

# Package ‘ccgarch’

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analytical.grad	<i>Analytical gradient of the log-likelihood function of the (E)CCC-GARCH(1,1) model</i>
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## Description

This function returns the analytical gradient of the log-likelihood function of the (E)CCC-GARCH(1,1) model.

## Usage

```
analytical.grad(a, A, B, R, u, model)
```

## Arguments

a	a vector of constants in the vector GARCH equation ( $N \times 1$ )
A	an ARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
B	a GARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
R	a constant conditional correlation matrix ( $N \times N$ )
u	a matrix of the data used for estimating the (E)CCC-GARCH(1,1) model ( $T \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

**Value**

a  $npar \times T$  matrix of gradients

**Note**

In the output, each column (not row) corresponds to the gradient at observation  $t$ .

**References**

Nakatani, T. and T. Teräsvirta (2009), “Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model”, *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Teräsvirta (2008), “Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*” Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

---

analytical.Hessian *Analytical Hessian of the (E)CCC-GARCH*

---

**Description**

This function computes the analytical Hessian of the log-likelihood function of the (E)CCC-GARCH model.

**Usage**

```
analytical.Hessian(a, A, B, R, u, model)
```

**Arguments**

a	a vector of constants in the vector GARCH equation ( $N \times 1$ )
A	an ARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
B	a GARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
R	a constant conditional correlation matrix ( $N \times N$ )
u	a matrix of the data data used for estimating the (E)CCC-GARCH(1,1) model ( $T \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

**Value**

a  $npar \times npar$  Hessian matrix of the log-likelihood function of the (E)CCC-GARCH model

## References

Nakatani, T. and T. Teräsvirta (2009), “Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model”, *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Teräsvirta (2008), “Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*” Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

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d2lv

*Hessian of the DCC log-likelihood function*

---

## Description

This function returns the analytical Hessian of the volatility part of the DCC log-likelihood function.

## Usage

```
d2lv(u, B, h, model)
```

## Arguments

u	a matrix of the data data used for estimating the (E)DCC-GARCH(1,1) model ( $T \times N$ )
B	a GARCH parameter matrix ( $N \times N$ )
h	a matrix of the conditional variances ( $T \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

## Value

the Hessian of the volatility part of the DCC log-likelihood function ( $T \times N^2$ )

## References

Engle, R.F. and K. Sheppard (2001), “Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH.” *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), “Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models.” *Journal of Business and Economic Statistics* **20**, 339–350.

Hafner, C.M. and H. Herwartz (2008), “Analytical Quasi Maximum Likelihood Inference in Multivariate Volatility Models.” *Metrika* **67**, 219–239.

---

dcc.est                      *Dynamic conditional correlations*

---

### Description

This function returns dynamic conditional correlations based on the parameters specified.

### Usage

```
dcc.est(dvar, param)
```

### Arguments

dvar	a matrix of the standardised residuals ( $T \times N$ )
param	a vector of the DCC parameters ( $2 \times 1$ )

### Value

a list with components:

DCC	a matrix of the dynamic conditional correlations ( $T \times N^2$ )
Q	a matrix of the $\mathbf{Q}_t$ ( $T \times N^2$ )

### Note

a constant matrix  $\mathbf{Q}$  in the DCC equation is computed by  $\mathbf{Q} = cov(dvar)$ .

### References

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

---

dcc.estimation      *Estimating an (E)DCC-GARCH model*

---

### Description

This function carries out the two step estimation of the (E)DCC-GARCH model and returns estimates, standardised residuals, the estimated conditional variances, and the dynamic conditional correlations.

### Usage

```
dcc.estimation(inia, iniA, iniB, ini.dcc, dvar, model,
method="BFGS", gradient=1, message=1)
```

### Arguments

<code>inia</code>	a vector of initial values for the constants in the GARCH equation $\text{length}(inia) = N$
<code>iniA</code>	a matrix of initial values for the ARCH parameter matrix ( $N \times N$ )
<code>iniB</code>	a matrix of initial values for the GARCH parameter matrix ( $N \times N$ )
<code>ini.dcc</code>	a vector of initial values for the DCC parameters ( $2 \times 1$ )
<code>dvar</code>	a matrix of the data ( $T \times N$ )
<code>model</code>	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model
<code>method</code>	a character string specifying the optimisation method in <code>optim</code> . There are three choices, namely, Nelder-Mead, BFGS (default) and CG.
<code>gradient</code>	a switch variable that determines the optimisation algorithm in the second stage optimisation. If <code>gradient=0</code> Nelder-Mead is invoked. Otherwise BFGS is used (default).
<code>message</code>	a switch variable to turn off the display of the message when the estimation is completed. If <code>message=0</code> , the message is suppressed. Otherwise, the message is displayed (default)

### Value

a list with components:

<code>out</code>	the parameter estimates and their standard errors
<code>loglik</code>	the value of the log-likelihood at the estimates
<code>h</code>	a matrix of the estimated conditional variances ( $T \times N$ )
<code>DCC</code>	a matrix of the estimated dynamic conditional correlations ( $T \times N^2$ )
<code>std.resid</code>	a matrix of the standardised residuals ( $T \times N$ ). See <i>Note</i> .
<code>first</code>	the results of the first stage estimation
<code>second</code>	the results of the second stage estimation

**Note**

The standardised residuals are calculated by dividing the original series `dvar` by the estimated conditional standard deviations `sqrt(h)`. See Engle (2002), in particular the equations (2) and (14), for details.

