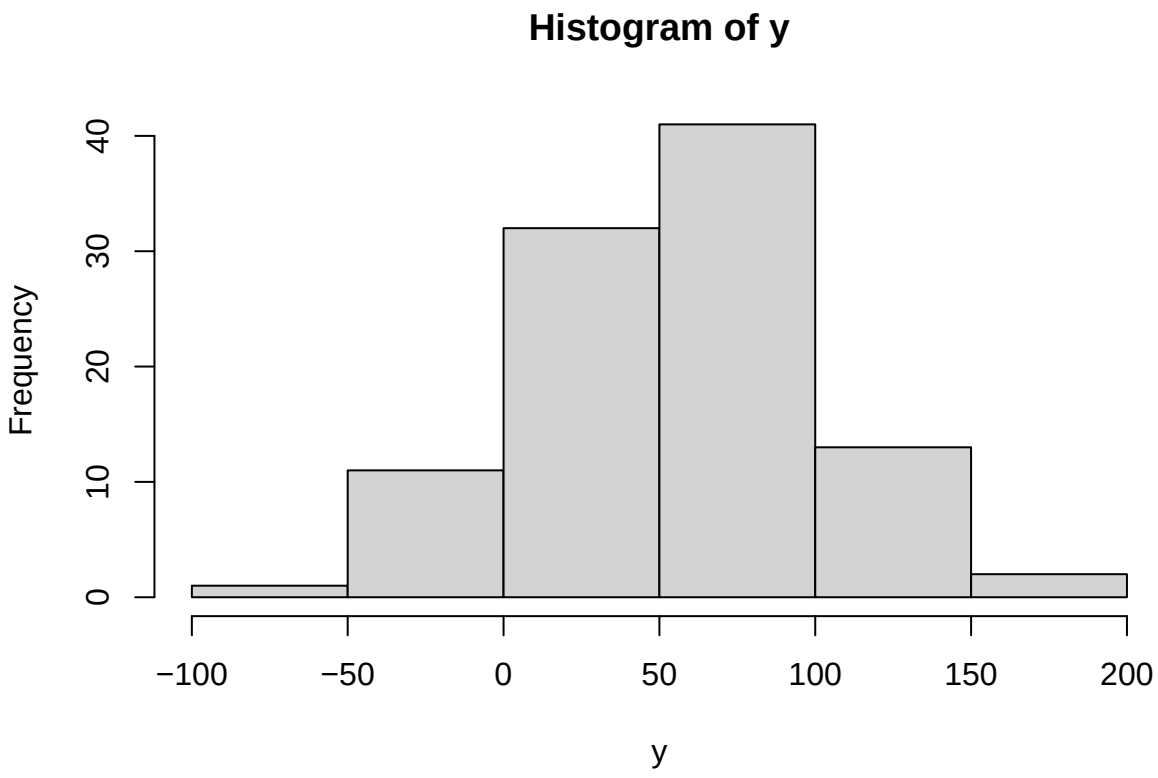
```
mean(y)
```

```
## [1] 51.44219
```

```
sd(y)
```

```
## [1] 44.03771
```

```
hist(y)
```




```
logvero <- function(param, y) {
  mu = param[1]
  sigma = param[2]
  lv = log((1/(sigma*sqrt(2*pi)))*exp(-0.5*((y - mu)/sigma)^2))
  soma = -sum(lv)
  return(soma)
}
```

```
N = 1000
T0 = NULL
T1 = NULL
```

```
for (i in 1:N){
  y = rnorm(n, mu, sigma)
  fit1 <- optim(par = c(mean(y),sd(y)),logvero,
                y = y,
                method = "BFGS",
                hessian = TRUE)

  T0[i] = fit1$par[1]
  T1[i] = fit1$par[2]
}
```

```
T0
```

```
##    [1] 55.61665 49.59694 50.89424 52.22635 57.60711 52.70953 52.02921 57.00676
##    [9] 50.90791 39.59763 55.82895 56.62517 54.64809 54.43094 49.42675 52.90737
##   [17] 48.27571 52.79432 49.68117 54.46057 59.73921 57.37479 55.46975 56.49930
```

```
##   [25] 48.99295 51.36570 40.02779 50.48127 55.65508 45.76414 51.91226 55.08744
##   [33] 50.92810 56.12538 51.34498 53.80432 50.49897 47.10407 55.19125 52.31922
##   [41] 52.13258 49.16714 52.01199 42.90989 54.03401 53.45484 51.14850 50.13520
##   [49] 50.22392 48.19963 50.69716 48.14365 53.27189 60.86889 48.77508 46.69531
##   [57] 53.30046 50.62087 44.25757 49.98985 52.48191 50.49547 52.87817 45.47657
##   [65] 52.63752 49.75298 48.15251 51.74578 52.07335 51.95364 46.59474 45.81915
##   [73] 50.54819 48.25970 49.74972 52.47934 49.05405 44.96854 47.84166 52.99386
##   [81] 47.56447 52.15685 56.85235 53.94279 44.40025 50.86336 53.93098 49.85091
##   [89] 48.69677 46.44314 51.16140 57.34788 56.37177 55.66390 46.09237 52.60166
##   [97] 51.55328 47.17596 53.61331 58.02992 52.54199 50.74476 52.48785 46.51256
##  [105] 47.29739 56.42893 53.37713 54.43075 50.22732 49.84854 54.58625 50.04059
##  [113] 49.21763 49.87012 54.79922 46.72636 54.49737 47.75035 54.22040 46.73999
##  [121] 49.23165 49.13510 55.12716 48.12888 45.36856 46.28317 56.97171 51.25505
##  [129] 49.05280 56.33567 54.03001 52.02125 49.10218 61.88362 51.96188 49.24563
##  [137] 53.98792 54.84832 53.46492 49.53467 46.97677 50.63698 46.71572 41.63798
##  [145] 50.86341 51.66027 47.52148 51.44624 57.44620 50.57776 50.24782 48.47752
##  [153] 50.35235 57.75823 52.08117 54.73926 43.66424 49.62620 52.30714 54.53688
##  [161] 53.71647 56.11037 46.70485 51.56705 49.48696 49.66997 47.00165 51.58636
##  [169] 48.97454 47.29349 56.51422 52.47787 43.38258 49.25606 43.90163 49.11696
##  [177] 50.00062 50.94764 54.41578 50.82577 46.42130 50.79359 50.93133 48.52397
##  [185] 58.68301 55.60145 53.72994 51.42888 46.17236 57.70584 56.77757 52.67880
##  [193] 50.24919 48.54126 47.04830 56.17920 49.08763 52.28362 53.82708 