Package ‘Copula.surv’

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Type Package

Title Analysis of Bivariate Survival Data Based on Copulas

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Description Simulating bivariate survival data from copula models.
Estimation of the association parameter in copula models.
Two different ways to estimate the association parameter in copula models are implemented.
A goodness-of-fit test for a given copula model is implemented.
See Emura, Lin and Wang (2010) <doi:10.1016/j.csda.2010.03.013> for details.

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Contents

`Copula.surv-package` *Analysis of Bivariate Survival Data*

Description

Simulating bivariate survival data from copula models (Emura et al. 2019). Estimation of the association parameter in copula models. Two different ways to estimate the association parameter in copula models are implemented. A goodness-of-fit test for a given copula model is implemented. See Emura, Lin and Wang (2010) <doi:10.1016/j.csda.2010.03.013> for details. Also, Weibull regression is implemented (Section 2.6.3 of Emura et al. (2019)).

Details

Details are seen from the references.

Author(s)

Takeshi Emura Maintainer: Takeshi Emura <takeshiemura@gmail.com>

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

simu.BB1 *Simulating data from the BB1 copula*

Description

n pairs of (U,V) are generated from the BB1 copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.BB1(n,alpha,delta=0,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

`n`	sample size
`alpha`	association (copula) parameter
`delta`	BB1 copula's departure parameter from the Clayton (0 is the default)
`scale1`	scale parameter for X
`scale2`	scale parameter for Y
`shape1`	shape parameter for X
`shape2`	shape parameter for Y
`Print`	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

`U`	uniformly distributed on (0,1)
`V`	uniformly distributed on (0,1)
`X`	Weibull distributed (scale1, shape1)
`Y`	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.BB1(n=n,alpha=1,delta=2,scale1=1,scale2=2,shape1=0.5,shape2=2)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

---

simu.BB1reg *Simulating data from the BB1 copula regression model*

Description

n pairs of (U,V) are generated from the BB1 copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.BB1reg(n,alpha,delta=0,scale1=1,scale2=1,shape1=1,shape2=1,
 beta1=0,beta2=0,beta12=0,Z.dist=runif,...)
```

Arguments

n	sample size
alpha	association (copula) parameter
delta	BB1 copula's departure parameter from the Clayton (0 is the default)
scale1	scale parameter for X
scale2	scale parameter for Y
shape1	shape parameter for X
shape2	shape parameter for Y
beta1	regression coefficient for X
beta2	regression coefficient for Y
beta12	regression coefficient for copula
Z.dist	distribution for covariates
...	parameters for Z.dist

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

`U`	uniformly distributed on (0,1)
`V`	uniformly distributed on (0,1)
`X`	Weibull distributed (scale1, shape1)
`Y`	Weibull distributed (scale2, shape2)
`Z`	Covariates

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=10
simu.BB1reg(n=n,alpha=1,delta=2,scale1=1,scale2=2,shape1=0.5,beta1=1,beta2=-1,beta12=2,shape2=2)
```

`simu.CC` *Simulating data from the Celebioglu-Cuadras (CC) copula*

Description

n pairs of (U,V) are generated from the CC copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.CC(n,alpha,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

`n`	sample size
`alpha`	association (copula) parameter, -1<=alpha<=1
`scale1`	scale parameter for X
`scale2`	scale parameter for Y
`shape1`	shape parameter for X
`shape2`	shape parameter for Y
`Print`	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

U	uniformly distributed on (0,1)
V	uniformly distributed on (0,1)
X	Weibull distributed (scale1, shape1)
Y	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.CC(n=n,alpha=-1,scale1=1,scale2=2,shape1=0.5,shape2=2)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

---

simu.Clayton *Simulating data from the Clayton copula*

Description

n pairs of (U,V) are generated from the Clayton copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.Clayton(n,alpha,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

`n`	sample size
`alpha`	association (copula) parameter
`scale1`	scale parameter for X
`scale2`	scale parameter for Y
`shape1`	shape parameter for X
`shape2`	shape parameter for Y
`Print`	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

