Package ‘HMMcopula’

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Type Package

Title Markov Regime Switching Copula Models Estimation and Goodness of Fit

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Description R functions to estimate and perform goodness of fit test for several Markov regime switching and mixture bivariate copula models. The goodness of fit test is based on a Cramer von Mises statistic and uses the Rosenblatt transform and parametric bootstrap to estimate the p-value. The estimation of the copula parameters are based on the pseudo-maximum likelihood method using pseudo-observations defined as normalized ranks.

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dilog

Dilogarithm function

Description

This function computes the dilogarithm of a number.

Usage

dilog(x)

Arguments

x  a real number

Value

out  dilogarithm
EstHMMCop

Estimation of bivariate Markov regime switching bivariate copula model

Description
This function estimates parameters from a bivariate Markov regime switching bivariate copula model.

Usage
EstHMMCop(y, reg, family, max_iter, eps)

Arguments
- **y**: (nx2) data matrix (observations or residuals) that will be transformed to pseudo-observations.
- **reg**: number of regimes.
- **family**: 'gaussian', 't', 'clayton', 'frank', 'gumbel'.
- **max_iter**: maximum number of iterations of the EM algorithm.
- **eps**: precision (stopping criteria); suggestion 0.0001.

Value
- **theta**: (1 x reg) estimated parameter of the copula according to CRAN copula package (except for Frank copula, where theta = log(theta_R_Package)) for each regime (except for degrees of freedom).
- **dof**: estimated degree of freedom, only for the Student copula.
- **Q**: (reg x reg) estimated transition matrix.
- **eta**: (n x reg) conditional probabilities of being in regime k at time t given observations up to time t.
- **tau**: estimated Kendall tau for each regime.
- **U**: (n x 2) matrix of Rosenblatt transforms.
- **W**: regime probabilities for the conditional distribution given the past Kendall’s tau.

Examples
Q <- matrix(c(0.8, 0.3, 0.2, 0.7),2,2) ; kendallTau <- c(0.3 ,0.7) ;
data <- SimHMMCop(Q, 'clayton', kendallTau, 10)$SimData;
estimations <- EstHMMCop(data,2,'clayton',10000,0.0001)
EstKendallTau \hspace{1cm} Sample Kendall’s tau Estimation

Description
This function estimates the sample Kendall’s tau of a bivariate data matrix

Usage
EstKendallTau(X)

Arguments
X \hspace{1cm} (n x 2) matrix

Value
KendallTau \hspace{1cm} estimated sample Kendall’s tau of the data

EstMixtureCop \hspace{1cm} Estimation of bivariate mixture bivariate copula model

Description
This function estimates parameters from a mixture bivariate copula model

Usage
EstMixtureCop(y, reg, family, max_iter, eps)

Arguments
y \hspace{1cm} (nx2) data matrix (observations or residuals) that will be transformed to pseudo-observations
reg \hspace{1cm} number of regimes
family \hspace{1cm} 'gaussian’, ’t’, ’clayton’, ’frank’, ’gumbel’
max_iter \hspace{1cm} maximum number of iterations of the EM algorithm
eps \hspace{1cm} precision (stopping criteria); suggestion 0.0001.
**Value**

- **theta**  
  (1 x reg) estimated parameter of the copula according to CRAN copula package (except for Frank copula, where theta = log(theta_R_Package)) for each component (except for degrees of freedom)

- **dof**  
  estimated degree of freedom, only for the Student copula

- **Q**  
  (1 x reg) estimated weights vector

- **eta**  
  (n x reg) conditional probabilities of being in regime k at time t given observations up to time t

- **tau**  
  estimated Kendall tau for each regime

- **U**  
  (n x 2) matrix of Rosenblatt transforms

- **cvm**  
  Cramer-von-Mises statistic for goodness-of-fit

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**GofHMMCop**

*Goodness-of-fit of Markov regime switching bivariate copula model*

**Description**

This function performs goodness-of-fit test of a Markov regime switching bivariate copula model

**Usage**

GofHMMCop(R, reg, family, max_iter, eps, n_sample, n_cores)

