Package 'CopulaGAMM'

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`berncpdf` *Bernoulli with p = 1/(1+exp(-th)) cdf/pdf and derivatives*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
berncpdf(z, th)
```

Arguments

`z`	vector of responses
`th`	linear combination of covariates (can be negative)

Value

`out`	Matrix of conditional cdf and pdf with derivative with respect to parameters

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = berncpdf(0,2.5)
```

coplik *Copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
coplik(u, v, family, rot = 0, cpar, dfC = NULL, du = FALSE)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
family	copula family: "gaussian", "t", "clayton", "frank", "fgm", "gumbel", "joe", "plackett".
rot	rotation: 0 (default), 90, 180 (survival), or 270
cpar	copula parameter
dfC	degrees of freedom for the Student copula (default is NULL)
du	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

out	Matrix of conditional cdf, pdf, and derivatives with respect to parameters

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = coplik(0.3,0.5,"clayton",cpar=2,du=TRUE)
```

dbvn *Normal density*

Description

Density at (x1,x2)

Usage

```
dbvn(x1, x2, rh)
```

Arguments

x1	vector of values
x2	vector of values
rh	correlation parameter, -1< rh <1

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dbvn(0.3,0.5,-0.6)
```

dbvn2 *Normal density (version 2)*

Description

Density at (x1,x2)

Usage

```
dbvn2(x1, x2, rh)
```

Arguments

x1	vector of values
x2	vector of values
rh	correlation parameter, -1< rh <1

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dbvn2(0.3,0.5,-0.4)
```

---

dbvncop *Normal copula density*

Description

Density at (u,v)

Usage

```
dbvncop(u, v, cpar)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter, -1< cpar<1

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dbvncop(0.3,0.5,-0.5)
```

dbvtcop *Student copula density*

Description

Density at (u,v)

Usage

```
dbvtcop(u, v, cpar, dfC)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter, -1< cpar<1
dfC	degrees of freedom

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dbvtcop(0.3,0.5,-0.7,25)
```

dcop *Copula pdf*

Description

Evaluates the copula density at given points (u,v)#'

Usage

```
dcop(u, v, family, rot = 0, cpar, dfC = NULL)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
family	copula family: "gaussian" ("normal), "t", "clayton", "frank", "fgm", "galambos", "gumbel", "joe", "huesler-reiss", "plackett".
rot	rotation: 0 (default), 90, 180 (survival), or 270
cpar	copula parameter
dfC	degrees of freedom for the Student copula (default is NULL)

Value

out	Copula density
out	Vector of pdf values

Author(s)

Pavel Krupskii and Bruno Remillard Mai 1, 2023

Examples

```
out = dcop(0.3,0.7,"clayton",270,2)
```

---

dfgm *Farlie-Gumbel-Morgenstern copula density, -1<= cpar<=*

Description

Density at (u,v)

Usage

```
dfgm(u, v, cpar)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter > 0

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dfgm(0.3,0.5,0.2)
```

`dfrk` *B3 bivariate Frank copula density*

Description

Density at (u,v)

Usage

```
dfrk(u, v, cpar)
```

Arguments

`u`	vector of values in (0,1)
`v`	vector of values in (0,1)
`cpar`	copula parameter, cpar>0 or cpar<0

Value

`out`	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dfrk(0.3,0.5,2)
```

`dgal` *B7 Galambos copula density, cpar>0*

Description

Density at (u,v)

Usage

```
dgal(u, v, cpar)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter > 0

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dgal(0.3,0.5,2)
```

---

dgum *B6 Gumbel copula density, cpar>1*

Description

Density at (u,v)

Usage

```
dgum(u, v, cpar)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter > 0

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dgum(0.3,0.5,2)
```

dhr — *B8 Huesler-Reiss copula density, cpar>0*

Description

Density at (u,v)

Usage

```
dhr(u, v, cpar)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter > 0

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dhr(0.3,0.5,2)
```

djoe — *B5 Joe copula density*

Description

Density at (u,v)

Usage

```
djoe(u, v, cpar)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter > 1

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = djoe(0.3,0.5,2)
```

---

dmtcj *B4 MTCJ copula density, cpar>0*

Description

Density at (u,v)

Usage

```
dmtcj(u, v, cpar)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter > 0

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dmtcj(0.3,0.5,2)
```

dpla — *B2 Plackett copula density*

Description

Density at (u,v)

Usage

```
dpla(u, v, cpar)
```

Arguments

u	vector of values in (0,1)
v	vector of values in (0,1)
cpar	copula parameter > 0

Value

out	Vector of densities

Author(s)

Pavel Krupskii

Examples

```
out = dpla(0.3,0.5,2)
```

EstContinuous — *Copula-based estimation of mixed regression models for continuous response*

Description

This function computes the estimation of a copula-based 2-level hierarchical model.

Usage

