Package 'bayesDccGarch'

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Type Package

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

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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>.

License GPL (>= 2)

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

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

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```
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 *Bayesian Estimation of the DCC-GARCH(1,1) Model.*

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 ν parameter if errorDist = 2 or initial value of δ 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 ω_i parameters. Default: rep(0.03, ncol(mY)).
alpha_ini	a numeric vector ($k \times 1$) with the initial values of α_i parameters. Default: rep(0.03, ncol(mY)).

beta_ini	a numeric vector ($k \times 1$) with the initial values of β_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 γ_i parameters. Default: rep(1.0, ncol(mY)).
errorDist	a probability distribution for errors. Use errorDist=1 for $SSNorm$, errorDist=2 for SST or errorDist=3 for $SSGED$. 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 μ_ν if errorDist=2 or the hyper-parameter μ_δ if errorDist=3. Default: 8

$mu_gamma a vector with the hyper-parameters μ_{γ_i}. Default: rep(0,ncol(mY)

$mu_omega a vector with the hyper-parameters μ_{ω_i}. Default: rep(0,ncol(mY)

$mu_alpha a vector with the hyper-parameters μ_{α_i}. Default: rep(0,ncol(mY)

$mu_beta a vector with the hyper-parameters μ_{β_i}. Default: rep(0,ncol(mY)

$mu_a the value of the hyper-parameter μ_a. Default: 0

$mu_b the value of the hyper-parameter μ_b. Default: 0

$sigma_tail the value of hyper-parameter σ_ν if errorDist=2 or the hyper-parameter σ_δ if errorDist=3. Default: 10

$sigma_gamma a vector with the hyper-parameters σ_{γ_i}. Default: rep(1.25,ncol(mY)

$sigma_omega a vector with the hyper-parameters σ_{ω_i}. Default: rep(10,ncol(mY)

$sigma_alpha a vector with the hyper-parameters σ_{α_i}. Default: rep(10,ncol(mY)

$sigma_beta a vector with the hyper-parameters σ_{β_i}. Default: rep(10,ncol(mY)

$sigma_a the value of the hyper-parameter σ_a. Default: 10

$sigma_b the value of the hyper-parameter σ_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:

`$control`	a list with the used `control` argument.
`$MC`	an objetic of `mcmc` class with the Markov Chain simulation for all parameters. (R package **coda**)
`$H`	a matrix with the Bayesian estimates of volatilities and co-volatilities.
`$R`	a matrix with the estimates of the dynamic coditional correlation.
`$H_n1`	Bayesian prediction of volatilities and co-volatilities for y_n+1.
`$R_n1`	Bayesian prediction of coditional correlation for y_n+1.
`$IC`	the Bayesian estimate of Akaike Information Criterion, Bayesian Information Criterion and Deviance Information Criterion.
`$elapsedTime`	an object of class `proc_time` 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>

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densityFunctions *Density functions of multivariate Standard Skew Norm, t-Student and GED distributions*

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)

dsst(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

`mY`	a matrix of the data ($n \times k$).
`omega`	a numeric vector ($k \times 1$) with the the values of ω_i parameters. Default: `rep(0.03, ncol(mY))`.
`alpha`	a numeric vector ($k \times 1$) with the the values of α_i parameters. Default: `rep(0.03, ncol(mY))`.

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

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:

$H	a matrix where the lines are the H_t values for t=1,...,n.
$value	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` *Plotting volatilities of time series*

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 coditional correlations*

Description

Bayesian forecast for volatilities and coditional 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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