`dcc.estimation` calls `dcc.estimation1` and `dcc.estimation2` for the first and second stage estimation, respectively.

The details of the first and second stage estimation are also saved.

The switch variable `simulation` is useful when one uses `dcc.estimation` for simulation. It suppresses the display of the completion message.

**References**

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

**See Also**

[dcc.estimation1](#), [dcc.estimation2](#), [loglik.dcc1](#), [loglik.dcc2](#), [vector.garch](#), [dcc.est](#)

**Examples**

```
# Simulating data from the original DCC-GARCH(1,1) process
nobs <- 1000; cut <- 1000
a <- c(0.003, 0.005, 0.001)
A <- diag(c(0.2, 0.3, 0.15))
B <- diag(c(0.75, 0.6, 0.8))
uncR <- matrix(c(1.0, 0.4, 0.3, 0.4, 1.0, 0.12, 0.3, 0.12, 1.0), 3, 3)
dcc.para <- c(0.01, 0.98)
dcc.data <- dcc.sim(nobs, a, A, B, uncR, dcc.para, model="diagonal")

# Estimating a DCC-GARCH(1,1) model
dcc.results <- dcc.estimation(inia=a, iniA=A, iniB=B, ini.dcc=dcc.para,
                             dvar=dcc.data$eps, model="diagonal")

# Parameter estimates and their robust standard errors
dcc.results$out
```

---

`dcc.estimation1`     *Maximising the first stage log-likelihood function of the (E)DCC-GARCH model*

---

### Description

This function carries out the first stage (volatility part) estimation of the (E)DCC-GARCH model.

### Usage

```
dcc.estimation1(dvar, a, A, B, model, method="BFGS")
```

### Arguments

<code>dvar</code>	a matrix of the data used for estimating the (E)DCC-GARCH(1,1) model ( $T \times N$ )
<code>a</code>	a vector of constants in the vector GARCH equation ( $N \times 1$ )
<code>A</code>	an ARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
<code>B</code>	a GARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
<code>model</code>	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model
<code>method</code>	a character string specifying the optimisation method in <code>optim</code> . There are three choices, namely, "Nelder-Mead", "BFGS" (default) and "CG".

### Value

a list of the estimation results. See the explanations in `optim`.

### References

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

### See Also

`optim`, [dcc.estimation2](#), [dcc.estimation](#)

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dcc. estimation2	<i>Maximising the second stage log-likelihood function of the (E)DCC-GARCH model</i>
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---

### Description

This function carries out the second stage (DCC part) estimation of the (E)DCC-GARCH model.

### Usage

```
dcc. estimation2 (dvar, para, gradient=0)
```

### Arguments

dvar	a matrix of the standardised residuals ( $T \times N$ )
para	a vector of the DCC parameters ( $2 \times 1$ )
gradient	a switch variable whether to use the gradient in the constraint optimisation. passed to <code>constrOptim</code>

### Value

a list of the estimation results. See the explanations for `constrOptim`.

### Note

`dcc. estimation2` is a wrapper to `constrOptim`. The restrictions are  $\alpha + \beta \leq 1$  and  $\alpha, \beta \geq 0$  in the DCC equation.

### References

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

### See Also

`constrOptim`, [dcc. estimation1](#), [dcc. estimation](#)

---

<code>dcc.results</code>	<i>Computing robust standard errors of the estimates in the (E)DCC-GARCH model</i>
--------------------------	--

---

### Description

This function computes the robust standard errors of the estimates of a DCC-GARCH model.

### Usage

```
dcc.results(u, garch.para, dcc.para, h, model)
```

### Arguments

<code>u</code>	a matrix of the data used for estimating the (E)DCC-GARCH model ( $T \times N$ )
<code>garch.para</code>	a vector of the estimates of the volatility parameters
<code>dcc.para</code>	a vector of the estimates of the DCC parameters ( $2 \times 1$ )
<code>h</code>	a matrix of the estimated conditional variances ( $T \times N$ )
<code>model</code>	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

### Value

A matrix with the estimates in the first row, and the standard errors in the second row.

### Note

`dcc.results` is called from `dcc.estimate`. When `model="diagonal"`, only the diagonal entries in A and B are used.

### References

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

### See Also

[dcc.estimate](#)

---

 dcc.sim

 Simulating an (E)DCC-GARCH(1,1) process
 

---

## Description

This function simulates data either from the original DCC-GARCH by Engle (2002) or from the Extended DCC-GARCH that has non-zero off-diagonal entries in the parameter matrices in the GARCH equation, with multivariate normal or student's  $t$  distributions.

The dimension ( $N$ ) is determined by the number of elements in the  $a$  vector.