```
EstContinuous(
  y,
  model,
  family,
  rot = 0,
  clu,
  xc = NULL,
  xm = NULL,
  start,
  LB,
  UB,
  nq = 31,
  dfM = NULL,
  dfC = NULL,
  prediction = TRUE
)
```

Arguments

y	n x 1 vector of response variable (assumed continuous).
model	function for margins: "gaussian" (normal), "t" (Student with known df=dfM), laplace" , "exponential", "weibull".
family	copula family: "gaussian" , "t" , "clayton" , "frank" , "fgm", "gumbel".
rot	rotation: 0 (default), 90, 180 (survival), or 270
clu	variable of size n defining the clusters; can be a factor
xc	covariates of size n for the estimation of the copula, in addition to the constant; default is NULL.
xm	covariates of size n for the estimation of the mean of the margin, in addition to the constant; default is NULL.
start	starting point for the estimation; could be the ones associated with a Gaussian-copula model defined by lmer.
LB	lower bound for the parameters.
UB	upper bound for the parameters.
nq	number of nodes and weighted for Gaussian quadrature of the product of conditional copulas; default is 25.
dfM	degrees of freedom for a Student margin; default is 0 for non-t distribution,
dfC	degrees of freedom for a Student margin; default is 5.
prediction	logical variable for prediction of latent variables V; default is TRUE.

Value

coefficients	Estimated parameters
sd	Standard deviations of the estimated parameters

tstat	T statistics for the estimated parameters
pval	P-values of the t statistics for the estimated parameters
gradient	Gradient of the log-likelihood
loglik	Log-likelihood
aic	AIC coefficient
bic	BIC coefficient
cov	Covariance matrix of the estimations
grd	Gradients by clusters
clu	Cluster values
Matxc	Matrix of covariates defining the copula parameters, including a constant
Matxm	Matrix of covariates defining the margin parameters, including a constant
V	Estimated value of the latent variable by clusters (if prediction=TRUE)
cluster	Unique values of clusters
family	Copula family
tau	Kendall's tau by observation
thC0	Estimated parameters of the copula by observation
thF	Estimated parameters of the margins by observation
pcond	Conditional copula cdf
fcpdf	Margin functions (cdf and pdf)
dfM	Degrees of freedom for Student margin (default is NULL)
dfC	Degrees of freedom for the Student copula (default is NULL)

Author(s)

Pavel Krupskii, Bouchra R. Nasri and Bruno N. Remillard

References

Krupskii, Nasri & Remillard (2023). On factor copula-based mixed regression models

Examples

```
data(normal) #simulated data with normal margins
start=c(0,0,0,1); LB=c(rep(-10,3),0.001);UB=c(rep(10,3),10)
y=normal$y; clu=normal$clu;xm=normal$xm
out=EstContinuous(y,model="gaussian",family="clayton",rot=90,clu=clu,xm=xm,start=start,LB=LB,UB=UB)
```

`EstDiscrete` *Copula-based estimation of mixed regression models for discrete response*

Description

This function computes the estimation of a copula-based 2-level hierarchical model.

Usage

```
EstDiscrete(
  y,
  model,
  family,
  rot = 0,
  clu,
  xc = NULL,
  xm = NULL,
  start,
  LB,
  UB,
  nq = 25,
  dfC = NULL,
  offset = NULL,
  prediction = TRUE
)
```

Arguments

`y`	n x 1 vector of response variable (assumed continuous).
`model`	margins: "binomial" or "bernoulli","poisson", "nbinom" (Negative Binomial), "geometric", "multinomial".
`family`	copula family: "gaussian" , "t" , "clayton" , "frank" , "fgm", gumbel".
`rot`	rotation: 0 (default), 90, 180 (survival), or 270
`clu`	variable of size n defining the clusters; can be a factor
`xc`	covariates of size n for the estimation of the copula, in addition to the constant; default is NULL.
`xm`	covariates of size n for the estimation of the mean of the margin, in addition to the constant; default is NULL.
`start`	starting point for the estimation; could be the ones associated with a Gaussian-copula model defined by lmer.
`LB`	lower bound for the parameters.
`UB`	upper bound for the parameters.

nq	number of nodes and weighted for Gaussian quadrature of the product of conditional copulas; default is 25.
dfC	degrees of freedom for a Student margin; default is 0.
offset	offset (default is NULL)
prediction	logical variable for prediction of latent variables V (default is TRUE).

Value

coefficients	Estimated parameters
sd	Standard deviations of the estimated parameters
tstat	T statistics for the estimated parameters
pval	P-values of the t statistics for the estimated parameters
gradient	Gradient of the log-likelihood
loglik	Log-likelihood
aic	AIC coefficient
bic	BIC coefficient
cov	Covariance matrix of the estimations
grd	Gradients by clusters
clu	Cluster values
Matxc	Matrix of covariates defining the copula parameters, including a constant
Matxm	Matrix of covariates defining the margin parameters, including a constant
V	Estimated value of the latent variable by clusters (if prediction=TRUE)
cluster	Unique clusters
family	Copula family
thC0	Estimated parameters of the copula by observation
thF	Estimated parameters of the margins by observation
rot	rotation
dfC	Degrees of freedom for the Student copula
model	Name of the margins
disc	Discrete margin number

Author(s)

Pavel Krupskii, Bouchra R. Nasri and Bruno N. Remillard

References

Krupskii, Nasri & Remillard (2023). On factor copula-based mixed regression models

Examples

