Package 'RTDE'

July 17, 2014

Type Package

Title Robust Tail Dependence Estimation

Version 0.1-0

Date 2014-07-31

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Description Robust tail dependence estimation for bivariate models. This package is based on two papers by the authors:'Robust and bias-corrected estimation of the coefficient of tail dependence' and 'Robust and bias-corrected estimation of extreme failure sets'. This work was supported by a research grant (VKR023480) from VILLUM FONDEN and an international project for scientific cooperation (PICS-6416).

Depends R (>= 3.0.0), parallel

Suggests tseries

License GPL (>= 2)

URL https://www.rmetrics.org/files/Paris2014/

NeedsCompilation no

Repository CRAN

Date/Publication 2014-07-17 18:41:53

R topics documented:

`dataRTDE` *Data object used for a Tail Dependence model*

Description

Data object used for a Tail Dependence model.

Usage

```
dataRTDE(obs, simu.nb, simu.marg=c("ufrechet", "upareto"),
    simu.cop=c("indep", "FGM", "Frank"), simu.cop.par=NULL,
    contamin.eps=NULL, contamin.method=c("NA","max+","+"),
    contamin.marg=c("ufrechet", "upareto"),
    contamin.cop=c("indep", "FGM", "Frank"),
    contamin.cop.par=NULL, control=list())


## S3 method for class 'dataRTDE'
print(x, ...)
## S3 method for class 'dataRTDE'
summary(object, ...)
## S3 method for class 'dataRTDE'
plot(x, which=1:2, ...)
```

Arguments

`obs`	bivariate numeric dataset.
`simu.nb`	a numeric for the sample size of simulated data.
`simu.marg`	a character string for the marginal distribution: either `"ufrechet"` (default) or `"upareto"`.
`simu.cop`	a character string ofr the copula: either `"indep"` (default), `"FGM"` or `"Frank"`.
`simu.cop.par`	a numeric for the copula parameter, default to `NULL`.
`contamin.eps`	a numeric for the percentage (of `simu.nb`) of contaminated data.
`contamin.method`	a character string for the contamination method: either `"NA"` (default), `"max+"` or `"+"`.

`contamin.marg`	a character string for the marginal distribution: either `"ufrechet"` (default) or `"upareto"`.
`contamin.cop`	a character string ofr the copula: either `"indep"` (default), `"FGM"` or `"Frank"`.
`contamin.cop.par`	a numeric for the copula parameter, default to `NULL`.
`control`	A list of control paremeters. Unused.
`x, object`	an R object inheriting from `"dataRTDE"`.
`...`	arguments to be passed to subsequent methods.
`which`	an integer (1 or 2) to specify whether to plot in original scale or unit-Pareto scale, respectively.

Details

The function `dataRTDE` handles empirical or simulated data and may add a contamination.

Empirical data When `obs` is provided, `dataRTDE` just wraps the two-column matrix $(X_i, Y_i)_i$.

Simulated data When `simu.XXX` are provided, `dataRTDE` simulates random vectors $(X_i, Y_i)_i$ from the copula `simu.cop` with parameter `simu.cop.par` and marginal `simu.marg`.

Note that end-user must choose between empirical data (`obs` is provided) and simulated data (`simu.XXX` are provided). Not both can be provided. In addition to data handling $(X_i, Y_i)_i$, a contamination can be processed by adding new simulated points $(\tilde{X}_i, \tilde{Y}_i)_i$ when `contamin.method != "NA"`. Those points $(\tilde{X}_i, \tilde{Y}_i)_i$ are simulated from the copula `contamin.cop` with parameter `contamin.cop.par` and marginal `contamin.cop.par`. If `contamin.method != "+"`, the points $(\tilde{X}_i, \tilde{Y}_i)_i$ are the contaminations, while if `contamin.method != "max+"` the contaminations are obtained by adding the component-wise maximum of the data: $(\tilde{X}_i + X_{n,n}, \tilde{Y}_i)_i + Y_{n,n}$, where $X_{n,n} = max(X_1, ..., X_n)$, idem for $Y_{n,n}$.

Value

`dataRTDE` returns an object of class `"dataRTDE"` having the following components:

`n` rownumber of `data`.

`n0` rownumber of `contamin`.

`data` original or simulated data.

`contamin` contaminated data.