`U`	uniformly distributed on (0,1)
`V`	uniformly distributed on (0,1)
`X`	Weibull distributed (scale1, shape1)
`Y`	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.Clayton(n=n,alpha=1,scale1=1,scale2=2,shape1=0.5,shape2=2)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

simu.FGM — *Simulating data from the FGM copula*

Description

n pairs of (U,V) are generated from the FGM copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.FGM(n,alpha,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

`n`	sample size
`alpha`	association (copula) parameter; -1<=alpha<=1
`scale1`	scale parameter for X
`scale2`	scale parameter for Y
`shape1`	shape parameter for X
`shape2`	shape parameter for Y
`Print`	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

`U`	uniformly distributed on (0,1)
`V`	uniformly distributed on (0,1)
`X`	Weibull distributed (scale1, shape1)
`Y`	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.FGM(n=n,alpha=1,scale1=1,scale2=2,shape1=0.5,shape2=2)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

---

simu.Frank *Simulating data from the Frank copula*

Description

n pairs of (U,V) are generated from the Frank copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.Frank(n,alpha,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

`n`	sample size
`alpha`	association (copula) parameter
`scale1`	scale parameter for X
`scale2`	scale parameter for Y
`shape1`	shape parameter for X
`shape2`	shape parameter for Y
`Print`	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

`U`	uniformly distributed on (0,1)
`V`	uniformly distributed on (0,1)
`X`	Weibull distributed (scale1, shape1)
`Y`	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.Frank(n=n,alpha=10,scale1=1,scale2=2,shape1=0.5,shape2=2)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

---

simu.GB *Simulating data from the Gumbel-Barnett (GB) copula*

Description

n pairs of (U,V) are generated from the GB copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.GB(n,alpha,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

n	sample size
alpha	association (copula) parameter, 0<=alpha<=1
scale1	scale parameter for X
scale2	scale parameter for Y
shape1	shape parameter for X
shape2	shape parameter for Y
Print	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

U	uniformly distributed on (0,1)
V	uniformly distributed on (0,1)
X	Weibull distributed (scale1, shape1)
Y	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.GB(n=n,alpha=1,scale1=1,scale2=2,shape1=0.5,shape2=2)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

---

simu.Gumbel *Simulating data from the Gumbel copula*

Description

n pairs of (U,V) are generated from the Gumbel copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.Gumbel(n,alpha,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

n	sample size
alpha	association (copula) parameter
scale1	scale parameter for X
scale2	scale parameter for Y
shape1	shape parameter for X
shape2	shape parameter for Y
Print	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

U	uniformly distributed on (0,1)
V	uniformly distributed on (0,1)
X	Weibull distributed (scale1, shape1)
Y	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.Gumbel(n=n,alpha=1,scale1=1,scale2=2,shape1=0.5,shape2=2)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

---

simu.Joe *Simulating data from the Joe copula*

Description

n pairs of (U,V) are generated from the Joe copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.Joe(n,alpha,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

n	sample size
alpha	association (copula) parameter
scale1	scale parameter for X
scale2	scale parameter for Y
shape1	shape parameter for X
shape2	shape parameter for Y
Print	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

U	uniformly distributed on (0,1)
V	uniformly distributed on (0,1)
X	Weibull distributed (scale1, shape1)
Y	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.Joe(n=n,alpha=1,scale1=1,scale2=2,shape1=0.5,shape2=2)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

simu.t *Simulating data from the t-copula*

Description

n pairs of (U,V) are generated from the t-copula. n paris of (X,Y) are generated from the corresponding bivariate survival model with the Weibull marginal distributions. The default parameters (scale1=scale2=shape1=shape2=1) give the unit exponential distributions.

Usage

```
simu.t(n,alpha,df=1,scale1=1,scale2=1,shape1=1,shape2=1,Print=FALSE)
```

Arguments

`n`	sample size
`alpha`	association (copula) parameter
`df`	degrees of freedom (d=1 is the default)
`scale1`	scale parameter for X
`scale2`	scale parameter for Y
`shape1`	shape parameter for X
`shape2`	shape parameter for Y
`Print`	print Kendall's tau and means of X and Y if "TRUE"

Details

See Section 2.6 of Emura et al.(2019) for copulas and bivariate survival times.