```
data(sim.poisson) #simulated data with Poisson margins
start=c(2,8,3,-1); LB =    c(-3,  3,  -7,  -6);UB=c( 7, 13,   13,   4)
y=sim.poisson$y; clu=sim.poisson$clu;
xc=sim.poisson$xc; xm=sim.poisson$xm
model = "poisson"; family="frank"
out.poisson=EstDiscrete(y,model,family,rot=0,clu,xc,xm,start,LB,UB,nq=31,prediction=TRUE)
```

---

expcond *Conditional expectation*

Description

This function computes the conditional expectation for a given copula family and a given margin variables for a clustered data model. The clusters ar3e independent but the observations with clusters are dependent, according to a one-factor copula model.

Usage

```
expcond(w, family, rot = 0, cpar, margin, dfC = NULL, subs = 1000)
```

Arguments

w	value of the conditioning random variable
family	copula model: "gaussian" , "t" , "clayton" ,"joe", "frank" , "gumbel", "plackett"
rot	rotation: 0 (default), 90, 180 (survival), or 270
cpar	copula parameter
margin	marginal distribution function
dfC	degrees of freedom for the Student copula (default is NULL)
subs	number of subdivisions for the integrals (default=1000)

Value

mest	Conditional expectations

Author(s)

Pavel Krupskii and Bruno N. Remillard

Examples

```
margin = function(x){ppois(x,10)}
expcond(0.4,'clayton',cpar=2,margin=margin)
```

expcondinv *Inverse conditional expectation for a vector of probabilities*

Description

This function computes the inverse conditional expecatation for a given copula family and a given margin variables for a clustered data model. The clusters ar3e independent but the observations with clusters are dependent, according to a one-factor copula model.

Usage

```
expcondinv(u, family, cpar, rot = 0, margin, subs = 1000, eps = 1e-04)
```

Arguments

u	conditional expectation
family	copula model: "gaussian" , "t" , "clayton" "joe", "frank" , "gumbel", "plackett"
cpar	copula parameter
rot	rotation: 0 (default), 90, 180 (survival), or 270
margin	marginal distribution function of the response
subs	number of subdivisions for the integrals (default=1000)
eps	precision required

Value

minv	Inverse conditional expectation

Author(s)

Pavel Krupskii and Bruno N. Remillard

expcondinv1 *Inverse conditional expectation for a single value*

Description

Inverse conditional expectation for a single value

Usage

```
expcondinv1(u, family, cpar, rot = 0, margin, subs = 1000, eps = 1e-04)
```

Arguments

u	conditional expectation
family	copula model: "gaussian" , "t" , "clayton" "joe", "frank" , "gumbel", "plackett"
cpar	copula parameter
rot	rotation: 0 (default), 90, 180 (survival), or 270
margin	marginal distribution function of the response
subs	number of subdivisions for the integrals (default=1000)
eps	precision required

Value

minv	Inverse conditional expectation

---

expcpdf *Exponential cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
expcpdf(z, th)
```

Arguments

z	vector of responses
th	th is rate > 0

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = expcpdf(2,3)
```

ffgmders *Farlie-Gumbel-Morgenstern copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
ffgmders(u, v, cpar, du = FALSE)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
cpar	copula parameter in [-1,1]
du	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

out	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = ffgmders(0.3,0.5,2,TRUE)
```

ffrkders *Frank copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
ffrkders(u, v, cpar, du = FALSE)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
cpar	copula parameter
du	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

out	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = ffrkders(0.3,0.5,2,TRUE)
```

---

fgumders *Gumbel copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
fgumders(u, v, cpar, du = FALSE)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
cpar	copula parameter > 1
du	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

out	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = fgumders(0.3,0.5,2,TRUE)
```

`fjoeders` *Joe copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
fjoeders(u, v, cpar, du = FALSE)
```

Arguments

`u`	vector of values in (0,1)
`v`	conditioning variable in (0,1)
`cpar`	copula parameter > 1
`du`	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

`out`	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = fjoeders(0.3,0.5,2,TRUE)
```

fmtcjders *Clayton copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
fmtcjders(u, v, cpar, du = FALSE)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
cpar	copula parameter > 0
du	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

out	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = fmtcjders(0.3,0.5,2,TRUE)
```

fnorders *Farlie-Gumbel-Morgenstern copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
fnorders(u, v, cpar, du = FALSE)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
cpar	copula parameter in (-1,1)
du	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

out	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = fnorders(0.3,0.5,0.6,TRUE)
```