Author(s)

Christophe Dutang

References

C. Dutang, Y. Goegebeur, A. Guillou (2014), *Robust and bias-corrected estimation of the coefficient of tail dependence*, Volume 57, Insurance: Mathematics and Economics

This work was supported by a research grant (VKR023480) from VILLUM FONDEN and an international project for scientific cooperation (PICS-6416).

See Also

See fitRTDE for the fitting process and zvalueRTDE for the z-value computation.

Examples

```
#####
# (1) simulation

n <- 100
x <- dataRTDE(simu.nb=n, simu.marg="ufrechet", simu.cop="indep")
print(x)
summary(x)
plot(x, xlab="x", ylab="y")

#####
# (2) part of the workers' compensation dataset

x1 <- c(
  21.798086,  22.640528,  22.572010,  24.789710,  25.876764,  28.033613,
  22.525887,  12.004031,  12.713178,  13.596610,  14.811727,  12.774073,
  20.245789,  24.242468,  50.216515,  56.099793,  58.109747,  67.807105,
  73.852437,  84.208474,  83.604216,  19.507341,  20.810822,  23.838122,
  24.212193,  25.367578,  35.401344,  37.580989,  12.428727,  13.492474,
  23.471988,  24.101833,  24.766193,  26.078216)

x2 <- c(
 0.538707, 0.439184, 1.059775, 0.560013, 1.004997, 1.097314, 0.609833, 0.270222,
 0.229566, 0.596850, 0.196539, 0.134248, 0.489312, 0.418218, 0.769208, 0.649707,
 0.503919, 0.675466, 0.545745, 1.562266, 0.931762, 0.291125, 0.499927, 0.151084,
 0.141910, 0.300373, 0.119761, 0.141300, 0.377662, 0.169574, 0.243585, 0.061215,
 0.055272, 0.312816, 0.160196, 0.623029, 0.280707, 0.174422, 0.176666, 0.153907,
 0.605122, 0.664457, 0.348918, 0.370878)

obs <- dataRTDE(cbind(x1, x2))
obs
summary(obs)

plot(obs)
```

EPD *The Extended Pareto Distribution*

Description

Density function, distribution function, quantile function, random generation.

Usage

```
dEPD(x, eta, delta, rho, tau, log = FALSE)
pEPD(q, eta, delta, rho, tau, lower.tail=TRUE, log.p = FALSE)
qEPD(p, eta, delta, rho, tau, lower.tail=TRUE, log.p = FALSE,
    control=list())
rEPD(n, eta, delta, rho, tau)
```

Arguments

`x, q`	vector of quantiles.
`p`	vector of probabilities.
`n`	number of observations. If `length(n) > 1`, the length is taken to be the number required.
`eta`	first shape parameter.
`delta`	nuisance parameter.
`rho, tau`	second shape parameter.
`log, log.p`	logical; if TRUE, probabilities p are given as log(p).
`lower.tail`	logical; if TRUE (default), probabilities are $P[X \le x]$, otherwise, $P[X > x]$.
`control`	A list of control paremeters. See section Details.

Details

The extended Pareto distribution is defined by the following density

$$f(x) = \frac{1}{\eta} x^{-1/\eta-1}[1+\delta(1-x^{-\tau})]^{-1/\eta-1}[1+\delta(1-(1-\tau)x^{-\tau})]$$

for all $x > 1$ when parametrized by τ. However, a typical parametrization is obtained by setting $\tau = -\rho/\eta$, i.e.

$$f(x) = \frac{1}{\eta} x^{-1/\eta-1}[1+\delta(1-x^{\rho/\eta})]^{-1/\eta-1}[1+\delta(1-(1+\rho/\eta)x^{\rho/\eta})]$$

for all $x > 1$ when parametrized by ρ.

The `control` argument is a list that can supply any of the following components:

- `upperbound` The upperbound used in the `optimize` function when computing numerical quantiles, default to `1e6`.
- `tol` the desired accuracy used in the `optimize` function when computing numerical quantiles, default to `1e-9`.

Value

`dEPD` gives the density, `pEPD` gives the distribution function, `qEPD` gives the quantile function, and `rEPD` generates random deviates.

The length of the result is determined by `n` for `rEPD`, and is the maximum of the lengths of the numerical parameters for the other functions.

The numerical parameters other than `n` are recycled to the length of the result. Only the first elements of the logical parameters are used.

