

# Package ‘bayesDccGarch’

May 7, 2026

**Type** Package

**Title** Methods and Tools for Bayesian Dynamic Conditional Correlation  
GARCH(1,1) Model

**Version** 3.0.4

**Author** Jose Augusto Fiorucci [aut, cre, cph] (ORCID:  
<<https://orcid.org/0000-0002-1201-9089>>),  
Ricardo Sanders Ehlers [aut, cph] (ORCID:  
<<https://orcid.org/0000-0001-9034-5173>>),  
Francisco Louzada [aut, cph] (ORCID:  
<<https://orcid.org/0000-0001-7815-9554>>)

**Maintainer** Jose Augusto Fiorucci <jafiorucci@gmail.com>

**Description** Bayesian estimation of dynamic conditional correlation GARCH model for multivariate time series volatility (Fioruci, J.A., Ehlers, R.S. and Andrade-Filho, M.G., (2014). <[doi:10.1080/02664763.2013.839635](https://doi.org/10.1080/02664763.2013.839635)>).

**License** GPL (>= 2)

**Encoding** UTF-8

**LazyData** true

**Depends** R (>= 2.0), numDeriv, coda

**BugReports** <https://github.com/jafiorucci/bayesDccGarch/issues>

**URL** <https://ui.adsabs.harvard.edu/abs/2014arXiv1412.2967F/abstract>

**NeedsCompilation** yes

**RoxygenNote** 7.1.2

**Repository** CRAN

**Date/Publication** 2023-04-22 07:20:02 UTC

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bayesDccGarch-package *bayesDccGARCH: Methods and tools for Bayesian analysis of DCC-GARCH(1,1) Model.*

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## Description

In this package we implemented functions for Bayesian analysis of DCC-GARCH(1,1) Model using the same modelling of Fioruci et al (2014a). Several probabilities distributions are available for the errors which can model both skewness and heavy tails. See Fioruci et al (2014b) for more details about the package.

## Details

Package: bayesDccGarch  
 Type: Package  
 Version: 3.0.4  
 Date: 2023-04-21  
 License: GPL (>=2.14)

```
bayesDccGarch(mY, n_sim = 10000)
```

## Author(s)

Jose Augusto Fiorucci, Ricardo Sandes Ehlers and Francisco Louzada. Maintainer: Jose Augusto Fiorucci <jafiorucci@gmail.com>

## References

Fioruci, J.A., Ehlers, R.S., Andrade Filho, M.G. *Bayesian multivariate GARCH models with dynamic correlations and asymmetric error distributions*, Journal of Applied Statistics, 41(2), 320–331, 2014a, <doi:10.1080/02664763.2013.839635>.

Fioruci, J.A., Ehlers, R.S., Louzada, F. *BayesDccGarch - An Implementation of Multivariate GARCH DCC Models*, ArXiv e-prints, 2014b. <https://ui.adsabs.harvard.edu/abs/2014arXiv1412.2967F/abstract>

## See Also

Available functions: [bayesDccGarch](#), [update](#), [predict](#), [plot](#), [logLikDccGarch](#), [dssnorm](#), [dsst](#), [dssged](#), [plotVol](#)

**Examples**

```

data(DaxCacNik)

out = bayesDccGarch(DaxCacNik)

summary(out)

plot(out)

```

---

bayesDccGarch	<i>Bayesian Estimation of the DCC-GARCH(1,1) Model.</i>
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---

**Description**

Performs a Markov Chain for all parameters of the DCC-GARCH(1,1) Model.

**Usage**

```

bayesDccGarch(mY, nSim = 10000, tail_ini = 8, omega_ini=0.1*diag(var(mY)),
  alpha_ini=rep(0.05, ncol(mY)), beta_ini=rep(0.85, ncol(mY)),
  a_ini = 0.04, b_ini = 0.8, gamma_ini = rep(1, ncol(mY)),
  errorDist = 2, control = list())

increaseSim(x, nSim=10000)

## S3 method for class 'bayesDccGarch'
update(object, ..., mY_new)

## S3 method for class 'bayesDccGarch'
window(x, start = NULL, end = NULL, thin = NULL, ...)