## Usage

```
dcc.sim(nobs, a, A, B, R, dcc.para, d.f=Inf, cut=1000, model)
```

## Arguments

nobs	a number of observations to be simulated ( $T$ )
a	a vector of constants in the vector GARCH equation ( $N \times 1$ )
A	an ARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
B	a GARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
R	an unconditional correlation matrix ( $N \times N$ )
dcc.para	a vector of the DCC parameters ( $2 \times 1$ )
d.f	the degrees of freedom parameter for the $t$ -distribution
cut	the number of observations to be thrown away for removing initial effects of simulation
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

## Value

A list with components:

z	a matrix of random draws from $N(\mathbf{0}, \mathbf{I})$ . ( $T \times N$ )
std.z	a matrix of the standardised residuals. $std.z_t \sim N(0, \mathbf{R}_t)$ where $\mathbf{R}_t$ is the DCC matrix at $t$ . If d.f is set to a finite positive real number, $\mathbf{z}_t \sim t_{d.f}(0, \mathbf{R}_t)$ ( $T \times N$ )
dcc	a matrix of the simulated dynamic conditional correlations ( $T \times N^2$ )
h	a matrix of the simulated conditional variances ( $T \times N$ )
eps	a matrix of the simulated time series with DCC-GARCH process ( $T \times N$ )

**Note**

When `d.f=Inf`, the innovations (the standardised residuals) follow the standard normal distribution. Otherwise, they follow a student's *t*-distribution with `d.f` degrees of freedom.

When `model="diagonal"`, only the diagonal entries in `A` and `B` are used. If the ARCH and GARCH matrices do not satisfy the stationarity condition, the simulation is terminated.

**References**

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series FIN-01-027* (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

**See Also**

[stcc.sim](#), [eccc.sim](#)

**Examples**

```
# Simulating data from the original DCC-GARCH(1,1) process
nobs <- 1000; cut <- 1000; nu <- 8
a <- c(0.003, 0.005, 0.001)
A <- diag(c(0.2, 0.3, 0.15))
B <- diag(c(0.75, 0.6, 0.8))
uncR <- matrix(c(1.0, 0.4, 0.3, 0.4, 1.0, 0.12, 0.3, 0.12, 1.0), 3, 3)
dcc.para <- c(0.01, 0.98)

# for normally distributed innovations
dcc.data <- dcc.sim(nobs, a, A, B, uncR, dcc.para, model="diagonal")

# for t distributed innovations
dcc.data.t <- dcc.sim(nobs, a, A, B, uncR, dcc.para, d.f=nu,
model="diagonal")
```

---

dlc

*Various partial derivatives of the DCC part of the log-likelihood function*

---

**Description**

This function computes various analytical derivatives of the second stage log-likelihood function (the DCC part) of the (E)DCC-GARCH model.

**Usage**

```
dlc(dcc.para, B, u, h, model)
```

**Arguments**

<code>dcc.para</code>	the estimates of the (E)DCC parameters ( $2 \times 1$ )
<code>B</code>	the estimated GARCH parameter matrix ( $N \times N$ )
<code>u</code>	a matrix of the used for estimating the (E)DCC-GARCH model ( $T \times N$ )
<code>h</code>	a matrix of the estimated conditional variances ( $T \times N$ )
<code>model</code>	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

**Value**

a list with components:

<code>dlc</code>	the gradient of the DCC log-likelihood function w.r.t. the DCC parameters ( $T \times 2$ )
<code>dvecP</code>	the partial derivatives of the DCC matrix, $P_t$ w.r.t. the DCC parameters ( $T \times N^2$ )
<code>dvecQ</code>	the partial derivatives of the $Q_t$ matrices w.r.t. the DCC parameters ( $T \times N^2$ )
<code>d2lc</code>	the Hessian of the DCC log-likelihood function w.r.t. the DCC parameters ( $T \times 4$ )
<code>dfdwd2lc</code>	the cross derivatives of the DCC log-likelihood function ( $T \times npar.h + 2$ ) $npar.h$ stand for the number of parameters in the GARCH part, $npar.h = 3N$ for "diagonal" and $npar.h = 2N^2 + N$ for "extended".

**References**

- Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.
- Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.
- Hafner, C.M. and H. Herwartz (2008), "Analytical Quasi Maximum Likelihood Inference in Multivariate Volatility Models." *Metrika* **67**, 219–239.

---

dlv *Gradient of the GARCH part of the log-likelihood function of an (E)DCC-GARCH model*

---

### Description

This function returns the analytical partial derivatives of the volatility part of the log-likelihood function of the DCC-GARCH model. The function is called from `dcc.results`.

### Usage

```
dlv(u, a, A, B, model)
```

### Arguments

u	a matrix of the data used for estimating an (E)DCC-GARCH model ( $T \times N$ )
a	a vector of the constants in the volatility part ( $N \times 1$ )
A	an ARCH parameter matrix ( $N \times N$ )
B	a GARCH parameter matrix ( $N \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

### Value

A matrix of partial derivatives. ( $T \times npar.h$ ) where  $npar.h$  stand for the number of parameters in the GARCH part,  $npar.h = 3N$  for "diagonal" and  $npar.h = 2N^2 + N$  for "extended".

### References

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

Hafner, C.M. and H. Herwartz (2008), "Analytical Quasi Maximum Likelihood Inference in Multivariate Volatility Models." *Metrika* **67**, 219–239.

### See Also

[dcc.estimation](#)

---

dlv.est	<i>Gradient of the GARCH part of the log-likelihood function of an (E)DCC GARCH model</i>
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---

### Description

This function returns the gradient of the volatility part of the log-likelihood function of the DCC.