---

fpladers *Plackett copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
fpladers(u, v, cpar, du = FALSE)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
cpar	copula parameter > 0
du	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

out	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = fpladers(0.3,0.5,2,TRUE)
```

`ftders` *Student copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
ftders(u, v, cpar, nu, du = FALSE)
```

Arguments

u	vector of values in (0,1)
v	conditioning variable in (0,1)
cpar	copula parameter in (-1,1)
nu	degrees of freedom >0
du	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

out	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = ftders(0.3,0.5,2,25)
```

`ftdersP` *Student copula cdf/pdf and ders*

Description

Derivatives C(u|v), C'_dl(u|v), c(u,v), c'_dl(u,v), c'_u(u,v) for the linking copula

Usage

```
ftdersP(u, v, cpar, dfC, du = FALSE)
```

Arguments

`u`	vector of values in (0,1)
`v`	conditioning variable in (0,1)
`cpar`	copula parameter in (-1,1)
`dfC`	degrees of freedom
`du`	logical value (default = FALSE) for the derivative of the copula density with respect to u

Value

`out`	Matrix of conditional cdf, pdf, and derivatives with respect to parameter

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = ftdersP(0.3,0.5,2,25,TRUE)
```

`geomcpdf` *Geometric with p = 1/(1+exp(-th)) cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
geomcpdf(z, th)
```

Arguments

z	vector of responses
th	linear combination of covariates (can be negative)

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = geomcpdf(0,-3)
```

---

invfunc *Inverse function*

Description

This function is used to get the inverse of a monotonic function on (0,1), depending on parameters, and using the bisection method

Usage

```
invfunc(q, func, th, lb = 1e-12, ub = 1 - 1e-12, tol = 1e-08, nbreak = 40)
```

Arguments

q	Function value (can be a vector if func() supports a vector argument)
func	Function of one argument to be inverted
th	Function parameters
lb	Lower bound for the possible values
ub	Upper bound for the possible values
tol	Tolerance for the inversion
nbreak	Maximum number of iterations (default is 40)

Value

out	Inverse values

Author(s)

Pavel Krupskii

lapcpdf *Laplace cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
lapcpdf(z, th)
```

Arguments

z	vector of responses
th	th[,1] is mean, th[,2] is standard deviation > 0

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = lapcpdf(2,c(-3,4))
```

linkCop *Link to copula parameter*

Description

Computes the copula parameters given a linear combination of covariates.

Usage

```
linkCop(th, family = "clayton")
```

Arguments

th	vector of linear combinations
family	copula family: "gaussian" , "t" , "clayton" , "claytonR" , "frank" , "gumbel", "gumbelR".

Value

cpar	Associated copula parameters
hder	Derivative of link function

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2023

References

Krupskii, Nasri & Remillard (2023). On factor copula-based mixed regression models

Examples

```
out = linkCop(-1,"gaussian")
```

MAP.continuous *Estimation of latent variables in the continuous case*

Description

This function computes the estimation of a latent variables for each cluster using the conditional a posteriori median.

Usage

```
MAP.continuous(u, family, rot, thC0k, dfC = NULL, nq = 35)
```

Arguments

u	vector of values in (0,1)
family	copula family: "gaussian" , "t" , "clayton" , "joe", "frank" , "fgm", gumbel", "plackett", "galambos", "huesler-reiss"
rot	rotation: 0 (default), 90, 180 (survival), or 270.
thC0k	vector of copula parameters
dfC	degrees of freedom for the Student copula (default is NULL)
nq	number of nodes and weighted for Gaussian quadrature of the product of conditional copulas; default is 31.

Value

condmed	Conditional a posteriori median.

Author(s)

Pavel Krupskii, Bouchra R. Nasri and Bruno N. Remillard

References

Krupskii, Nasri & Remillard (2023). On factor copula-based mixed regression models

Examples

```
u = c(0.5228155, 0.3064417, 0.2789849, 0.5176489, 0.3587144)
thC0k=rep(17.54873,5)
MAP.continuous(u,"clayton",rot=90,thC0k,nq=35)
```

`MAP.discrete` *Estimation of latent variable in the dicrete case*

Description

This function computes the estimation of a latent variables foe=r each cluster using the conditional a posteriori median.