50.86439
##  [201] 55.32207 51.35807 48.57605 47.97732 49.63146 49.98473 57.05270 47.76573
##  [209] 49.75179 51.92368 52.14515 44.96579 52.18109 54.49733 54.10309 45.85972
##  [217] 54.38082 50.27616 47.07157 52.37885 59.18855 55.92617 57.09932 59.44254
##  [225] 54.81733 55.01534 51.05597 44.28270 50.70107 49.49816 53.72217 49.53658
##  [233] 55.86629 47.73157 49.27155 56.39690 47.99097 45.25195 45.48967 55.07338
##  [241] 44.18953 54.82901 49.60557 52.44446 54.42930 40.35833 54.25992 51.54347
##  [249] 54.38548 53.94577 49.92570 51.52107 52.26869 50.99403 44.57175 51.15902
##  [257] 55.86155 52.62620 47.93487 54.39292 47.47238 53.94787 54.29426 51.96678
##  [265] 51.39346 48.35957 48.78903 51.55747 48.31063 60.13795 54.55849 55.04317
##  [273] 47.74390 50.37740 52.47630 51.96207 56.82430 52.48197 51.18565 45.64081
##  [281] 50.32779 56.25593 54.36346 55.01105 51.68622 58.17046 52.10988 46.68765
##  [289] 52.71076 50.86386 48.98264 52.74731 54.05112 49.04932 49.31763 44.35056
##  [297] 53.33470 50.51870 44.11982 52.52186 48.67380 48.56148 58.03814 57.30230
##  [305] 54.99418 44.34507 54.36698 52.36991 52.32240 53.36904 55.55803 50.67168
##  [313] 47.88199 42.57363 50.10184 47.05330 54.16590 55.46993 49.71271 55.82770
##  [321] 50.81844 53.41697 47.40865 51.12710 53.02073 54.54628 47.19331 54.42151
##  [329] 51.38901 47.19857 51.38740 48.66059 54.14706 51.57597 50.01270 49.29046
##  [337] 47.42215 43.61738 48.15869 44.77774 50.42851 52.41170 56.81490 53.90589
##  [345] 55.16013 50.09804 46.41689 55.08666 49.42157 53.70060 49.15938 60.46620
##  [353] 46.15218 58.94766 56.60958 53.77094 57.53058 54.06773 54.95639 53.15997
##  [361] 56.90693 48.69307 49.39422 57.04004 52.13137 48.11580 54.70223 53.02402
##  [369] 49.84423 47.80747 51.47550 50.87068 57.18374 48.50502 60.57244 52.20996
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```

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mean(T0)
```

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```

```
vicio_l
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## [1] 0.1044936
```

```
EQM_l = var(T0) + vicio_l^2; EQM_l
```

```
## [1] 16.02203
```

```
vicio_s = mean(T1) - sigma
EQM_s = var(T1) + vicio_s^2
```

```
Tabela <- data.frame("Vícios" = c(vicio_l, vicio_s),
                     "EQMs" = c(EQM_l, EQM_s),
                     "Estimativa" = c(mean(T0), mean(T1)),
                     "Verdadeiro" = c(mu, sigma),
                     row.names = c("mu", "Sigma"))
```

```
Tabela
```

```
##           Vícios      EQMs Estimativa Verdadeiro
## mu     0.1044936 16.022030   51.21536   51.11086
## Sigma -0.2133870  7.865354   39.78661   40.00000
```