### Usage

```
dlv.est(par, dvar, model)
```

### Arguments

par	a vector of the parameters in the vector GARCH equation
dvar	a matrix of the data used for estimating an (E)DCC-GARCH model ( $T \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

### Value

A vector of the gradient. ( $3N \times 1$ ) for "diagonal" and ( $2N^2 + N \times 1$ ) for "extended".

### Note

The function can be called from `optim` in `dcc. estimation1`. For obtaining the gradient for all  $t$ , use `dlv` instead.

### References

- Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.
- Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.
- Hafner, C.M. and H. Herwartz (2008), "Analytical Quasi Maximum Likelihood Inference in Multivariate Volatility Models." *Metrika* **67**, 219–239.

### See Also

`dcc. estimation1`, `dlv`

---

eccc.estimation      *Estimating an (E)CCC-GARCH model*

---

### Description

This function estimates an (E)CCC-GARCH(1,1) model and returns estimates, estimated volatility and various diagnostic statistics.

### Usage

```
eccc.estimation(a, A, B, R, dvar, model, method="BFGS")
```

### Arguments

a	initial values for constants ( $N \times 1$ )
A	initial values for an ARCH parameter matrix ( $N \times N$ )
B	initial values for a GARCH parameter matrix ( $N \times N$ )
R	initial values a constant conditional correlation matrix ( $N \times N$ )
dvar	a matrix of data used for (E)CCC-GARCH estimation ( $T \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model
method	a character string specifying the optimisation method in <code>optim</code> . There are three choices, namely, Nelder–Mead, BFGS (default) and CG.

### Value

A list with components:

out	a ( $4 \times npar$ ) matrix. The estimates are contained in the first row. The remaining rows report standard errors based on three different methods of estimating the asymptotic covariance matrix
h	the estimated conditional variances ( $T \times N$ )
std.resid	a matrix of the standardised residuals ( $T \times N$ ). See <i>Note</i> .
opt	the detailed results of the optimisation
para.mat	vectorised parameter estimates

### Note

The standardised residuals are calculated through dividing the original series by the estimated conditional standard deviations. See, for instance, p.303 of Bollerslev (1990) for details.

## References

- Bollerslev, T. (1990), “Modelling the Coherence in Short-run Nominal Exchange Rates: A Multivariate Generalized ARCH Model”, *Review of Economics and Statistics*, **20**, 498–505.
- Nakatani, T. and T. Teräsvirta (2009), “Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model”, *Econometrics Journal*, **12**, 147–163.
- Nakatani, T. and T. Teräsvirta (2008), “Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*” Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

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 eccc.sim

 Simulating an (E)CCC-GARCH(1,1) process
 

---

## Description

This function simulates data either from the original CCC-GARCH by Bollerslev (1990) or from the Extended CCC-GARCH that has non-zero off-diagonal entries in the parameter matrices in the GARCH equation. The innovations (the standardised residuals) can be either a normal or student’s  $t$  distribution.

The dimension ( $N$ ) is determined by the number of elements in the  $\mathbf{a}$  vector.

## Usage

```
eccc.sim(nobs, a, A, B, R, d.f=Inf, cut=1000, model)
```

## Arguments

nobs	a number of observations to be simulated ( $T$ )
a	a vector of constants in the GARCH equation ( $N \times 1$ )
A	an ARCH parameter matrix in the GARCH equation. $\mathbf{A}$ can be a diagonal matrix for the original CCC-GARCH model or a full matrix for the extended model ( $N \times N$ )
B	a GARCH parameter matrix in the GARCH equation. $\mathbf{B}$ can be a diagonal matrix for the original CCC-GARCH model or a full matrix for the extended model ( $N \times N$ )
R	a constant conditional correlation matrix ( $N \times N$ )
d.f	the degrees of freedom parameter for the $t$ -distribution
cut	the number of observations to be thrown away for removing initial effects of simulation
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

**Value**

A list with components:

`h` a matrix of the simulated conditional variances ( $T \times N$ )  
`eps` a matrix of the simulated time series with (E)CCC-GARCH process ( $T \times N$ )

**Note**

When `d.f=Inf`, the innovations (the standardised residuals) follow the standard normal distribution. Otherwise, they follow a student's  $t$ -distribution with `d.f` degrees of freedom equal.

When `model="diagonal"`, only the diagonal entries in **A** and **B** are used. If the ARCH and GARCH matrices do not satisfy the stationarity condition, the simulation is terminated.

**References**

Bollerslev, T. (1990), "Modeling the Coherence in Short-Run Nominal Exchange Rates: A Multivariate Generalized ARCH Approach", *Review of Economics and Statistics*, **72**, 498–505.