**Arguments**

- **R**  
  (n x 2) data matrix that will be transformed to pseudo-observations

- **reg**  
  number of regimes

- **family**  
  'gaussian', 't', 'clayton', 'frank', 'gumbel'

- **max_iter**  
  maximum number of iterations of the EM algorithm

- **eps**  
  precision (stopping criteria); suggestion 0.0001

- **n_sample**  
  number of bootstrap; suggestion 1000

- **n_cores**  
  number of cores to use in the parallel computing

**Value**

- **pvalue**  
  pvalue (significant when the result is greater than 5)

- **theta**  
  (1 x reg) estimated parameter of the copula according to CRAN copula package (except for Frank copula, where theta = log(theta_R_Package)) for each regime (except for degrees of freedom)

- **dof**  
  estimated degree of freedom, only for the Student copula

- **Q**  
  (reg x reg) estimated transition matrix
GofMixtureCop

Description

This function performs goodness-of-fit test of a mixture bivariate copula model

Usage

GofMixtureCop(R, reg, family, max_iter, eps, n_sample, n_cores)

Arguments

R (nx2) data matrix (observations or residuals) that will be transformed to pseudo-observations
reg number of regimes
family 'gaussian', 't', 'clayton', 'frank', 'gumbel'
max_iter maximum number of iterations of the EM algorithm
eps precision (stopping criteria); suggestion 0.0001
n_sample number of bootstrap; suggestion 1000
n_cores number of cores to use in the parallel computing

Value

pvalue pvalue (significant when the result is greater than 5)
theta (1 x reg) estimated parameter of the copula according to CRAN copula package (except for Frank copula, where theta = log(theta_R_Package)) for each component (except for degrees of freedom)
dof estimated degree of freedom, only for the Student copula
Q (1 x reg) estimated weights vector
eta (n x reg) conditional probabilities of being in regime k at time t given observations up to time t
tau estimated Kendall tau for each regime
U (n x 2) matrix of Rosenblatt transforms
cvm Cramer-von-Mises statistic for goodness-of-fit
**KendallTau**

| KendallTau | Kendall's tau of a copula |

**Description**
This function computes the Kendall’s tau of a copula family with a unconstrained parameter alpha.

**Usage**
KendallTau(family, alpha)

**Arguments**
- family: "gaussian", "t", "clayton", "frank", "gumbel"
- alpha: unconstrained parameters of the copula family

**Value**
- tau: estimated Kendall’s tau

---

**ParamCop**

| ParamCop | Theta estimation |

**Description**
This function computes the parameter of the copula according to CRAN copula package (except for Frank copula, where theta = log(theta_R_Package)), corresponding to the unconstrained parameters alpha.

**Usage**
ParamCop(family, alpha)

**Arguments**
- family: "gaussian", "t", "clayton", "frank", "gumbel"
- alpha: unconstrained parameters of the copula family

**Value**
- theta: matlab parameters
**ParamTau**  
*Alpha estimation*

**Description**
This function computes the unconstrained parameter alpha for given Kendall’s tau value

**Usage**
```r
ParamTau(family, tau)
```

**Arguments**
- **family**: `'gaussian'`, `'t'`, `'clayton'`, `'frank'`, `'gumbel'`
- **tau**: Kendall’s tau of the copula family

**Value**
- **alpha**: estimated unconstrained parameter

**RosenblattClayton**  
*Rosenblatt transform for Clayton copula*

**Description**
This function computes the Rosenblatt transform for the Clayton copula

**Usage**
```r
RosenblattClayton(u, theta)
```

**Arguments**
- **u**: `(n x d)` matrix of pseudos-observations (normalized ranks)
- **theta**: parameter of the Clayton copula

**Value**
- **R**: Rosenblatt transform
RosenblattFrank

Rosenblatt transform for Frank copula

Description

This function computes the Rosenblatt transform for the Frank copula

Usage

RosenblattFrank(U, theta)

Arguments

U (n x d) matrix of pseudos-observations (normalized ranks)
theta parameter of the Frank copula

Value

R Rosenblatt transform

RosenblattGaussian

Rosenblatt transform for Gaussian copula

Description

This function computes the Rosenblatt transform for the Gaussian copula

Usage

RosenblattGaussian(u, rho)

Arguments

u (n x d) matrix of pseudos-observations (normalized ranks)
rho (d x d) correlation matrix, or the correlation coefficient (if, d = 2)

Value

R Rosenblatt transform
RosenblattGumbel

*Rosenblatt transform for Gumbel copula*

**Description**

This function computes the Rosenblatt transform for the Gumbel copula.