Usage

```
MAP.discrete(vv, uu, family, rot, thC0k, dfC = NULL, nq = 35)
```

Arguments

`vv`	vector of values in (0,1)
`uu`	vector of values in (0,1)
`family`	copula family "gaussian" , "t" , "clayton" , "joe", "frank" , "fgm", gumbel", "plackett", "galambos", "huesler-reiss"
`rot`	rotation: 0 (default), 90, 180 (survival), or 270.
`thC0k`	vector of copula parameters
`dfC`	degrees of freedom for the Student copula (default is NULL)
`nq`	number of nodes and weighted for Gaussian quadrature of the product of conditional copulas; default is 31.

Value

`condmed`	Conditional a posteriori median.

Author(s)

Pavel Krupskii, Bouchra R. Nasri and Bruno N. Remillard

References

Krupskii, Nasri & Remillard (2023). On factor copula-based mixed regression models

Examples

```
uu = c(0.5228155, 0.3064417, 0.2789849, 0.5176489, 0.3587144)
vv = c(0.7816627, 0.6688788, 0.6351364, 0.7774917, 0.7264787)
thC0k=rep(17.54873,5)
MAP.discrete(vv,uu,"clayton",rot=90,thC0k,nq=35)
```

`margins` *Margins cdf/pdf and their derivatives*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
margins(z, th, model, x = NULL, dfM = NULL)
```

Arguments

`z`	vector of responses
`th`	linear combination of covariates (can be negative)
`model`	model for margin: "binomial" (bernoulli), "poisson", "nbinom" (mean is the parameter),"nbinom1" (p is the parameter), "geometric", "multinomial", "exponential", "weibull", "normal","t", "laplace"
`x`	covariates for the multinomial margin (default is NULL)
`dfM`	degrees of freedom for the Student margin (default is NULL)

Value

`out`	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = margins(0,2.5,"binomial")
```

`mlecop` *Estimation of the parameter of a bivariate copula (Clayton, Frank, Gumbel)*

Description

Computes the MLE estimation for a bivariate copula using gradient. The likelihood is likelihood is c(u,v;theta)

Usage

```
mlecop(u, v, fcopders, start = 2, LB = 1.01, UB = 7)
```

Arguments

`u`	vector of values in (0,1)
`v`	vector of values in (0,1)
`fcopders`	ffrkders, fgumders or fmtcjders
`start`	starting value for the parameter (default =2)
`LB`	lower bound for the parameter (default is 1.01)
`UB`	upper bound for the parameter (default is 7)

Value

`mle`	List of outputs from nlm function

Author(s)

Pavel Krupskii

Examples

```
set.seed(2)
v = runif(250)
w = runif(250)
u = 1/sqrt(1+(w^(-2/3)-1)/v^2) # Clayton copula with parameter 2 (tau=0.5)
out = mlecop(u,v,fmtcjders)
```

`mlecop.disc` *Estimation of the parameter of a bivariate copula (Clayton, Frank, Gumbel) when the first observation is 0 or 1*

Description

Computes the MLE estimation for a bivariate copula using gradient. The likelihood is likelihood is C(1-plv;theta) if y=0 and 1-C(1-plv;theta) if y=1

Usage

```
mlecop.disc(y, v, fcopders, start = 2, LB = 1.01, UB = 7)
```

Arguments

`y`	vector of binary values 0 or 1
`v`	vector of values in (0,1)
`fcopders`	ffrkders, fgumders or fmtcjders
`start`	starting value for the parameter (default =2)
`LB`	lower bound for the parameter (default is 1.01)
`UB`	upper bound for the parameter (default is 7)

Value

`mle`	List of outputs from nlm function

Author(s)

Pavel Krupskii

Examples

```
set.seed(2)
v = runif(250)
w = runif(250)
u = 1/sqrt(1+(w^(-2/3)-1)/v^2) #Clayton with parameter 2
y = as.numeric(u>0.6) # if one takes (u<4), one obtains a rotation of the Clayton!
out = mlecop.disc(y,v,fmtcjders)
```

multinomcpdf *Multinomial with p = 1/(1+exp(-th)) cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
multinomcpdf(z, th, x)
```

Arguments

z	vector of responses taking values in 1,...,nL: as.number(z) if z is a factor!
th	th is a n x (L-1) matrix of parameters, i.e., mpar = a=[a_1,1,...a_1,k2,a_2,1,...a_2,k2,... a_L-1,1... a_L-1,k2], and first level is the baseline.
x	matrix of covariates (including the constant)

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
x=matrix(c(1,1,-1,-1,0,2),nrow=2)
z = c(1,3)
th = matrix(c(1,2,3,4,5,6),nrow=2)
out = multinomcpdf(z,th,x = x)
```

multinomial *Simulated data*

Description

Simulated clustered data from a Clayton copula with parameter 2, and multinomial margins with 3 levels and parameters 1.0,-1 for level 2 and 0.5, 2 for level 3. Clusters and covariates are included.