```

**Arguments**

mY	a matrix of the data ( $n \times k$ ).
nSim	length of Markov chain. Default: 10000.
tail_ini	initial value of $\nu$ parameter if errorDist = 2 or initial value of $\delta$ parameter if errorDist = 3. If errorDist = 1 this arguments is not used.
omega_ini	a numeric vector ( $k \times 1$ ) with the initial values of $\omega_i$ parameters. Default: rep(0.03, ncol(mY)).
alpha_ini	a numeric vector ( $k \times 1$ ) with the initial values of $\alpha_i$ parameters. Default: rep(0.03, ncol(mY)).

beta_ini	a numeric vector ( $k \times 1$ ) with the initial values of $\beta_i$ parameters. Default: rep(0.8, ncol(mY)).
a_ini	a numeric value of the initial values of $a$ parameter. Default: 0.03.
b_ini	a numeric value of the initial values of $b$ parameter. Default: 0.8.
gamma_ini	a numeric vector ( $k \times 1$ ) with the initial values of $\gamma_i$ parameters. Default: rep(1.0, ncol(mY)).
errorDist	a probability distribution for errors. Use errorDist=1 for <i>SSNorm</i> , errorDist=2 for <i>SST</i> or errorDist=3 for <i>SSGED</i> . Default: 2.
control	list of control arguments (See *Details*).
x, object	an object of bayesDccGarch class.
mY_new	a matrix of new data ( $n_{new} \times k$ ).
start	the first iteration of interest from Markov chain.
end	the last iteration of interest from Markov chain.
thin	the required interval between successive samples.
...	additional arguments for S3 generic window function

## Details

The bayesDccGarch() function performs a Markov Chain for all parameters of the model DCC-GARCH(1,1) (or GARCH(1,1) in the univariate case). There are three options of probability distributions for the error component. These are the standardized skew versions of normal, t-student and ged distributions. See Fioruci et al (2014a) and Fioruci et al (2014b) for any detail. The control argument can be used for define the prior hyper-parameters and the simulation algorithm parameters. It is a list that can supply any of the following components:

- \$mu\_tail** the value of hyper-parameter  $\mu_\nu$  if errorDist=2 or the hyper-parameter  $\mu_\delta$  if errorDist=3. Default: 8
- \$mu\_gamma** a vector with the hyper-parameters  $\mu_{\gamma_i}$ . Default: rep(0, ncol(mY))
- \$mu\_omega** a vector with the hyper-parameters  $\mu_{\omega_i}$ . Default: rep(0, ncol(mY))
- \$mu\_alpha** a vector with the hyper-parameters  $\mu_{\alpha_i}$ . Default: rep(0, ncol(mY))
- \$mu\_beta** a vector with the hyper-parameters  $\mu_{\beta_i}$ . Default: rep(0, ncol(mY))
- \$mu\_a** the value of the hyper-parameter  $\mu_a$ . Default: 0
- \$mu\_b** the value of the hyper-parameter  $\mu_b$ . Default: 0
- \$sigma\_tail** the value of hyper-parameter  $\sigma_\nu$  if errorDist=2 or the hyper-parameter  $\sigma_\delta$  if errorDist=3. Default: 10
- \$sigma\_gamma** a vector with the hyper-parameters  $\sigma_{\gamma_i}$ . Default: rep(1.25, ncol(mY))
- \$sigma\_omega** a vector with the hyper-parameters  $\sigma_{\omega_i}$ . Default: rep(10, ncol(mY))
- \$sigma\_alpha** a vector with the hyper-parameters  $\sigma_{\alpha_i}$ . Default: rep(10, ncol(mY))
- \$sigma\_beta** a vector with the hyper-parameters  $\sigma_{\beta_i}$ . Default: rep(10, ncol(mY))
- \$sigma\_a** the value of the hyper-parameter  $\sigma_a$ . Default: 10
- \$sigma\_b** the value of the hyper-parameter  $\sigma_b$ . Default: 10

- \$simAlg** the random walk Metropolis-Hasting algorithm update. Use 1 for update all parameters as one block, use 2 for update one parameter for each time and use 3 for an automatic choice.
- \$nPilotSim** number of simulation for pilot sample if `control$simAlg=3`. Default:1000
- \$cholCov** the cholesky decomposition matrix of the covariance matrix for simulation by one-block Metropolis-Hasting. It must to be passed if `control$simAlg=1`.
- \$sdSim** a vector with the standard deviations for simulation by one-dimensional Metropolis-Hasting. It must to be passed if `control$simAlg=2`.
- \$print** a logical variable for if the function should report the number of interactions in each 100 interactions or not. Default: TRUE

The function `increaseSim()` can be used to increase the length of Markov chain simulation.

The function `window()` can be used to filter the Markov chain simulation. In this case, all statistics are recomputed.