Nakatani, T. and T. Teräsvirta (2009), "Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model", *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Teräsvirta (2008), "Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*" Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

**See Also**

[dcc.sim](#), [stcc.sim](#)

**Examples**

```
# Simulating data from the original CCC-GARCH(1,1) process
nobs <- 1000; cut <- 1000; nu <- 10
a <- c(0.003, 0.005, 0.001)
A <- diag(c(0.2, 0.3, 0.15))
B <- diag(c(0.79, 0.6, 0.8))
R <- matrix(c(1.0, 0.4, 0.3, 0.4, 1.0, 0.12, 0.3, 0.12, 1.0), 3, 3)
ccc.data <- eccc.sim(nobs, a, A, B, R, model="diagonal")
ccc.data.t <- eccc.sim(nobs, a, A, B, R, d.f=nu, model="diagonal")
```

---

fourth

*Fourth-order moment condition for the vector GARCH equation*

---

**Description**

This function computes the fourth-order moment condition for the vector GARCH equation in the (E)CCC-GARCH models.

**Usage**

```
fourth(A, B, R)
```

**Arguments**

A            an ARCH parameter matrix ( $N \times N$ )  
B            a GARCH parameter matrix ( $N \times N$ )  
R            a constant conditional correlation matrix ( $N \times N$ )

**Value**

a scalar. If strictly less than unity, the condition is satisfied.

**References**

He, C. and T. Teräsvirta (2004): “An Extended Constant Conditional Correlation GARCH model and its Fourth-moment Structure”, *Econometric Theory*, **20**, 904–926.

Nakatani, T. and T. Teräsvirta (2009), “Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model”, *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Teräsvirta (2008), “Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*” Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

**See Also**

[stationarity](#)

---

grad.dcc.full	<i>Numerical gradient of the full log-likelihood function of the (E)DCC-GARCH model</i>
---------------	---

---

**Description**

This function computes numerical gradient of the full log-likelihood function of the (E)DCC-GARCH(1,1) model with respect to its parameters.

**Usage**

```
grad.dcc.full(a, A, B, dcc.para, dvar, d=1e-5, model)
```

**Arguments**

a	a constant vector in the vector GARCH equation ( $N \times 1$ )
A	an ARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
B	a GARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
dcc.param	a vector of the DCC parameters ( $2 \times 1$ )
dvar	a matrix of the data used for estimating the (E)DCC-GARCH model ( $T \times N$ )
d	a step size for computing numerical gradient
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

**Value**

a matrix of partial derivatives ( $T \times npar$ )

**Note**

this function is currently not in use.

---

grad.dcc2

*Numerical gradient of the DCC part of the log-likelihood function*


---

**Description**

This function computes numerical gradient of the second stage log-likelihood function of the DCC-GARCH model w.r.t. its parameters.

**Usage**

```
grad.dcc2(param, dvar, d=1e-5)
```

**Arguments**

param	a vector of DCC parameters ( $2 \times 1$ )
dvar	a matrix of the standardised residuals ( $T \times N$ )
d	a step size for computing numerical gradient

**Value**

a vector of partial derivatives ( $2 \times 1$ )

**Note**

The function is used only from `dcc.estimate2` when the switch variable `gradient!=0`. `dlc$dlc` in `dlc` contains the analytical gradient of the second stage log-likelihood function.

**See Also**

[dlc](#), [dcc.estimation](#)

---

jb.test

*The Lomnicki-Jarque-Bera Test of normality (JB test)*

---

**Description**

This function performs the Lomnicki-Jarque-Bera Test of normality and returns test statistics and associated p-values.

**Usage**

```
jb.test(x)
```

**Arguments**

x a vector or matrix of variables to be tested

**Value**

Vector of test statistics and p-value

**References**

Jarque, C.M. and A.K. Bera (1987), "A Test for Normality of Observations and Regression Residuals", *International Statistical Review*, **55**, 163–172.

Lomnicki, Z.A. (1961), "Tests for Departure from Normality in the Case of Linear Stochastic Processes", *Metrika*, **4**, 37–62.

**See Also**

[rob.sk](#), [rob.kr](#), [ljung.box.test](#)

**Examples**

```
# for a vector
x <- rnorm(1000)
jb.test(x)

# for a matrix
X <- matrix(rnorm(10000), 5000, 2)
jb.test(X)
```

---

ljung.box.test      *The Ljung-Box Test statistic*

---

### Description

This function performs the Ljung-Box Test for a univariate time series.

### Usage

```
ljung.box.test(x)
```

### Arguments

`x`                      a vector of variables to be tested

### Value

LB test statistics and associated p-values for lags 5, 10, ..., 50.

### Note

Argument `x` must be a vector. When `x` is squared residuals, the test is equivalent to the McLeod and Li (1983) test.

### References

Ljung, G.M. and G.E.P. Box (1978): "On a Measure of Lack of Fit in Time-Series Models", *Biometrika*, **65**, 297–303.

McLeod, A.I., and W.K. Li (1983): "Diagnostic checking ARMA time series models using squared-residual autocorrelations", *Journal of Time Series Analysis*, **4**, 269–273.

### See Also

[rob.sk](#), [rob.kr](#), [jb.test](#)

### Examples

```
x <- rnorm(1000)
ljung.box.test(x)                      # returns the LB Test statistic
ljung.box.test(x^2)                    # returns the McLeod-Li Test for no-ARCH effect
```

loglik.dcc

*The log-likelihood function for the (E)DCC GARCH model***Description**

This function returns a log-likelihood of the (E)DCC-GARCH model.