Value

`U`	uniformly distributed on (0,1)
`V`	uniformly distributed on (0,1)
`X`	Weibull distributed (scale1, shape1)
`Y`	Weibull distributed (scale2, shape2)

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
n=100
Dat=simu.t(n=n,alpha=0.8,df=1,scale1=1,scale2=2,shape1=0.5,shape2=2,Print=TRUE)
plot(Dat[,"U"],Dat[,"V"])
cor(Dat[,"U"],Dat[,"V"],method="kendall")
plot(Dat[,"X"],Dat[,"Y"])
cor(Dat[,"X"],Dat[,"Y"],method="kendall")
```

`Test.Clayton` *A goodness-of-fit test for the Clayton copula*

Description

Perform a goodness-of-fit test for the Clayton copula based on Emura, Lin and Wang (2010). The test is asymptotically equivalent to the test of Shih (1998).

Usage

```
Test.Clayton(x.obs,y.obs,dx,dy,lower=0.001,upper=50,U.plot=TRUE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`lower`	lower bound for the association parameter
`upper`	upper bound for the association parameter
`U.plot`	if TRUE, draw the plot of U_1(theta)

Details

See the references.

Value

`theta1`	association parameter by the pseudo-likelihood estimator
`theta2`	association parameter by the unweighted estimator
`Stat`	log(theta1+1)-log(theta2+1)
`Z`	Z-value of the goodness-of-fit for the Clayton copula
`P`	P-value of the goodness-of-fit for the Clayton copula

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Shih JH (1998) A goodness-of-fit test for association in a bivariate survival model. Biometrika 85: 189-200

Examples

```
n=20
theta_true=2 ## association parameter ##
r1_true=2 ## hazard for X
r2_true=2 ## hazard for Y

set.seed(1)
V1=runif(n)
V2=runif(n)
X=-1/r1_true*log(1-V1)
W=(1-V1)^(-theta_true)
Y=1/theta_true/r2_true*log(  1-W+W*(1-V2)^(-theta_true/(theta_true+1))  )
C=runif(n,min=0,max=5)

x.obs=pmin(X,C)
y.obs=pmin(Y,C)
dx=X<=C
dy=Y<=C

Test.Clayton(x.obs,y.obs,dx,dy)
```

`Test.Gumbel` *A goodness-of-fit test for the Gumbel copula*

Description

Perform a goodness-of-fit test for the Gumbel copula based on Emura, Lin and Wang (2010).

Usage

```
Test.Gumbel(x.obs,y.obs,dx,dy,lower=0.01,upper=50,U.plot=TRUE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`lower`	lower bound for the association parameter
`upper`	upper bound for the association parameter
`U.plot`	if TRUE, draw the plot of U_1(theta) and U_2(theta)

Details

See the references.

Value

theta1	association parameter by the pseudo-likelihood estimator
theta2	association parameter by the unweighted estimator
Stat	log(theta1)-log(theta2)
Z	Z-value of the goodness-of-fit for the Clayton copula
P	P-value of the goodness-of-fit for the Clayton copula

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Examples

```
x.obs=c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)
y.obs=c(2,1,4,5,6,8,3,7,10,9,11,12,13,14,15)
dx=c(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1)
dy=c(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1)
Test.Gumbel(x.obs,y.obs,dx,dy)
```

U1.Clayton *Estimation of an association parameter via the pseudo-likelihood*

Description

Estimate the association parameter of the Clayton copula using bivariate survival data. The estimator was derived by Clayton (1978) and reformulated by Emura, Lin and Wang (2010).

Usage

```
U1.Clayton(x.obs,y.obs,dx,dy,lower=0.001,upper=50,U.plot=TRUE)
```

Arguments

x.obs	censored times for X
y.obs	censored times for Y
dx	censoring indicators for X
dy	censoring indicators for Y
lower	lower bound for the association parameter
upper	upper bound for the association parameter
U.plot	if TRUE, draw the plot of U_1(theta)

Details

Details are seen from the references.

Value

theta	association parameter
tau	Kendall's tau (=theta/(theta+2))

Author(s)

Takeshi Emura

References

Clayton DG (1978). A model for association in bivariate life tables and its application to epidemiological studies of familial tendency in chronic disease incidence. Biometrika 65: 141-51.

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Examples