Author(s)

Christophe Dutang

References

J. Beirlant, E. Joossens, J. Segers (2009), *Second-order refined peaks-over-threshold modelling for heavy-tailed distributions*, Journal of Statistical Planning and Inference, Volume 139, Issue 8, Pages 2800-2815.

C. Dutang, Y. Goegebeur, A. Guillou (2014), *Robust and bias-corrected estimation of the coefficient of tail dependence*, Insurance: Mathematics and Economics

This work was supported by a research grant (VKR023480) from VILLUM FONDEN and an international project for scientific cooperation (PICS-6416).

Examples

```
#####
# (1) density function
x <- seq(0, 5, length=24)

cbind(x, dEPD(x, 1/2, 1/4, -1))

#####
# (2) distribution function

cbind(x, pEPD(x, 1/2, 1/4, -1, lower=FALSE))
```

FGM *The Eyraud Farlie Gumbel Morgenstern Distribution*

Description

Density function, distribution function, quantile function, random generation.

Usage

```
dFGM(u, v, alpha, log = FALSE)
pFGM(u, v, alpha, lower.tail=TRUE, log.p = FALSE)
qFGM(p, alpha, lower.tail=TRUE, log.p = FALSE)
rFGM(n, alpha)
```

Arguments

`u, v`	vector of quantiles.
`p`	vector of probabilities.
`n`	number of observations. If `length(n) > 1`, the length is taken to be the number required.
`alpha`	shape parameter.
`log, log.p`	logical; if TRUE, probabilities p are given as log(p).
`lower.tail`	logical; if TRUE (default), probabilities are $P[X \le x]$, otherwise, $P[X > x]$.

Details

The FGM is defined by the following distribution function

$$C(u, v) = u * v * (1 + \alpha * (1 - u) * (1 - v))$$

for all u, v in [0,1] and α in [0,1]. When `lower.tail=FALSE`, `pFGM` returns the survival copula $P(U > u, V > v)$.

Value

`dFGM` gives the density, `pFGM` gives the distribution function, `qFGM` gives the quantile function, and `rFGM` generates random deviates.

The length of the result is determined by `n` for `rFGM`, and is the maximum of the lengths of the numerical parameters for the other functions.

The numerical parameters other than `n` are recycled to the length of the result. Only the first elements of the logical parameters are used.

Author(s)

Christophe Dutang

References

Nelsen, R. (2006), *An Introduction to Copula, Second Edition*, Springer.

Examples

```
#####
# (1) density function
u <- v <- seq(0, 1, length=25)

cbind(u, v, dFGM(u, v, 1/2))
cbind(u, v, outer(u, v, dFGM, alpha=1/2))


#####
# (2) distribution function
```

```
cbind(u, v, pFGM(u, v, 1/2))
cbind(u, v, outer(u, v, pFGM, alpha=1/2))
```

fitRTDE *Fitting a Tail Dependence model with a Robust Estimator*

Description

Fit a Tail Dependence model with a Robust Estimator.

Usage

```
fitRTDE(obs, nbpoint, alpha, omega, method="MDPDE", fix.arg=list(rho=-1),
    boundary.method="log", control=list())


## S3 method for class 'fitRTDE'
print(x, ...)
## S3 method for class 'fitRTDE'
summary(object, ...)
## S3 method for class 'fitRTDE'
plot(x, which=1:2, main, ...)
```

Arguments

`obs`	bivariate numeric dataset.
`nbpoint`	a numeric for the number of largest points to be selected.
`alpha`	a numeric for the power divergence parameter.
`omega`	a numeric for omega, see section Details.
`method`	a character string equals to `"MDPDE"`.
`fix.arg`	a named list of fixed arguments: either rho only e.g. `list(rho=-1)` or $rho, delta$ e.g. `list(rho=-1, delta=0)`.
`boundary.method`	a character string: either "log" or "simple", see section Details.
`control`	A list of control paremeters. See section Details.
`x, object`	an R object inheriting from `"fitRTDE"`.
`...`	arguments to be passed to subsequent methods.
`which`	an integer (1 or 2) to specify whether to plot eta or delta, respectively.
`main`	a main title for the plot.

