Package 'Copula.Markov'

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Type Package

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

Version 2.1

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Description Estimation and statistical process control are performed under copula-based time-series models.
Available are statistical methods in Long and Emura (2014 JCSA),
Emura et al. (2017 Commun Stat-Simul) <DOI:10.1080/03610918.2015.1073303>,
and Chen and Emura (2018-, submitted).

License GPL-2

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R topics documented:

Copula.Markov-package *Copula-Based Estimation and Statistical Process Control for Serially Correlated Time Series*

Description

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

Emura T, Long TH, Sun LH (2017), R routines for performing estimation and statistical process control under copula-based time series models, Communications in Statistics - Simulation and Computation, 46 (4): 3067-87

Long TH and Emura T (2014), A control chart using copula-based Markov chain models, Journal of the Chinese Statistical Association 52 (No.4): 466-96

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

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

Emura T, Long TH, Sun LH (2017), R routines for performing estimation and statistical process control under copula-based time series models, Communications in Statistics - Simulation and Computation, 46 (4): 3067-87

Long TH and Emura T (2014), A control chart using copula-based Markov chain models, Journal of the Chinese Statistical Association 52 (No.4): 466-96

Examples

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

Clayton.Markov.DATA.binom

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))
```

`Clayton.Markov.MLE` *Maximum Likelihood Estimation and Statistical Process Control Under the Clayton 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 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

Emura T, Long TH, Sun LH (2017), R routines for performing estimation and statistical process control under copula-based time series models, Communications in Statistics - Simulation and Computation, 46 (4): 3067-87

Long TH and Emura T (2014), A control chart using copula-based Markov chain models, Journal of the Chinese Statistical Association 52 (No.4): 466-96

Examples

```
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*

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.binom(Y, size, k = 3, plot = TRUE)
```

Arguments

`Y`	vector of observations
`size`	numbe 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

Emura T, Long TH, Sun LH (2017), R routines for performing estimation and statistical process control under copula-based time series models, Communications in Statistics - Simulation and Computation, 46 (4): 3067-87

Long TS and Emura T (2014), A control chart using copula-based Markov chain models, Journal of the Chinese Statistical Association 52 (No.4): 466-96

Examples

```
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

```
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`	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

Emura T, Long TH, Sun LH (2017), R routines for performing estimation and statistical process control under copula-based time series models, Communications in Statistics - Simulation and Computation, 46 (4): 3067-87

Long TH and Emura T (2014), A control chart using copula-based Markov chain models, Journal of the Chinese Statistical Association 52 (No.4): 466-96

Examples

```
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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