### Value

An object of `bayesDccGarch` class, which contains a list with elements:

- |                            |   |
|----------------------------|---|
| <code>\$control</code>     | a list with the used <code>control</code> argument.   |
| <code>\$MC</code>          | an object of <code>mcmc</code> class with the Markov Chain simulation for all parameters. (R package <b>coda</b> )                                    |
| <code>\$H</code>           | a matrix with the Bayesian estimates of volatilities and co-volatilities.   |
| <code>\$R</code>           | a matrix with the estimates of the dynamic conditional correlation.   |
| <code>\$H_n1</code>        | Bayesian prediction of volatilities and co-volatilities for $y_{n+1}$ .   |
| <code>\$R_n1</code>        | Bayesian prediction of conditional correlation for $y_{n+1}$ .  |
| <code>\$IC</code>          | the Bayesian estimate of Akaike Information Criterion, Bayesian Information Criterion and Deviance Information Criterion.                             |
| <code>\$elapsedTime</code> | an object of class <code>proc_time</code> which is a numeric vector of length 5, containing the user, system, and total elapsed times of the process. |

### Author(s)

Jose Augusto Fiorucci, Ricardo Sandes Ehlers and Francisco Louzada

### References

- Fioruci, J.A., Ehlers, R.S., Andrade Filho, M.G. *Bayesian multivariate GARCH models with dynamic correlations and asymmetric error distributions*, Journal of Applied Statistics, 41(2), 320–331, 2014a. <doi:10.1080/02664763.2013.839635>
- Fioruci, J.A., Ehlers, R.S., Louzada, F. *BayesDccGarch - An Implementation of Multivariate GARCH DCC Models*, ArXiv e-prints, 2014b. <https://ui.adsabs.harvard.edu/abs/2014arXiv1412.2967F/abstract>.

### See Also

[bayesDccGarch-package](#), [logLikDccGarch](#), [plot](#), [plotVol](#)

## Examples

```

data(DaxCacNik)

### Bayes DCC-GARCH(1,1) ###
mY = head(DaxCacNik, 1500)
out1 = bayesDccGarch(mY)
  # more 50000 simulations
out2 = increaseSim(out1, 50000)
  # remove first 10000 simulations and take at intervals of 20
out3 = window(out2, start=10000, thin = 20)
summary(out3)

# Plotting volatilities
plot(out3)

# Plotting Markov Chain
plot(out3$MC)

# Forecast volatility
H_pred = predict(out3, n_ahead=200)$H
plot.ts(rbind(out3$H, H_pred), main="volatility: historical and forecast")

# New data
out4 = update(out3, mY_new=DaxCacNik[1501:1628,])
plot(out4)

### Bayes univariate GARCH(1,1) ###
Dax = DaxCacNik[,1]
out = bayesDccGarch(Dax)
summary(out)
plot(out)

```

---

DaxCacNik

*Log-returns of daily indices of stock markets in Frankfurt, Paris and  
Tokio*

---

## Description

The matrix `DaxCacNik` contains daily observations of the hundredfold log-returns of daily indices of stock markets in Frankfurt (DAX), Paris (CAC40) and Tokyo (NIKKEI), from 10 October 1991 until 30 December 1997 (a total of 1627 days). The stock market data is freely available at <https://robjhyndman.com/tsdldata/data/FVD1.dat>.

## Usage

```
data(DaxCacNik)
```

**Author(s)**

Jose Augusto Fiorucci, Ricardo Sandes Ehlers and Francisco Louzada

**References**

Fioruci, J.A., Ehlers, R.S. Andrade Filho, M.G. *Bayesian multivariate GARCH models with dynamic correlations and asymmetric error distributions*, Journal of Applied Statistics, 41(2), 320–331, 2014. <doi:10.1080/02664763.2013.839635>

---

densityFunctions	<i>Density functions of multivariate Standard Skew Norm, t-Student and GED distributions</i>
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---

**Description**

Compute the density function of Standard Skew Normal distribution (SSNORM) or density function of Standard Skew t-Student distribution (SST) or density function of Standard Skew GED distribution (SSGED)

**Usage**

```
dssnorm(x, gamma=rep(1,length(x)), log=FALSE)
```

```
dssst(x, gamma=rep(1,length(x)), nu=10, log=FALSE)
```

```
dssged(x, gamma=rep(1,length(x)), delta=2, log=FALSE)
```

**Arguments**

x	a numeric vector for the point which the density will be computed.
gamma	a numeric vector for skew parameters. Must be positive.
nu	a numeric value of shape parameter of the multivariate Standard Skew t-Student distribution. Must be greater than 2.
delta	a numeric value of shape parameter of GED distribution. Must be positive.
log	logical; if TRUE, densities p are returned as log(p).