Details

The function `fitRTDE` fits an extended Pareto distribution (η, τ are fitted while ρ is fixed) on the relative excess of Z_ω (see `zvalueRTDE`) using a robust estimator based on the minimum distance power divergence criterion (see `MDPD`). The boundary enforcement on η, τ is either done by the bounded BFGS algorithm (see `optim` with `method="L-BFGS-B"`) or by the bounded Nelder-Mead algorithm (see `constrOptim` with `method="Nelder-Mead"`) .

Value

`fitRTDE` returns an object of class `"fitRTDE"` having the following components:

`n` rownumber of `data`.

`n0` rownumber of `contamin`.

`alpha` a vector of `alpha` parameters.

`omega` a vector of `omega` parameters.

`m` a vector of `nbpoint`.

`rho` a numeric for `rho`.

`eta` estimate of eta.

`delta` estimate of $delta$.

`Ztilde` see `zvalueRTDE`.

Author(s)

Christophe Dutang

References

C. Dutang, Y. Goegebeur, A. Guillou (2014), *Robust and bias-corrected estimation of the coefficient of tail dependence*, Volume 57, Insurance: Mathematics and Economics

This work was supported by a research grant (VKR023480) from VILLUM FONDEN and an international project for scientific cooperation (PICS-6416).

Examples

```
#####
# (1) simulation

omega <- 1/2
m <- 48
n <- 100
obs <- cbind(rupareto(n), rupareto(n)) + rupareto(n)

#function of m
system.time(
x <- fitRTDE(obs, nbpoint=m:(n-m), 0, 1/2)
)
```

```
x
summary(x)
plot(x, which=1)
plot(x, which=2)
```

Frank *The Eyraud Farlie Gumbel Morgenstern Distribution*

Description

Density function, distribution function, quantile function, random generation.

Usage

```
dfrank(u, v, alpha, log = FALSE)
pfrank(u, v, alpha, lower.tail=TRUE, log.p = FALSE)
qfrank(p, alpha, lower.tail=TRUE, log.p = FALSE)
rfrank(n, alpha)
```

Arguments

`u, v`	vector of quantiles.
`p`	vector of probabilities.
`n`	number of observations. If `length(n) > 1`, the length is taken to be the number required.
`alpha`	shape parameter.
`log, log.p`	logical; if TRUE, probabilities p are given as log(p).
`lower.tail`	logical; if TRUE (default), probabilities are $P[X \le x]$, otherwise, $P[X > x]$.

Details

The Frank is defined by the following distribution function

$$C(u,v) = -\frac{1}{\alpha} \log \left[1 - \frac{(1-e^{-\alpha u})(1-e^{-\alpha v})}{1-e^{-\alpha}} \right],$$

for all u, v in [0,1]. When `lower.tail=FALSE`, `pfrank` returns the survival copula $P(U > u, V > v)$.

Value

`dfrank` gives the density, `pfrank` gives the distribution function, `qfrank` gives the quantile function, and `rfrank` generates random deviates.

The length of the result is determined by `n` for `rfrank`, and is the maximum of the lengths of the numerical parameters for the other functions.

The numerical parameters other than `n` are recycled to the length of the result. Only the first elements of the logical parameters are used.

Author(s)

Christophe Dutang

References

Nelsen, R. (2006), *An Introduction to Copula, Second Edition*, Springer.

Examples

```
#####
# (1) density function
u <- v <- seq(0, 1, length=25)

cbind(u, v, dfrank(u, v, 1/2))
cbind(u, v, outer(u, v, dfrank, alpha=1/2))


#####
# (2) distribution function

cbind(u, v, pfrank(u, v, 1/2))
cbind(u, v, outer(u, v, pfrank, alpha=1/2))
```

Frechet *The Frechet Distribution*

Description

Density function, distribution function, quantile function, random generation.

Usage

```
dfrechet(x, shape, xmin, log = FALSE)
pfrechet(q, shape, xmin, lower.tail=TRUE, log.p = FALSE)
qfrechet(p, shape, xmin, lower.tail=TRUE, log.p = FALSE)
rfrechet(n, shape, xmin)

dufrechet(x, log = FALSE)
pufrechet(q, lower.tail=TRUE, log.p = FALSE)
qufrechet(p, lower.tail=TRUE, log.p = FALSE)
rufrechet(n)
```

Arguments

`x, q`	vector of quantiles.
`p`	vector of probabilities.
`n`	number of observations. If `length(n) > 1`, the length is taken to be the number required.
`shape`	shape parameter.
`xmin`	lower bound parameter.
`log, log.p`	logical; if TRUE, probabilities p are given as log(p).
`lower.tail`	logical; if TRUE (default), probabilities are $P[X \le x]$, otherwise, $P[X > x]$.