**Usage**

```
loglik.dcc(param, dvar, model)
```

**Arguments**

param	a vector of all the parameters in the (E)DCC-GARCH model
dvar	a matrix of the data used for estimating the (E)DCC-GARCH model ( $T \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

**Value**

the negative of the full log-likelihood of the (E)DCC-GARCH model

**Note**

param must be made by stacking all the parameter matrices.

**References**

Robert F. Engle and Kevin Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Robert F. Engle (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalised Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

**Examples**

```
# Simulating data from the original DCC-GARCH(1,1) process
nobs <- 1000; cut <- 1000
a <- c(0.003, 0.005, 0.001)
A <- diag(c(0.2, 0.3, 0.15))
B <- diag(c(0.75, 0.6, 0.8))
uncR <- matrix(c(1.0, 0.4, 0.3, 0.4, 1.0, 0.12, 0.3, 0.12, 1.0), 3, 3)
dcc.para <- c(0.01, 0.98)
dcc.data <- dcc.sim(nobs, a, A, B, uncR, dcc.para, model="diagonal")

# Estimating a DCC-GARCH(1,1) model
```

```

dcc.results <- dcc.estimation(inia=a, iniA=A, iniB=B, ini.dcc=dcc.para,
                             dvar=dcc.data$eps, model="diagonal")

# Parameter estimates and their robust standard errors
dcc.results$out

# Computing the value of the log-likelihood at the estimates
loglik.dcc(dcc.results$out[1,], dcc.data$eps, model="diagonal")

```

---

loglik.dcc1

*The 1st stage log-likelihood function for the (E)DCC GARCH*


---

### Description

This function returns a log-likelihood of the (E)DCC-GARCH model in the first stage estimation.

### Usage

```
loglik.dcc1(param, dvar, model)
```

### Arguments

param	initial values for a vector of the parameters ( $npar \times 1$ )
dvar	a matrix of the data ( $T \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

### Value

the negative of the first stage log-likelihood

### Note

The function is used in `optim` in [dcc.estimation1](#).

### References

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

### See Also

[dcc.estimation](#), [dcc.estimation1](#)

---

`loglik.dcc2`*The 2nd stage log-likelihood function for the (E)DCC GARCH*

---

**Description**

This function returns a log-likelihood of the (E)DCC-GARCH model in the 2nd step estimation.

**Usage**

```
loglik.dcc2(param, dvar)
```

**Arguments**

<code>param</code>	initial values for the DCC parameters ( $2 \times 1$ )
<code>dvar</code>	a matrix of the standardised residuals ( $T \times N$ )

**Value**

the negative of the second stage log-likelihood

**Note**

The function is used in `constrOptim` in [dcc.estimation2](#).

**References**

Engle, R.F. and K. Sheppard (2001), "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." *Stern Finance Working Paper Series* FIN-01-027 (Revised in Dec. 2001), New York University Stern School of Business.

Engle, R.F. (2002), "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business and Economic Statistics* **20**, 339–350.

**See Also**

[dcc.estimation](#), [dcc.estimation2](#)

---

loglik.eccc

*The log-likelihood function of the (E)CCC-GARCH model*


---

**Description**

This function computes a log-likelihood of the (E)CCC-GARCH(1,1) model.

**Usage**

```
loglik.eccc(param, dvar, model)
```

**Arguments**

param	a vector of all the parameters in the (E)CCC-GARCH model
dvar	a matrix of the data used for estimating the (E)DCC-GARCH model ( $T \times N$ )
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

**Value**

the negative of the (E)CCC-GARCH log-likelihood

**References**

Nakatani, T. and T. Teräsvirta (2009), "Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model", *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Teräsvirta (2008), "Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*" Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

---

p.mat

*Re-arranging a vector into parameter matrices*


---

**Description**

A utility function that re-arranges a vector of parameters into parameter matrices in the CC-GARCH(1,1) model.

**Usage**

```
p.mat(para, model, ndim)
```

**Arguments**

para	a vector of parameters to be re-arranged into parameter matrices
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model
ndim	the number of dimension of the model

**Value**

A list with components:

a	a vector of constants in the vector GARCH equation
A	an ARCH parameter matrix
B	a GARCH parameter matrix
R	a constant conditional correlation matrix

**References**

Nakatani, T. and T. Teräsvirta (2009), "Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model", *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Teräsvirta (2008), "Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*" Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

---

 rob.kr

---

*Computing standard and robustified excess kurtosis*


---

**Description**

This function computes standard and robustified excess kurtosis of a vector or matrix of variables.

**Usage**

```
rob.kr(x)
```

**Arguments**

x	vector or matrix of variables
---	-------------------------------

**Value**

Vector of excess kurtosis and robustified excess kurtosis

**References**

Kim, T-H. and H. White (2004), “On More Robust Estimation of Skewness and Kurtosis”, *Finance Research Letters*, **1**, 56–73.

**See Also**

[rob.sk](#), [ljung.box.test](#), [jb.test](#)

**Examples**

```
x <- matrix(rnorm(1000), 100, 10)
rob.kr(x)
```

---

rob.sk

*Computing standard and robustified skewness*

---

**Description**

This function computes standard and robustified skewness measures of a vector or matrix of variables.