**Usage**

\[ \text{RosenblattGumbel}(U, \theta) \]

**Arguments**

- **U**: \((n \times d)\) matrix of pseudos-observations (normalized ranks)
- **\theta**: parameter of the Gumbel copula

**Value**

- **R**: Rosenblatt transform

RosenblattStudent

*Rosenblatt transform for Student copula*

**Description**

This function computes the Rosenblatt transform for the Student copula.

**Usage**

\[ \text{RosenblattStudent}(u, \rho, \nu) \]

**Arguments**

- **u**: \((n \times d)\) matrix of pseudos-observations (normalized ranks)
- **\rho**: \((d \times d)\) correlation matrix
- **\nu**: degrees of freedom

**Value**

- **R**: Rosenblatt transform
**SimHMMCop**

*Simulation of bivariate Markov regime switching copula model*

**Description**

This function simulates observation from a bivariate Markov regime switching copula model

**Usage**

```r
SimHMMCop(Q, family, KendallTau, n, DoF)
```

**Arguments**

- `Q`: Transition probability matrix (d x d);
- `family`: 'gaussian', 't', 'clayton', 'frank', 'gumbel'
- `KendallTau`: Kendall's rank correlation
- `n`: number of simulated vectors
- `DoF`: degree of freedom only for the Student copula

**Value**

- `SimData`: Simulated Data
- `MC`: Markov chain regimes
- `alpha`: parameters alpha

**Examples**

```r
Q <- matrix(c(0.8, 0.3, 0.2, 0.7), 2, 2)
kendallTau <- c(0.3, 0.7)
simulations <- SimHMMCop(Q, 'gumbel', kendallTau, 300)
```

**SimMarkovChain**

*Markov chain simulation*

**Description**

This function generates a Markov chain $X(1), ..., X(n)$ with transition matrix $Q$, starting from a state $\eta_0$ or the uniform distribution on $1, ..., r$

**Usage**

```r
SimMarkovChain(Q, n, eta0)
```
SimMixtureCop

Arguments

Q Transition probability matrix (d x d)
n number of simulated vectors
eta0 variable eta

SimMixtureCop Simulation of bivariate mixture copula model

Description

This function simulates observation from a bivariate mixture copula model

Usage

SimMixtureCop(Q, family, KendallTau, n, DoF)

Arguments

Q Weights vector (1 x component);
family 'gaussian', 't', 'clayton', 'frank', 'gumbel'
KendallTau Kendall’s rank correlation
n number of simulated vectors
DoF vector of degree of freedom only for the Student copula

Value

SimData Simulated Data
MC Markov chain regimes
alpha parameters alpha

Examples

Q <- matrix(c(0.8, 0.2),1,2) ; kendallTau <- c(0.3, 0.7) ;
simulations <- SimMixtureCop(Q, 'gaussian', kendallTau, 300)
**SnB**

*Cramer-von Mises statistic SnB for GOF based on the Rosenblatt transform*

**Description**

This function computes the Cramer-von Mises statistic SnB for GOF based on the Rosenblatt transform.

**Usage**

SnB(E)

**Arguments**

E  
(n x d) matrix of pseudos-observations (normalized ranks)

**Value**

Sn  
Cramer-von Mises statistic

---

**Tau2Rho**

*Spearman’s rho*

**Description**

This function estimates the Spearman’s rho corresponding to a constrained (matlab) parameter theta for a copula family.

**Usage**

Tau2Rho(family, theta)

**Arguments**

family  
'gaussian', 't', 'clayton', 'frank', 'gumbel'

theta  
parameter of the copula according to CRAN copula package (except for Frank copula, where theta = log(theta_R_Package))

**Value**

rho  
estimated Spearman’s rho
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