**Value**

Returns the computed value of the density.

**Author(s)**

Jose Augusto Fiorucci, Ricardo Sandes Ehlers and Francisco Louzada

## References

Fioruci, J.A., Ehlers, R.S. Andrade Filho, M.G. *Bayesian multivariate GARCH models with dynamic correlations and asymmetric error distributions*, Journal of Applied Statistics, 41(2), 320–331, 2014. <doi:10.1080/02664763.2013.839635>

## See Also

[bayesDccGarch-package](#)

## Examples

```
### Univariate symmetric standard norm distributions ###
dssnorm(x=0)
dsst(x=0, nu=100)
dssged(x=0, delta=2)

### Univariate standard skew norm distributions ###
dssnorm(x=0, gamma=1.5)
dsst(x=0, gamma=1.5, nu=100)
dssged(x=0, gamma=1.5, delta=2)

### Multivariate standard skew norm distributions ###
dssnorm(x=c(0,0), gamma=c(1.5,0.7))
dsst(x=c(0,0), gamma=c(1.5,0.7), nu=100)
dssged(x=c(0,0), gamma=c(1.5,0.7), delta=2)
```

---

logLikDccGarch

*The logarithm of likelihood function of DCC-GARCH(1,1) Model.*

---

## Description

Compute the logarithm of likelihood function of DCC-GARCH(1,1) Model if `mY` is a matrix or the logarithm of likelihood function of GARCH(1,1) Model if `mY` is numeric vector.

## Usage

```
logLikDccGarch(mY, omega = rep(0.03, ncol(mY)), alpha = rep(0.03, ncol(mY)),
beta = rep(0.8, ncol(mY)), a = 0.03, b = 0.8, gamma = rep(1, ncol(mY)),
tail = 10, errorDist = 2)
```

## Arguments

<code>mY</code>	a matrix of the data ( $n \times k$ ).
<code>omega</code>	a numeric vector ( $k \times 1$ ) with the the values of $\omega_i$ parameters. Default: <code>rep(0.03, ncol(mY))</code> .
<code>alpha</code>	a numeric vector ( $k \times 1$ ) with the the values of $\alpha_i$ parameters. Default: <code>rep(0.03, ncol(mY))</code> .

beta	a numeric vector ( $k \times 1$ ) with the the values of $\beta_i$ parameters. Default: <code>rep(0.80, ncol(mY))</code> .
a	a numeric value of the $a$ parameter. Default: <code>0.03</code> .
b	a numeric value of the $b$ parameter. Default: <code>0.8</code> .
gamma	a numeric vector ( $k \times 1$ ) with the values of $\gamma_i$ parameters. Default: <code>rep(1.0, ncol(mY))</code> .
tail	a numeric value of $\nu$ parameter if <code>errorDist = 2</code> or of $\delta$ parameter if <code>errorDist = 3</code> . If <code>errorDist = 1</code> so this arguments is no used.
errorDist	a probability distribution for errors. Use <code>errorDist=1</code> for <i>SSNorm</i> , <code>errorDist=2</code> for <i>SST</i> or <code>errorDist=3</code> for <i>SSGED</i> . Default: <code>2</code> .

### Details

The log-likelihood of the model GARCH(1,1) is computed if `mY` has just one column. The arguments `a` and `b` are not consider in this case.

### Value

Return a list with the elements:

<code>\$H</code>	a matrix where the lines are the $H_t$ values for $t=1, \dots, n$ .
<code>\$value</code>	the value of the logarithm of likelihood function.

### Author(s)

Jose Augusto Fiorucci, Ricardo Sandes Ehlers and Francisco Louzada

### References

- Fioruci, J.A., Ehlers, R.S., Andrade Filho, M.G. *Bayesian multivariate GARCH models with dynamic correlations and asymmetric error distributions*, Journal of Applied Statistics, 41(2), 320–331, 2014a. <doi:10.1080/02664763.2013.839635>
- Fioruci, J.A., Ehlers, R.S., Louzada, F. *BayesDccGarch - An Implementation of Multivariate GARCH DCC Models*, ArXiv e-prints, 2014b. <https://ui.adsabs.harvard.edu/abs/2014arXiv1412.2967F/abstract>.