**Usage**

```
rob.sk(x)
```

**Arguments**

x                    a vector or matrix of variables

**Value**

Vector of skewness and robustified skewness

**References**

Kim, T-H. and H. White (2004), “On More Robust Estimation of Skewness and Kurtosis”, *Finance Research Letters*, **1**, 56–73.

**See Also**

[rob.kr](#), [ljung.box.test](#), [jb.test](#)

**Examples**

```
x <- matrix(rnorm(1000), 100, 10)
rob.sk(x)
```

---

`stationarity`*The stationarity condition in Extended CC-GARCH models*

---

**Description**

A utility function that checks if the two parameter matrices in a vector GARCH model satisfy the stationarity condition.

**Usage**

```
stationarity(A, B)
```

**Arguments**

- |   |  |
|---|--|
| A | an ARCH parameter matrix in the vector GARCH equation ( $N \times N$ ) |
| B | a GARCH parameter matrix in the vector GARCH equation ( $N \times N$ ) |

**Value**

a scalar. If strictly less than unity, the condition is satisfied.

**References**

He, C. and T. Teräsvirta (2004): “An Extended Constant Conditional Correlation GARCH model and its Fourth-moment Structure”, *Econometric Theory*, **20**, 904–926.

Nakatani, T. and T. Teräsvirta (2009), “Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model”, *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Teräsvirta (2008), “Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*” Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

**See Also**

[fourth](#)

stcc.sim

*Simulating Data from an STCC-GARCH(1,1) process***Description**

This function simulates data either from the original STCC-GARCH by Silvennoinen and Teräsvirta (2005) or from the Extended STCC-GARCH that has non-zero off-diagonal entries in the parameter matrices in the GARCH equation, with multivariate normal or student's  $t$  distribution.

The dimension ( $N$ ) is determined by the number of elements in the **a** vector.

**Usage**

```
stcc.sim(nobs, a, A, B, R1, R2, tr.par, st.par, d.f=Inf,
         cut=1000, model)
```

**Arguments**

nobs	a number of observations to be simulated ( $T$ )
a	a vector of constants in the vector GARCH equation ( $N \times 1$ )
A	an ARCH parameter matrix in the vector GARCH equation. ( $N \times N$ )
B	a GARCH parameter matrix in the vector GARCH equation. ( $N \times N$ )
R1	a conditional correlation matrix in regime 1 ( $N \times N$ )
R2	a conditional correlation matrix in regime 2 ( $N \times N$ )
tr.par	a vector of scale and location parameters in the transition function ( $2 \times 1$ )
st.par	a vector of parameters for the GARCH(1,1) transition variable ( $3 \times 1$ )
d.f	the degrees of freedom parameter for the $t$ -distribution
cut	the number of observations to be thrown away for removing initial effects of simulation
model	a character string describing the model. "diagonal" for the diagonal model and "extended" for the extended (full ARCH and GARCH parameter matrices) model

**Value**

A list with components:

h	a matrix of conditional variances ( $T \times N$ )
eps	a matrix of time series with DCC-GARCH process ( $T \times N$ )
tr.var	a vector of the transition variable
st	a vector of time series of the transition function
vecR	a ( $T \times N^2$ ) matrix of Smooth Transition Conditional Correlations

**Note**

When `d.f=Inf`, the innovations (the standardised residuals) follow the standard normal distribution. Otherwise, they follow a student's *t*-distribution with `d.f` degrees of freedom equal.

When `model="diagonal"`, only the diagonal entries in **A** and **B** are used. If the ARCH and GARCH matrices do not satisfy the stationarity condition, the simulation is terminated.

**References**

Silvennoinen, A. and T. Teräsvirta (2005), "Multivariate Autoregressive Conditional Heteroskedasticity with Smooth Transitions in Conditional Correlations." *SSE/EFI Working Paper Series in Economics and Finance* No. 577, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0577.htm>.

**See Also**

[dcc.sim](#), [eccc.sim](#)

**Examples**

```
# Simulating data from the original STCC-GARCH(1,1) process
nobs <- 1000; cut <- 1000
a <- c(0.003, 0.005, 0.001)
A <- diag(c(0.2,0.3,0.15))
B <- diag(c(0.79, 0.6, 0.8))
# Conditional Correlation Matrix for regime 1
R1 <- matrix(c(1.0, 0.4, 0.3, 0.4, 1.0, 0.12, 0.3, 0.12, 1.0),3,3)
# Conditional Correlation Matrix for regime 2
R2 <- matrix(c(1.0, 0.01, -0.3, 0.01, 1.0, 0.8, -0.3, 0.8, 1.0),3,3)
# a parameter vector for the scale and location parameters
# in the logistic function
tr.para <- c(5,0)
# a parameter vector for a GARCH(1,1) transition variable
st.para <- c(0.02,0.04, 0.95)
nu <- 15
stcc.data <- stcc.sim(nobs, a, A, B, R1, R2,
                    tr.par=tr.para, st.par=st.para, model="diagonal")
stcc.data.t. <- stcc.sim(nobs, a, A, B, R1, R2,
                       tr.par=tr.para, st.par=st.para, d.f=nu, model="diagonal")
```

---

tr.func

*Logistic transition function*


---

**Description**

This function computes values from a Logistic transition function.