Usage

```
data(multinomial)
```

Format

Data frame of numerical values

Examples

```
data(multinomial)
```

`nbinom1cpdf` *Negative binomial cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
nbinom1cpdf(z, th)
```

Arguments

`z`	vector of responses
`th`	th[,1] is size > 0 and th[,2] is mean > 0; size does not have to be integer

Value

`out`	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = nbinom1cpdf(0,c(1,0.5))
```

nbinomcpdf *Negative binomial cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
nbinomcpdf(z, th)
```

Arguments

z	vector of responses
th	th[,1] is size > 0 and th[,2] is p, with 0<p<1; size does not have to be integer

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = nbinomcpdf(0,c(1,0.5))
```

normal *Simulated data*

Description

Simulated clustered data from a Clayton copula with parameter 2, rotation = 90, and normal margins with 1,-1 for the mean, ans sd = 4. Clusters and covariates are included.

Usage

```
data(normal)
```

Format

List of simulated values (y, clu, xm)

Examples

```
data(normal)
```

normcpdf *normal cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
normcpdf(z, th)
```

Arguments

z	vector of responses
th	th[,1] is mean, th[,2] is standard deviation > 0;

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = normcpdf(2,c(-3,4))
```

out.normal *EstContinuous object*

Description

Output of EstContinuous for the simulated clustered data normal.

Usage

```
data(out.normal)
```

Format

Data frame of numerical values

Examples

```
data(out.normal)
```

out.poisson *EstDiscrete object*

Description

Output of EstDiscrete for the simulated clustered data poisson.

Usage

```
data(out.poisson)
```

Format

Data frame of numerical values

Examples

```
data(out.poisson)
```

pcond *Conditional cdf*

Description

This function computes the conditional cdf C(U|V) for a copula C

Usage

```
pcond(U, V, family, rot = 0, cpar, dfC = NULL)
```

Arguments

U	values at which the cdf is evaluated
V	value of the conditioning variable in (0,1)
family	"gaussian" , "t" , "clayton" , "joe", "frank" , "fgm", gumbel", "plackett", "galambos", "huesler-reiss"
rot	rotation: 0 (default), 90, 180 (survival), or 270
cpar	copula parameter (vector)
dfC	degrees of freedom of the Student copula (default is NULL)

Value

p	Conditional cdf

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
p = pcond(0.1,0.2,"clayton",rot=270,cpar=0.87)
```

---

pcondcla *Conditional Clayton*

Description

Conditional Clayton

Usage

```
pcondcla(u, v, cpar)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter

Value

ccdf	Conditional cdf

Examples

```
pcondcla(0.5,0.6,2)
```

---

pcondfgm *Conditional FGM (B10)*

Description

Conditional FGM (B10)

Usage

```
pcondfgm(u, v, cpar)
```

Arguments

u	probability
v	value of the conditioning variable in (0,1)
cpar	copula parameter -1<=cpar<=1

Value

ccdf	Conditional cdf

Examples

```
pcondfgm(0.5,0.6,0.9)
```

---

pcondfrk *Conditional Frank (B3)*

Description

Conditional Frank (B3)

Usage

```
pcondfrk(u, v, cpar)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter

Value

ccdf	Conditional cdf

Examples

```
pcondfrk(0.5,0.6,2)
```

pcondgal *Conditional Galambos (B7)*

Description

Conditional Galambos (B7)

Usage

```
pcondgal(u, v, cpar)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter

Value

ccdf	Conditional cdf

Examples

```
pcondgal(0.5,0.6,2)
```

pcondgum *Conditional Gumbel (B6)*

Description

Conditional Gumbel (B6)

Usage

```
pcondgum(u, v, cpar)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter >1

Value

ccdf	Conditional cdf

Examples

```
pcondgum(0.5,0.6,2)
```

---

pcondhr *Conditional Huesler-Reiss (B8)*

Description

Conditional Huesler-Reiss (B8)

Usage

```
pcondhr(u, v, cpar)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter >0

Value

ccdf	Conditional cdf

Examples

```
pcondhr(0.5,0.6,2)
```

---

pcondjoe *Conditional Joe (B5)*

Description

Conditional Joe (B5)

Usage

```
pcondjoe(u, v, cpar)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter

Value

ccdf	Conditional cdf

Examples

```
pcondjoe(0.5,0.6,2)
```

---

pcondnor *Conditional Gaussian*

Description

Conditional Gaussian

Usage

```
pcondnor(u, v, cpar)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter

Value

ccdf	Conditional cdf

Examples

```
pcondnor(0.5,0.6,0.6)
```

---

pcondpla *Conditional Plackett (B2)*

Description

Conditional Plackett (B2)

Usage

```
pcondpla(u, v, cpar)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter >1

Value

ccdf	Conditional cdf

Examples