Details

The Frechet distribution is defined by the following density

$$f(x) = shape * (x - xmin)^{(-shape-1)} * exp(-(x - xmin)^{(-shape)})$$

for all $x > xmin$. The unit Frechet distribution corresponds to `xmin=0` and `shape=1`.

Value

`dfrechet, dufrechet` give the density, `pfrechet, pufrechet` give the distribution function, `qfrechet, qufrechet` give the quantile function, and `rfrechet, rufrechet` generate random deviates.

The length of the result is determined by `n` for `rfrechet, rufrechet`, and is the maximum of the lengths of the numerical parameters for the other functions.

The numerical parameters other than `n` are recycled to the length of the result. Only the first elements of the logical parameters are used.

Author(s)

Christophe Dutang

References

Kotz, S. and Nadarajah, S. (2000), *Extreme Value Distributions: Theory and Applications*, Imperial College Press.

Beirlant, J., Goegebeur, Y., Teugels, J., Segers (2004), *Statistics of Extremes: Theory and Applications*, John Wiley and Sons.

Examples

```
#####
# (1) density function
x <- seq(0, 5, length=24)

cbind(x, dfrechet(x, 1/2, 1/4))
```

```
#####
# (2) distribution function

cbind(x, pfrechet(x, 1/2, 1/4))
```

MDPD *The Minimum Distance Power Divergence statistics*

Description

Computes the power divergence statistics then used a minimization problem.

Usage

```
MDPD(theta, densfun, obs, alpha, ..., control=list())
```

Arguments

`theta`	the parameter of the distribution given as a vector.
`densfun`	a function computing the theoretical density function.
`obs`	a numeric vector of observations
`alpha`	a numeric for the power divergence parameter.
`...`	further arguments to be passed to the density function.
`control`	A list of control paremeters. See section Details.

Details

The Power Divergence for a density function f and observations $X_1, ..., X_n$ is defined as

$$\Delta(f,\alpha) = \int_R f^{1+\alpha}(x)dx - \left(1+\frac{1}{\alpha}\right)\frac{1}{n}\sum_{i=1}^{n} f^{\alpha}(X_i)$$

for $\alpha > 0$

$$\Delta(f,0) = -\frac{1}{n}\sum_{i=1}^{n}\log f(X_i)$$

for $\alpha = 0$.

The `control` argument is a list that can supply any of the following components:

`eps` a small positive floating-point number used when `integrate` stalled, default to `1e-3`.

`tol` the desired accuracy used in the `integrate` function when computing the power divergence, default to `1e-3`.

`lower` the lower bound of the domain of the density function, default to 1.

`upper` the lower bound of the domain of the density function, default to infinity.

Value

`MDPD` returns the power divergence against the density function `densfun` as a numeric.

Author(s)

Christophe Dutang

References

Basu, A., Harris, I.R., Hjort, N.L., Jones, M.C., (1998). *Robust and efficient estimation by minimizing a density power divergence*, Biometrika, 85, 549-559.

C. Dutang, Y. Goegebeur, A. Guillou (2014), *Robust and bias-corrected estimation of the coefficient of tail dependence*, Insurance: Mathematics and Economics

This work was supported by a research grant (VKR023480) from VILLUM FONDEN and an international project for scientific cooperation (PICS-6416).

Examples

```
#####
# (1) small example

omega <- 1/2
m <- 10
n <- 100
obs <- cbind(rupareto(n), rupareto(n)) + rupareto(n)

#unit Pareto transform
z <- zvalueRTDE(obs, omega, nbpoint=m, output="relexcess")

MDPD(c(1/2, 1/4), dEPD, z$Z, alpha=0, rho=-1)
```

qqparetoplot *The QQ Pareto plot*

Description

Plot the quantile-quantile Pareto plot

Usage

```
qqparetoplot(x, ..., highlight=c("red","cross"))
```

Arguments

`x`	data vector.
`highlight`	character string used in `points` to plot outliers.
`...`	further arguments for `plot.default`.

Details

`qqparetoplot` plots the quantile-quantile Pareto plot and may highlight some points having name `"new"`.

Value

Invisible list with component `x` for the x-coordinates and `y` for the y-coordinates.

