Package ‘Copula.Markov’

July 23, 2018

Type Package

Title Copula-Based Estimation and Statistical Process Control for Serially Correlated Time Series

Version 2.1

Date 2018-07-23

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License GPL-2

NeedsCompilation no

Repository CRAN

Date/Publication 2018-07-23 07:30:21 UTC

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Copulas are applied to model serial dependence in time series. The Clayton and Joe copulas are available for the dependence structure. The normal and binomial distributions are available for the marginal model.

**Details**

- **Package:** Copula.Markov
- **Type:** Package
- **Version:** 2.1
- **Date:** 2018-07-23
- **License:** GPL-2

**Author(s)**

Takeshi Emura <takeshiemura@gmail.com>

**References**

- Chen W (2018) Copula-based Markov chain model with binomial data, NCU Library
- Chen W, Emura T (2018-), A control chart using a copula-based Markov chain for attribute data, submitted for publication

**Description**

Time-series datasets are generated under a copula-based Markov chain model with the Clayton copula.
Usage

Clayton.Markov.DATA(n, mu, sigma, alpha)

Arguments

n sample size
mu mean
sigma standard deviation
alpha association parameter

Details

-1<alpha<0 for negative association; alpha>0 for positive association

Value

time series data

Author(s)

Takeshi Emura

References


Examples

set.seed(1)
Y=Clayton.Markov.DATA(n=1000,mu=0,sigma=1,alpha=8)
Clayton.Markov.MLE(Y,plot=TRUE)

Generating Time Series Data Under a Copula-Based Markov Chain Model with the Clayton Copula and Binomial Margin.

Description

Time-series datasets are generated under a copula-based Markov chain model with the Clayton copula and binomial margin.
Usage

Clayton.Markov.DATA.binom(n, size, prob, alpha)

Arguments

n number of observations
size number of binomial trials
prob binomial probability; 0<p<1
alpha association parameter

Details

-1<alpha<0 for negative association; alpha>0 for positive association

Value

time series data

Author(s)

Weiru Chen, Takeshi Emura

References

Chen W (2018) Copula-based Markov chain model with binomial data, NCU Library
Chen W, Emura T (2018-) A control chart using a copula-based Markov chain for attribute data, submitted for publication

Examples

size=50
prob=0.5
alpha=2
set.seed(1)
Y=Clayton.Markov.DATA.binom(n=500, size, prob, alpha)
### sample mean and SD ###
mean(Y)
sd(Y)
### true mean and SD ###
size*prob
sqrt(size*prob*(1-prob))
Description

The maximum likelihood estimates are produced and the Shewhart control chart is drawn with k-sigma control limits (e.g., 3-sigma). The dependence model follows the Clayton copula and the marginal (stationary) distribution follows the normal distribution.

Usage

Clayton.Markov.MLE(y, k = 3, D = 1, plot = TRUE, GOF = FALSE)

Arguments

- **y**: vector of datasets
- **k**: constant determining the length between LCL and UCL (k=3 corresponds to 3-sigma limit)
- **D**: diameter for U(-D, D) used in randomized Newton-Raphson
- **plot**: show the control chart if TRUE
- **GOF**: show the model diagnostic plot if TRUE

Value

- estimates: estimates
- out_of_control: IDs for out-of-control points
- Gradient: gradients (must be zero)
- Hessian: Hessian matrix
- mineigenvalue_Hessian: Minimum eigenvalue for the Hessian matrix
- CM.test: Cramer-von Mises test statistics
- KS.test: Kolmogorov-Smirnov test statistics

Author(s)

Takeshi Emura

References


Examples

```r
set.seed(1)
Y = Clayton.Markov.DATA(n=1000, mu=0, sigma=1, alpha=2)
Clayton.Markov.MLE(Y, plot=TRUE)
```

---

### Clayton.Markov.MLE.binom

*Maximum Likelihood Estimation and Statistical Process Control Under the Clayton Copula*

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### Description

The maximum likelihood estimates are produced and the Shewhart control chart is drawn with k-sigma control limits (e.g., 3-sigma). The dependence model follows the Clayton copula and the marginal (stationary) distribution follows the normal distribution.

### Usage

```r
Clayton.Markov.MLE.binom(Y, size, k = 3, plot = TRUE)
```

### Arguments

- **Y**: vector of observations
- **size**: number of binomial trials
- **k**: constant determining the length between LCL and UCL (k=3 corresponds to 3-sigma limit)
- **plot**: show the control chart if TRUE

### Value

- **p**: estimate, SE, and 95CI
- **alpha**: estimate, SE, and 95CI
- **out_of_control**: IDs for out-of-control points
- **Gradient**: gradients (must be zero)
- **Hessian**: Hessian matrix
- **mineigenvalue_hessian**: Minimum eigenvalue for the Hessian matrix

### Author(s)

Takeshi Emura
References
Chen W (2018) Copula-based Markov chain model with binomial data, NCU Library
Chen W, Emura T (2018-) A control chart using a copula-based Markov chain for attribute data, submitted for publication

Examples
size=50
prob=0.5
alpha=2
set.seed(1)
Y=Clayton.Markov.DATA.binom(n=500,size,prob,alpha)
Clayton.Markov.MLE.binom(Y,size=size,k=3,plot=TRUE)

Joe.Markov.DATA	Generating Time Series Data Under a Copula-Based Markov Chain Model with the Joe Copula

Description
Time-series datasets are generated under a copula-based Markov chain model with the Joe copula.

Usage
Joe.Markov.DATA(n, mu, sigma, alpha)

Arguments
n sample size
mu mean
sigma standard deviation
alpha association parameter

Details
alpha>=1 for positive association

Value
Time series data

Author(s)
Takeshi Emura
References


Examples

```r
n=1000
alpha=2.856 ### Kendall's tau =0.5 ###
mu=2
sigma=1
Y=Joe.Markov.DATA(n,mu,sigma,alpha)
mean(Y)
sd(Y)
cor(Y[-1],Y[-n],method="kendall")

Joe.Markov.MLE(Y,k=2)
```

---

### Joe.Markov.MLE

Maximum Likelihood Estimation and Statistical Process Control Under the Joe Copula

Description

The maximum likelihood estimates are produced and the Shewhart control chart is drawn with k-sigma control limits (e.g., 3-sigma). The dependence model follows the Joe copula and the marginal (stationary) distribution follows the normal distribution.

Usage

```r
Joe.Markov.MLE(Y, k = 3, D = 1, plot = TRUE,GOF=FALSE)
```

Arguments

- `Y` vector of datasets
- `k` constant determining the length between LCL and UCL (k=3 corresponds to 3-sigma limit)
- `D` diameter for U(-D, D) used in randomized Newton-Raphson
- `plot` show the control chart if TRUE
- `GOF` show the model diagnostic plot if TRUE
**Value**

- estimates
- out_of_control
  - IDs for out-of-control points
- Gradient
  - gradients (must be zero)
- Hessian
  - Hessian matrix
- mineigenvalue_Hessian
  - Minimum eigenvalue for the Hessian matrix
- CM.test
  - Cramer-von Mises test statistics
- KS.test
  - Kolmogorov-Smirnov test statistics

**Author(s)**

- Takeshi Emura

**References**


**Examples**

```r
n=1000
alpha=2.856 ### Kendall's tau =0.5 ###
mu=2
sigma=1
Y=Joe.Markov.DATA(n,mu,sigma,alpha)
mean(Y)
sd(Y)
cor(Y[-1],Y[-n],method="kendall")

Joe.Markov.MLE(Y,k=2)
```
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