```
pcondpla(0.5,0.6,2)
```

---

pcondt *Conditional Student*

Description

Conditional Student is Y2|Y1=y1 ~ t(nu+1,location=rho*y1, sigma(y1)), where here sigma^2 = (1-rho^2)(nu+y1^2)/(nu+1)

Usage

```
pcondt(u, v, cpar, dfC)
```

Arguments

u	values at which the cdf is evaluated
v	value of the conditioning variable in (0,1)
cpar	copula parameter
dfC	degrees of freedom

Value

ccdf	Conditional cdf

Examples

```
pcondt(0.5,0.6,0.6,15)
```

poiscpdf *Poisson cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
poiscpdf(z, th)
```

Arguments

z	vector of responses
th	values of lambda >0

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = poiscpdf(0,2.5)
```

predictContinuous *Conditional expectation for a copula-based estimation of mixed regression models for continuous response*

Description

Compute the conditional expectation of a copula-based 2-level hierarchical model for continuous response.

Usage

```
predictContinuous(object, newdata = NULL, nq = 25)
```

Arguments

object	Object of class "EstContinuous" generated by EstContinuous.
newdata	List of variables for be predicted ("clu" for clusters, "xc" for the copula covariates, and "xm" for the margins covariates). The covariates can be NULL.
nq	number of nodes and weighted for Gaussian quadrature of the product of conditional copulas; default is 25.

Value

mest	Conditional expectations

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2023

References

Krupskii, Nasri & Remillard (2023). On factor copula-based mixed regression models

Examples

```
data(out.normal)
newdata=list(clu=c(1:50),xm=rep(0.4,50))
pred= predictContinuous(out.normal,newdata)
```

---

predictDiscrete *Conditional expectation for a copula-based estimation of mixed regression models for discrete response*

Description

Compute the conditional expectation of a copula-based 2-level hierarchical model for disctrete response.

Usage

```
predictDiscrete(object, newdata, m = 100)
```

Arguments

object	Object of class "EstDiscrete" generated by EstDiscrete.
newdata	List of variables for be predicted ("clu" for clusters, "xc" for the copula covariates, and "xm" for the margins covariates). The covariates can be NULL.
m	Number of points for the numerical integration (default is 100).

Value

mest	Conditional expectations (conditional probabilities for the multinomial case

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2023

References

Krupskii, Nasri & Remillard (2023). On factor copula-based mixed regression models

Examples

```
data(out.poisson)
newdata = list(clu=c(1:50),xc=rep(0.2,50),xm=rep(0.5,50))
pred= predictDiscrete(out.poisson,newdata,m=100)
```

---

pseudosC *Estimation cdf, left-continuous cdf, and pseudo-observations*

Description

This function estimates the empirical cdf, its left limit, and pseudo-observations for a univatiate vector y

Usage

```
pseudosC(y)
```

Arguments

y	univariate data

Value

Fn	Empririal cdf
Fm	Left-contniuous cdf
U	Pseudo-obsevations

Author(s)

Bruno N. Remillard, January 20, 2022

Examples

```
y = rpois(100,2)
out=pseudosC(y)
```

qcond *Inverse conditional cdf*

Description

This function computes the quantile of conditional cdf C(U|v) for a copula C

Usage

```
qcond(w, v, family, cpar, rot = 0)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
family	"gaussian" , "t" , "clayton" , "fgm", "frank" , "gumbel", "plackett", "galambos", "huesler-reiss"
cpar	copula parameter (vector)
rot	rotation: 0 (default), 90, 180 (survival), or 270

Value

U	Conditional quantile
U	Conditional quantile

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
U = qcond(0.1,0.2,"gaussian",0.87)
```

qcondcla *Inverse clayton*

Description

Inverse clayton

Usage

```
qcondcla(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter

Value

out	Conditional quantile

---

qcondfgm *Inverse FGM (B10)*

Description

Inverse FGM (B10)

Usage

```
qcondfgm(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter -1<=th<=1

Value

out	Conditional quantile

---

qcondfra *Inverse Frank*

Description

Inverse Frank

Usage

```
qcondfra(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter

Value

out	Conditional quantile

---

qcondgal *Inverse Galambos*

Description

Inverse Galambos

Usage

```
qcondgal(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter >0

Value

out	Conditional quantile

---

qcondgum *Inverse Gumbel*

Description

Inverse Gumbel

Usage

```
qcondgum(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter

Value

out	Conditional quantile

---

qcondhr *Inverse Huesler-Reiss*

Description

Inverse Huesler-Reiss

Usage

```
qcondhr(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter >0

Value

out	Conditional quantile

---

qcondjoe *Inverse Joe*

Description

Inverse Joe

Usage

```
qcondjoe(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter >-1

Value

out	Conditional quantile

---

qcondnor *Inverse Gaussian*

Description

Inverse Gaussian

Usage

```
qcondnor(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter (correlation)

Value

out	Conditional quantile

---

qcondpla *Inverse Plackett*

Description

Inverse Plackett

Usage

```
qcondpla(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter

Value

out	Conditional quantile

---

qcondt *Inverse Student*

Description

Inverse Student

Usage

```
qcondt(w, v, th)
```

Arguments

w	probability
v	value of the conditioning variable in (0,1)
th	copula parameter

Value

out	Conditional quantile

---

sim.poisson *Simulated data*

Description

Simulated clustered data from a Frank copula with parC=c(2,8), and Poisson margins with parM=c(3.0,-0.1). Clusters and covariates (both uniform) are included.