Author(s)

Christophe Dutang

Examples

```
#####
# (1) small examples

set.seed(1234)
x <- rupareto(100)
qqparetoplot(x)

x <- rexp(100)
qqparetoplot(x)
```

RTDE *Data object used for a Tail Dependence model*

Description

Data object used for a Tail Dependence model.

Usage

```
RTDE(obs=NULL, simu=list(), contamin=list(),
    nbpoint, alpha, omega, method="MDPDE", fix.arg=list(rho=-1),
    boundary.method="log", core=1, keepdata, control=list())


## S3 method for class 'RTDE'
print(x, ...)
## S3 method for class 'RTDE'
summary(object, ...)
## S3 method for class 'RTDE'
plot(x, which=1:3, FUN=mean, main, ...)

prob(object, q, ...)
## Default S3 method:
prob(object, q, ...)
## S3 method for class 'RTDE'
prob(object, q, ...)
```

Arguments

- `obs` bivariate numeric dataset.
- `simu` a names list with components: "nb", "marg", "cop", "replicate". When needed, "cop.par" must be provided, see dataRTDE.
- `contamin` a names list with components: "eps", "method", "marg", "cop". When needed, "cop.par" must be provided, see dataRTDE.
- `nbpoint` a numeric for the number of largest points to be selected.
- `alpha` a numeric for the power divergence parameter.
- `omega` a numeric for omega, see section Details.
- `method` a character string equals to "MDPDE".
- `fix.arg` a named list of fixed arguments: either rho only e.g. `list(rho=-1)` or $rho, delta$ e.g. `list(rho=-1, delta=0)`.
- `boundary.method`
  a character string: either "log" or "simple", see section Details.

core	a numeric for the number of core to be used, only relevant for simulated data.
keepdata	a logical whether to return or not the dataset.
control	A list of control paremeters for fitRTDE.
x, object	an R object inheriting from "RTDE".
...	arguments to be passed to subsequent methods.
which	an integer to specify what to plot: 1 eta, 2 delta, 3 probability estimates.
FUN	the function to be applied, default to mean.
main	a main title for the plot.
q	vector of quantiles.

Details

The function RTDE handles (empirical or simulated) data (cf. dataRTDE) and then fits a bivariate tail model using a method criterion (cf. fitRTDE and MDPD) based on an extended Pareto distribution approximation (EPD). Typical distributions for simulated data and/or contaminations are

- MarginalUnit Pareto upareto, Frechet Frechet.
- CopulaFrank Frank, FGM FGM.

For a good introduction, please refer to references.

Value

RTDE returns an object of class "RTDE" having the following components:

obs.type see dataRTDE.

data see dataRTDE.

fit see fitRTDE.

simu see dataRTDE.

contamin see dataRTDE.

setting a list summarizing the computation.

Author(s)

Christophe Dutang

References

C. Dutang, Y. Goegebeur, A. Guillou (2014), *Robust and bias-corrected estimation of the coefficient of tail dependence*, Volume 57, Insurance: Mathematics and Economics

This work was supported by a research grant (VKR023480) from VILLUM FONDEN and an international project for scientific cooperation (PICS-6416).

See Also

See fitRTDE for the fitting process and dataRTDE for the data-handling process.

Examples

```
#####
# (1) simulation

n <- 100
x <- RTDE(simu=list(nb=n, marg="ufrechet", cop="indep", replicate=1),
nbpoint=10:11, alpha=0, omega=1/2)
x
summary(x)
```

`upareto` *The unit Pareto Distribution*

Description

Density function, distribution function, quantile function, random generation.

Usage

```
dupareto(x, log = FALSE)
pupareto(q, lower.tail=TRUE, log.p = FALSE)
qupareto(p, lower.tail=TRUE, log.p = FALSE)
rupareto(n)
```

Arguments

`x, q`	vector of quantiles.
`p`	vector of probabilities.
`n`	number of observations. If `length(n) > 1`, the length is taken to be the number required.
`log, log.p`	logical; if TRUE, probabilities p are given as log(p).
`lower.tail`	logical; if TRUE (default), probabilities are $P[X \le x]$, otherwise, $P[X > x]$.

Details

The extended Pareto distribution is defined by the following density and distribution function

$$f(x) = \frac{1}{x^2}, F(x) = 1 - \frac{1}{x},$$

for all $x > 0$.