**Usage**

```
tr.func(tr.par, tr.var)
```

**Arguments**

`tr.par` a vector of parameters ( $2 \times 1$ )  
`tr.var` a vector of transition variable ( $T \times 1$ )

**Value**

a vector of transition function ( $T \times 1$ )

**Note**

this function is used in `stcc.sim`

**References**

Teräsvirta, T. (1994): “Specification, Estimation, and Evaluation of Smooth Transition Autoregressive Models”, *Journal of the American Statistical Association*, **89**, 208–218.

**See Also**

`stcc.sim`

---

`uni.vola`

*Computing univariate GARCH(1,1) conditional variances*

---

**Description**

This function returns an univariate GARCH(1,1) conditional variances.

**Usage**

```
uni.vola(a, u)
```

**Arguments**

`a` a vector of parameters in the GARCH(1,1) equation ( $3 \times 1$ )  
`u` a vector of the data ( $T \times 1$ )

**Value**

a vector of GARCH(1,1) conditional variances ( $T \times 1$ )

**References**

Bollerslev, T. (1986): “Generalized Autoregressive Conditional Heteroskedasticity”, *Journal of Econometrics*, **31**, 307–327.

**See Also**

[uni.vola.sim](#)

**Examples**

```
a <- c(0.01, 0.04, 0.95) # a <- c(a constant, ARCH parameter, GARCH parameter)
u <- rnorm(1000)
h <- uni.vola(a, u)
```

---

uni.vola.sim	<i>Simulating a series with univariate GARCH(1,1) conditional variances</i>
--------------	---

---

**Description**

This function simulates an univariate time series with GARCH(1,1) conditional variances.

**Usage**

```
uni.vola.sim(a, nobs, d.f=Inf, cut=1000)
```

**Arguments**

a	a vector of parameters ( $3 \times 1$ )
nobs	a number of observations simulated ( $T$ )
d.f	degrees of freedom parameter for $t$ -distribution
cut	a number of observations to be removed to minimise the initial effects

**Value**

A list with components:

h	GARCH(1,1) conditional variances ( $T \times 1$ )
eps	a series of error term with the conditional variances "h" ( $T \times 1$ )

**Note**

When `d.f=Inf`, the innovations (the standardised residuals) follow the standard normal distribution. Otherwise, they follow a student's  $t$ -distribution with `d.f` degrees of freedom.

**References**

Bollerslev, T. (1986), "Generalized Autoregressive Conditional Heteroskedasticity", *Journal of Econometrics*, **31**, 307–327.

Fiorentini, G., G. Calzolari and L. Panattoni (1996), "Analytic Derivatives and the Computation of GARCH Estimates", *Journal of Applied Econometrics*, **11**, 399–417.

**See Also**

[uni.vola](#)

**Examples**

```
nobs <- 1000
nu <- 8
a <- c(0.1,0.2,0.7)          # a <- c(a constant, ARCH parameter, GARCH parameter)
# with normal innovations
eps <- uni.vola.sim(a, nobs)
# with t innovations
eps.t <- uni.vola.sim(a, nobs, d.f = df)
```

---

vdR

*Computing partial derivatives of the CCC matrix*

---

**Description**

This function computes partial derivatives of the CCC matrix with respect to its correlation coefficients.

**Usage**

```
vdR(n)
```

**Arguments**

n                    the number of dimension of the model

**Value**

a matrix of zeros and ones  $((N(N - 1))/2 \times N^2)$

**References**

Nakatani, T. and T. Teräsvirta (2009), “Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model”, *Econometrics Journal*, **12**, 147-163.

Nakatani, T. and T. Teräsvirta (2008), “Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*” Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

---

 vec.garch.derivative

*Computing partial derivatives of a vector GARCH(1, 1) equation*


---

**Description**

This function computes partial derivatives of a vector GARCH(1, 1) equation with respect to its parameters.

**Usage**

```
vec.garch.derivative(dvar, B, h)
```

**Arguments**

dvar	a matrix of the data used for estimating an ECCG or DCC GARCH model ( $T \times N$ )
B	a GARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
h	a matrix of conditional variances ( $T \times N$ )

**Value**

a vector of partial derivatives ( $T \times N * npar.h$ )

**References**

Nakatani, T. and T. Teräsvirta (2009), “Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model”, *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Teräsvirta (2008), “Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*” Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

---

 vector.garch

*A vector GARCH(1,1) conditional variances*


---

**Description**

This function computes a vector GARCH(1,1) conditional variances.

**Usage**

```
vector.garch(dvar, a, A, B)
```

**Arguments**

dvar	a matrix of the data, used as epsilon ( $T \times N$ )
a	initial values for constants in the vector GARCH equation ( $N \times 1$ )
A	initial values for an ARCH parameter matrix in the vector GARCH equation ( $N \times N$ )
B	initial values for a GARCH parameter matrix in the vector GARCH equation ( $N \times N$ )

**Value**

a matrix of conditional variances ( $T \times N$ )

**References**

Nakatani, T. and T. Teräsvirta (2009), “Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model”, *Econometrics Journal*, **12**, 147-163.

Nakatani, T. and T. Teräsvirta (2008), “Appendix to *Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model*” Department of Economic Statistics, Stockholm School of Economics, available at <http://swopec.hhs.se/hastef/abs/hastef0649.htm>.

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