Usage

```
data(sim.poisson)
```

Format

List of simulated values (y, clu,xc,xm) together with true parameters

Examples

```
data(sim.poisson)
```

`SimGenCluster` *Simulation of clustered data*

Description

Generate a random sample of observations from a copula-based mixed regression model.

Usage

```
SimGenCluster(
  parC,
  parM,
  clu,
  xc = NULL,
  xm = NULL,
  family,
  rot = 0,
  dfC = NULL,
  model,
  dfM = NULL,
  offset = NULL
)
```

Arguments

`parC`	vector of copula parameters; k1 is the number of covariates + constant for the copula
`parM`	vector of margin parameters; k2 is the number of covariates + constant for the margins
`clu`	vector of clusters (can be a factor)
`xc`	matrix (N x k1) of covariates for the copula, not including the constant (can be NULL)
`xm`	matrix (N x k2) of covariates for the margins, not including the constant (can be NULL)
`family`	copula family: "gaussian" , "t" , "clayton" , "joe", "frank" , "gumbel", "plackett"
`rot`	rotation: 0 (default), 90, 180 (survival), or 270
`dfC`	degrees of freedom for the Student copula (default is NULL)
`model`	marginal distribution: "binomial" (bernoulli), "poisson", "nbinom" (mean is the parameter),"nbinom1" (p is the parameter), "geometric", "multinomial", exponential", "weibull", "normal" (gaussian),"t", "laplace"
`dfM`	degrees of freedom for the Student margins (default is NULL)
`offset`	offset for the margins (default is NULL)

Value

y	Simulated response
y	Simulated values

Author(s)

Bruno N. Remillard

Examples

```
K=50 #number of clusters
n=5  #size of each cluster
N=n*K
set.seed(1)
clu=rep(c(1:K),each=n)
parC = 0 # yields tau = 0.5 for Clayton
parM= c(1,-1,4)
xm = runif(N)
y=SimGenCluster(parC,parM,xm,family="clayton",rot=90,clu=clu,model="gaussian")
```

SimMultinomial *Simulation of multinomial clustered data*

Description

Generate a random sample of multinomial observations from a copula-based mixed regression model.

Usage

```
SimMultinomial(
  parC,
  parM,
  clu,
  xc = NULL,
  xm = NULL,
  family,
  rot = 0,
  dfC = NULL,
  offset = NULL
)
```

Arguments

parC	copula parameters
parM	matrix of dimension (L-1)x k2 of margin parameters; L is the number of levels and k2 is the number of covariates+constant for the margins

clu	vector of clusters (can be a factor)
xc	matrix of covariates for the copula, not including the constant (can be NULL)
xm	matrix of covariates for the margins, not including the constant (can be NULL)
family	copula family: "gaussian" , "t" , "clayton" , "joe", "frank" , "gumbel", "plackett"
rot	rotation: 0 (default), 90, 180 (survival), or 270
dfC	degrees of freedom for student copula (default is NULL)
offset	offset for the margins (default is NULL)

Value

y	Simulated factor

Author(s)

Bruno N. Remillard

Examples

```
K=50 #number of clusters
n=5  #size of each cluster
N=n*K
set.seed(1)
clu=rep(c(1:K),each=n)
parC = 2
parM=matrix(c(1,-1,0.5,2),byrow=TRUE,ncol=2)
xm = runif(N)
y=SimMultinomial(parC,parM,clu,xm=xm,family="clayton",rot=90)
```

---

tcpdf *Student cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
tcpdf(z, th, df)
```

Arguments

z	vector of responses
th	th[,1] is mean, th[,2] is standard deviation > 0
df	degrees of freedom

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = tcpdf(2,c(-3,4),25)
```

---

weibcpdf *Weibul cdf/pdf and ders*

Description

This function computes the cdf, pdf, and associated derivatives

Usage

```
weibcpdf(z, th)
```

Arguments

z	vector of responses
th	th[,1] is rate>0, th[,2] is shape > 0;

Value

out	Matrix of conditional cdf, derivative with respect to parameter, pdf,

Author(s)

Pavel Krupskii and Bruno N. Remillard, January 20, 2022

Examples

```
out = weibcpdf(2,c(2,3))
```

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