Package ‘MHTcop’

January 21, 2019

Type Package

Title Tests Controlling the FDR / FWER under Certain Copula Models

Version 0.1.1

Description Implements tests controlling the false discovery rate (FDR) / family-wise error rate (FWER) for some copula models.

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Encoding UTF-8

LazyData true

RoxygenNote 6.1.1

Imports stats, copula, matrixStats, mvtnorm, stabledist, MCMCpack

Suggests knitr, rmarkdown, pbapply

VignetteBuilder knitr

NeedsCompilation no

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Repository CRAN

Date/Publication 2019-01-21 16:10:03 UTC

R topics documented:

ac_fdr.test *Perform a FDR controlling test on marginal p-values that are distributed according to an Archmidean copula*

Description

Performs a test on marginal p-values according to the procedure described in Bodnar, Dickhaus (2014). See the vignette `vignette('fdr-test',package='MHTcop')` for a detailed explanation of the example.

Usage

```
ac_fdr.test(p, cop, m0Lower, alpha = 0.05, num.reps = 1e+05)
```

Arguments

`p`	The vector of marginal p-values
`cop`	The dependency model for the p-values (for example copula::copClayton)
`m0Lower`	A lower bound on the number of true null hypotheses (i.e. m0Lower is a reasonable lower bound for the number of true null hypotheses), $1 \leq m0Lower \leq length(p)$
`alpha`	The desired FDR level
`num.reps`	The number of samples to draw for the Monte-Carlo integration (default = 1e5)

Value

The adjusted p-values `p.adjusted` such that performing the test by rejecting the i-th hypothesis if and only if `p.adjusted[i]` $\leq$ `alpha` is a test at FDR level `alpha`

References

T. Bodnar and T. Dickhaus (2014). False discovery rate control under Archimedean copula. *Electronic Journal of Statistics* Volume 8, Number 2 (2014), 2207-2241.

Examples

```
#(Using p-values generated from the model (16))
library(copula)
set.seed(1)
m <- 20
m0 <- 0.8*m
p_values <- rCopula(1,onacopulaL(copClayton,list(1,1:20)))
mu<-runif(m-m0, min=-1, max=-1/2)
p_values[1,(m0+1):m]<-pnorm(sqrt(m)*mu+qnorm(p_values[(m0+1):m]),0,1)
ac_fdr.test(p_values,setTheta(copClayton,1),m0,0.05,1e4)$test
```

bolshev.rec.vec — *Distribution function of the order statistics of i.i.d. uniform random variables*

Description

`bolshev.rec.vec` is a vectorized and unrolled implementation of the Bolshev recursion described in Shorack, Wellner (1986) which can be utilized to calculate probabilities for order statistics of i.i.d. uniform random variables.

Usage

```
bolshev.rec.vec(m)
```

Arguments

`m`	matrix whose columns are p-values sorted in descending order

Details

Denote by $U_1, \cdots, U_n$ n i.i.d. uniform random variables on $[0, 1]$. Denote by $U_{1:n}, \cdots, U_{n:n}$ their order statistics. Then the return value `p` contains the probabilities

$$p[i,j] = P\left(\bigcap_{k=i}^{n} \{m[n-k+1,j] \leq U_{k:n}\}\right)$$

Value

matrix p containing the calculated probabilities

References

G. R. Shorack and J. A. Wellner (1986). Empirical Processes with Applications to Statistics

Examples

```
bolshev.rec.vec(cbind(rev(c(0.7,0.8,0.9))))
#result: c(0.016, 0.079, 0.271)
#monte carlo simulation
sim <- function(v) mean(replicate(1e4,all(v <= sort(runif(3)))))
set.seed(0)
c(sim(c(0.7,0.8,0.9)),sim(c(0,0.8,0.9)),sim(c(0,0,0.9)))
#similar result: c(0.0176, 0.0799, 0.2709)
```

`fwer.support_test` *Copula-based multiple support test which controlls the FWER*

Description

Perform a multiple support test controlling the family-wise error rate (FWER) using the procedure described in Stange, Bodnar, Dickhaus (2015).

