Package ‘ccgarch’

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Title Conditional Correlation GARCH models

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Description Functions for estimating and simulating the family of the CC-GARCH models.

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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

`inia`	a vector of initial values for the constants in the GARCH equation `length(inia)=N`
`iniA`	a matrix of initial values for the ARCH parameter matrix $(N \times N)$
`iniB`	a matrix of initial values for the GARCH parameter matrix $(N \times N)$
`ini.dcc`	a vector of initial values for the DCC parameters (2×1)
`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
`method`	a character string specifying the optimisation method in `optim`. There are three choices, namely, `Nelder-Mead`, `BFGS` (default) and `CG`.
`gradient`	a switch variable that determines the optimisation algorithm in the second stage optimisation. If `gradient=0` `Nelder-Mead` is invokded. Otherwise `BFGS` is used (default).
`message`	a switch variable to turn off the display of the message when the estimation is completed. If `message=0`, the message is suppressed. Otherwise, the message is displayed (default)

Value

a list with components:

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

The details of the first and second stage estimation are also saved in `first` and `second`, respectively.

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.sim`

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")

## Not run:
# 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

## End(Not run)
```

`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 (2×1)
`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)

## Not run:

# 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")

## End(Not run)
```

---

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 optim. 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 *Note*.
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. Ter\"asvirta (2009), "Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model", *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Ter\"asvirta (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.

`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 $\mathbf{A}$ and $\mathbf{B}$ 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. Ter\"asvirta (2009), "Testing for Volatility Interactions in the Constant Conditional Correlation GARCH Model", *Econometrics Journal*, **12**, 147–163.

Nakatani, T. and T. Ter\"asvirta (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)

## Not run:
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")

## End(Not run)
```

---

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. Ter\"asvirta (2004): "An Extended Constant Conditional Correlation GARCH model and its Fourth-moment Structure", *Econometric Theory*, **20**, 904–926.

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

Nakatani, T. and T. Ter\"asvirta (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`

---

hh.test — *Carrying out the test of Hafner and Herwartz*

Description

This function computes the test statistic and the associated p-value of the test for causality in conditiona variance in the CC-GARCH models.

Usage

```
hh.test(dvar)
```

Arguments

`dvar`	$(T \times N)$

Value

A vector containing the test statistic and the associated p-value

References

Hafner, C.M. and H. Herwartz (2006), "A Lagrange Multiplier Test for Causality in Variance." *Economics Letters* **93**, 137–141.

See Also

`nt.test`

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 McLeord 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 McLeord-Li Test for no-ARCH effect
```

nt.test *Carrying out the test of Nakatani and Ter\"asvirta*

Description

This function computes the test statistic and the associated p-value of the test for causality in conditiona variance in the CC-GARCH models.

Usage

```
nt.test(dvar)
```

Arguments

dvar	$(T \times N)$

Value

A matrix containing the test statistics of the standard (non-robust) test and the robust version, and the associated p-values

References

Nakatani, T and T. Ter\"asvirta (2010), “An Alternative Test for Causality in Variance in the Conditional Correlation GARCH models.” *mimeo*, Stockholm School of Economics.

See Also

hh.test

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. Ter\"asvirta (2004): "An Extende Constant Conditional Correlation GARCH model and its Fourth-moment Structure", *Econometric Theory*, **20**, 904–926.

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

Nakatani, T. and T. Ter\"asvirta (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 Ter\"asvirta (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 $\mathbf{a}$ 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 (2×1)
st.par	a vector of parameters for the GARCH(1,1) transition variable (3×1)
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 $\mathbf{A}$ and $\mathbf{B}$ are used. If the ARCH and GARCH matrices do not satisfy the stationarity condition, the simulation is terminated.

References

Silvennoinen, A. and T. Ter\"asvirta (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

## Not run:
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")

## End(Not run)
```

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