Value

dupareto gives the density, pupareto gives the distribution function, qupareto gives the quantile function, and rupareto generates random deviates.

The length of the result is determined by n for rupareto, and is the maximum of the lengths of the numerical parameters for the other functions.

The numerical parameters other than n are recycled to the length of the result. Only the first elements of the logical parameters are used.

Author(s)

Christophe Dutang

References

Johnson, N.L., Kotz, S. and Balakrishnan, N. (2000), *Continuous Univariate Distributions, Volume 1, Second Edition*, John Wiley and Sons.

Examples

```
#####
# (1) density function
x <- seq(0, 5, length=24)

cbind(x, dupareto(x))

#####
# (2) distribution function

cbind(x, pupareto(x))
```

---

zvalueRTDE *The Z-value random variable*

Description

Compute the Z-value variable from a bivariate dataset.

Usage

```
zvalueRTDE(obs, omega, nbpoint, output=c("orig", "relexcess"),
    marg=c("upareto", "ufrechet", "uunif"))

## S3 method for class 'zvalueRTDE'
print(x, ...)
## S3 method for class 'zvalueRTDE'
summary(object, ...)


relexcess(x, nbpoint, ...)
## Default S3 method:
relexcess(x, nbpoint, ...)
## S3 method for class 'zvalueRTDE'
relexcess(x, nbpoint, ...)
```

Arguments

`obs`	bivariate numeric dataset.
`omega`	a numeric for omega, see Details.
`nbpoint`	a numeric for the number of largest points to be selected.
`output`	a character string for the output: either `"orig"` for original value or `"relexcess"` for relative excess.
`marg`	a character string for the empirical margin transformation: either `"upareto"` for unit Pareto, `"ufrechet"` for unit Frechet or `"uunif"` for unit uniform margin.
`x, object`	an R object inheriting from `"zvalueRTDE"`.
`...`	arguments to be passed to subsequent methods.

Details

Given a bivariate dataset $(X_i, Y_i)_i$ of n points, two variables are defined: (1) for `output="orig"`, the $\tilde{Z}_{\omega,i}$ variable

$$\tilde{Z}_{\omega,i} = \min\left(f\left(\frac{R_i^X}{n+1}\right), \frac{\omega}{1-\omega} f\left(\frac{R_i^Y}{n+1}\right)\right)$$

where $f(x)$ is the margin transformation and $i = 1, ..., n$; (2) for `output="relexcess"`, the Z_j variable

$$\frac{\widetilde{Z}_{\omega,n-m+j,n}}{\widetilde{Z}_{\omega,n-m,n}}$$

where m equals `nbpoint`, $j = 1, \ldots, m$, and $\widetilde{Z}_{\omega,1,n}$, ..., $\widetilde{Z}_{\omega,n,n}$ are the order statistics of $\widetilde{Z}_{\omega,1}$, ..., $\widetilde{Z}_{\omega,n}$. The margin transformation is

$$f(x) = \frac{1}{1-x}, f(x) = \frac{1}{-\log(x)}, f(x) = x,$$

respectively for unit Pareto (`marg="upareto"`), unit Frechet (`marg="ufrechet"`) and unit uniform margin (`marg="uunif"`).

Value

zvalueRTDE computes the Z-variable and returns an object of class "zvalueRTDE" having the following components type (either "orig" or "relexcess"), omega, Ztilde or Z, n, possibly m.

relexcess computes the relative excesses from a Z-variable and returns an object of class "zvalueRTDE" of type "relexcess".

Author(s)

Christophe Dutang

References

C. Dutang, Y. Goegebeur, A. Guillou (2014), *Robust and bias-corrected estimation of the coefficient of tail dependence*, Volume 57, Insurance: Mathematics and Economics

This work was supported by a research grant (VKR023480) from VILLUM FONDEN and an international project for scientific cooperation (PICS-6416).

See Also

See fitRTDE for the fitting process and dataRTDE for the data-handling process.

Examples

```
#####
# (1) example

omega <- 1/2
m <- 10
n <- 100
obs <- cbind(rupareto(n), rupareto(n)) + rupareto(n)

#unit Pareto transform
zvalueRTDE(obs, omega, output="orig")

relexcess(zvalueRTDE(obs, omega, output="orig"), m)
zvalueRTDE(obs, omega, nbpoint=m, output="relexcess")
```

Index