Usage

```
fwer.support_test(sample, theta, alpha = 3, beta = 4,
  boot.reps = NULL, sigLevel = 0.05)
```

Arguments

`sample`	The observed sample (a matrix whose columsn are the observations)
`theta`	The hypothesized scale `theta=c(`$\vartheta_1^*, \cdots, \vartheta_m^*$`)`
`alpha`	First shape parameter of the Beta margins
`beta`	Second shape parameter of the Beta margins
`boot.reps`	number of bootstrap repetitions for estimating the parameter η of the Gumbel copula. If this parameter is NULL then η is estimated from Kendalls tau and no bootstrap is performed.
`sigLevel`	The desired significance level

Details

The test is performed assuming an i.i.d. sample $X_1, \cdots, X_n$ which has the stochastic representation

$$X_{i,j} = \vartheta_j Z_j$$

where Z_j takes values in $[0, 1]$ and which is distributed according to a Gumbel copula with Beta margins. The test simultaneously tests the hypotheses $H_{0,j} : \vartheta_j \leq \vartheta_j^*$ versus the corresponding alternatives $H_{1,j} : \vartheta_j > \vartheta_j^*$.

For usage examples and figure reproduction see `vignette('fwer-support-test',package='MHTcop')`.

Note: If the copula is only in the domain of attraction of the Gumbel copula (but not a Gumbel copula) then it is necessary to pass the number of boot strap repetitions `boot.reps` as an additional parameter since the non-bootstrapped parameter estimate would not be consistent.

Value

list l, where

- l$statistic contains the values of the test statistics,
- l$critvalues are the calibrated critical values,
- l$test contains the test decisions,
- l$etahat is estimated parameter of the Gumbel copula

References

J. Stange, T. Bodnar and T. Dickhaus (2015). Uncertainty quantification for the family-wise error rate in multivariate copula models. *AStA Advances in Statistical Analysis* 99.3 (2015): 281-310.

`fwer.ztest` *Copula-based multiple z-test which controlls the FWER*

Description

Perform a multiple (two-sided) z-test controlling the family-wise error rate (FWER) using the procedure described in Stange, Bodnar, Dickhaus (2015).

Usage

```
fwer.ztest(sample, mu, sigma = NULL, sigLevel = 0.05)
```

Arguments

`sample`	The observed sample
`mu`	The mean μ^*
`sigma`	The estimated covariance matrix (the copula parameter). If it is omitted it will be estimated from an AR(1) model
`sigLevel`	The desired significance level

Details

Let $X_1, \cdots, X_n$ denote an i.i.d. sample with values in $\mathbb{R}^m$. Furthermore let $\mu_j = \mathbb{E}[X_{1,j}]$ be the component-wise expectations. Then the multiple (two-sided) z-test simultaneously tests the hypotheses $H_{0,j} : \mu_j = \mu_j^*$ versus the corresponding alternatives $H_{1,j} : \mu_j \neq \mu_j^*$.

For usage examples and figure reproduction see `vignette('fwer-ztest',package='MHTcop')`.

Note: If the parameter `sigma` is passed it needs to be a consistent estimate of the covariance matrix of X_1.

Value

list l, where

- l$statistic contains the values of the test statistics,
- l$critvalues are the calibrated critical values,
- l$test contains the test decisions,
- l$etahat is estimated parameter of the Gumbel copula

References

J. Stange, T. Bodnar and T. Dickhaus (2015). Uncertainty quantification for the family-wise error rate in multivariate copula models. *AStA Advances in Statistical Analysis* 99.3 (2015): 281-310.

`sample.discrete` *Generate a sample from a discrete distribution*

Description

`sample.discrete` generates a sample of size `n` given its density function `df`

Usage

```
sample.discrete(df, n)
```

Arguments

`df`	The density function - It is assumed that the support is a subset of the natural numbers
`n`	The desired sample size

`sample.Z` *Generate a sample from the inverse Laplace-Stieltjes transform of a copula's generator*

Description

`sample.Z` generates a sample of size `n` from the inverse Laplace-Stieltjes transform of the generator of the copula `cop`. For further details see https://doi.org/10.1016/j.csda.2008.05.019 (especially table 1).

Usage

```
sample.Z(cop, n)
```

Arguments

`cop`	The copula
`n`	The desired sample size

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