### See Also

[bayesDccGarch-package](#), [bayesDccGarch](#)

### Examples

```
data(DaxCacNik)

Dax = DaxCacNik[,1]

##### log-likelihood function of GARCH(1,1) model with SST innovations ####
logLikDccGarch(Dax, omega=0.03, alpha=0.03, beta=0.8, gamma=0.7)$value
```

```
##### log-likelihood function of DCC-GARCH(1,1) model with SST innovations ####
logLikDccGarch(DaxCacNik, beta=c(0.82,0.91,0.85), gamma=c(0.7, 1.3, 1.7), tail=10)$value
```

---

plot.bayesDccGarch      *Plotting volatilities for Bayesian DCC-GARCH model*

---

### Description

Produces a plot of time series and the volatilities. This is a particular case of plotVol function.

### Usage

```
## S3 method for class 'bayesDccGarch'
plot(x, ts.names=NULL, colors = c("grey","red"), ...)
```

### Arguments

x	Object of class “bayesDccGarch”.
ts.names	a vector of length $k$ with the names of the time series.
colors	a vector with the colors for plotting the returns and volatilities.
...	additional arguments for plot function

### Value

No return value

### Author(s)

Ricardo Sandes Ehlers, Jose Augusto Fiorucci and Francisco Louzada

### References

Fioruci, J.A., Ehlers, R.S., Andrade Filho, M.G. *Bayesian multivariate GARCH models with dynamic correlations and asymmetric error distributions*, Journal of Applied Statistics, 41(2), 320–331, 2014a. <doi:10.1080/02664763.2013.839635>

Fioruci, J.A., Ehlers, R.S., Louzada, F. *BayesDccGarch - An Implementation of Multivariate GARCH DCC Models*, ArXiv e-prints, 2014b. <https://ui.adsabs.harvard.edu/abs/2014arXiv1412.2967F/abstract>.

### See Also

[bayesDccGarch-package](#), [bayesDccGarch](#), [plotVol](#)

## Examples

```
data(DaxCacNik)

mY = DaxCacNik

out = bayesDccGarch(mY, nSim=1000)
plot(out)
```

---

plotVol	<i>Plotting volatilities of time series</i>
---------	---

---

## Description

Plotting method for volatilities of time series.

## Usage

```
plotVol(mY, vol, ts.names=paste("TS_", 1:ncol(mY), sep=""), colors = c("grey", "red"), ...)
```

## Arguments

mY	a matrix of the data ( $n \times k$ ).
vol	a matrix ( $n \times k$ ) with the volatility estimates.
ts.names	a vector of length $k$ with the names of the time series.
colors	a vector with name of the colors for plotting the returns and volatilities.
...	additional arguments for plot function

## Value

No return value

## Author(s)

Ricardo Sandes Ehlers, Jose Augusto Fiorucci and Francisco Louzada

## References

- Fioruci, J.A., Ehlers, R.S., Andrade Filho, M.G. *Bayesian multivariate GARCH models with dynamic correlations and asymmetric error distributions*, Journal of Applied Statistics, 41(2), 320–331, 2014a. <doi:10.1080/02664763.2013.839635>
- Fioruci, J.A., Ehlers, R.S., Louzada, F. *BayesDccGarch - An Implementation of Multivariate GARCH DCC Models*, ArXiv e-prints, 2014b. <https://ui.adsabs.harvard.edu/abs/2014arXiv1412.2967F/abstract>.

**See Also**

[bayesDccGarch-package](#), [bayesDccGarch](#), [plot.bayesDccGarch](#)

**Examples**

```
data(DaxCacNik)

mY = DaxCacNik

out = bayesDccGarch(mY)

## The code
plotVol(mY, out$H[,c("H_1,1", "H_2,2", "H_3,3")], c("DAX", "CAC40", "NIKKEI"))

## gives the result of ##
plot(out)
```

---

predict.bayesDccGarch *Bayesian forecast for volatilities and conditional correlations*

---

**Description**

Bayesian forecast for volatilities and conditional correlations

**Usage**

```
## S3 method for class 'bayesDccGarch'
predict(object, ..., n_ahead = 5, bayes = T)
```

**Arguments**

object	a bayesDccGarch object
...	default argument of predict function, not used
n_ahead	number of steps ahead forecast
bayes	a boolean. If True, then the forecast is calculated as being the average of the forecasts across all states in the Markov chain (much slower). If False then predictions are calculated using estimation parameters (much faster).

**Value**

A list with elements H and R

## **References**

Engle, R.F. and Sheppard, K. Theoretical and empirical properties of dynamic conditional correlation multivariate GARCH, 2001, NBER Working Paper.

## **Examples**

```
out = bayesDccGarch(DaxCacNik)
predict.bayesDccGarch(out, n_ahead=5)
```

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