```
n=200
theta_true=2 ## association parameter ##
r1_true=1 ## hazard for X
r2_true=1 ## hazard for Y

set.seed(1)
V1=runif(n)
V2=runif(n)
X=-1/r1_true*log(1-V1)
W=(1-V1)^(-theta_true)
Y=1/theta_true/r2_true*log(  1-W+W*(1-V2)^(-theta_true/(theta_true+1))  )
C=runif(n,min=0,max=5)

x.obs=pmin(X,C)
y.obs=pmin(Y,C)
dx=X<=C
dy=Y<=C
```

```
U1.Clayton(x.obs,y.obs,dx,dy)
```

U1.Gumbel *Estimation of an association parameter via the unweighted estimator*

Description

Estimate the association parameter of the Gumbel copula using bivariate survival data. The estimator was derived by Emura, Lin and Wang (2010).

Usage

```
U1.Gumbel(x.obs,y.obs,dx,dy,lower=0.01,upper=50,U.plot=TRUE)
```

Arguments

x.obs	censored times for X
y.obs	censored times for Y
dx	censoring indicators for X
dy	censoring indicators for Y
lower	lower bound for the association parameter
upper	upper bound for the association parameter
U.plot	if TRUE, draw the plot of U_1(theta)

Details

Details are seen from the references.

Value

theta	association parameter
tau	Kendall's tau (=theta/(theta+2))

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Examples

```
x.obs=c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)
y.obs=c(2,1,4,5,6,8,3,7,10,9,11,12,13,14,15)
dx=c(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1)
dy=c(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1)
U1.Gumbel(x.obs,y.obs,dx,dy)
```

U2.Clayton *Estimation of an association parameter via the unweighted estimator*

Description

Estimate the association parameter of the Clayton copula using bivariate survival data. The estimator was defined as the unweighted estimator in Emura, Lin and Wang (2010).

Usage

```
U2.Clayton(x.obs,y.obs,dx,dy,lower=0.001,upper=50,U.plot=TRUE)
```

Arguments

x.obs	censored times for X
y.obs	censored times for Y
dx	censoring indicators for X
dy	censoring indicators for Y
lower	lower bound for the association parameter
upper	upper bound for the association parameter
U.plot	if TRUE, draw the plot of U_2(theta)

Details

Details are seen from the references.

Value

theta	association parameter
tau	Kendall's tau (=theta/(theta+2))

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Examples

```
n=200
theta_true=2 ## association parameter ##
r1_true=1 ## hazard for X
r2_true=1 ## hazard for Y

set.seed(1)
V1=runif(n)
V2=runif(n)
X=-1/r1_true*log(1-V1)
W=(1-V1)^(-theta_true)
Y=1/theta_true/r2_true*log(  1-W+W*(1-V2)^(-theta_true/(theta_true+1))  )
C=runif(n,min=0,max=5)

x.obs=pmin(X,C)
y.obs=pmin(Y,C)
dx=X<=C
dy=Y<=C

U2.Clayton(x.obs,y.obs,dx,dy)
```

U2.Gumbel — *Estimation of an association parameter via the pseudo-likelihood*

Description

Estimate the association parameter of the Gumbel copula using bivariate survival data. The estimator was derived by Emura, Lin and Wang (2010).

Usage

```
U2.Gumbel(x.obs,y.obs,dx,dy,lower=0.01,upper=50,U.plot=TRUE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`lower`	lower bound for the association parameter
`upper`	upper bound for the association parameter
`U.plot`	if TRUE, draw the plot of U_2(theta)

Details

Details are seen from the references.

Value

theta	association parameter
tau	Kendall's tau (=theta/(theta+1))

Author(s)

Takeshi Emura

References

Emura T, Lin CW, Wang W (2010) A goodness-of-fit test for Archimedean copula models in the presence of right censoring, Compt Stat Data Anal 54: 3033-43

Examples

```
x.obs=c(1,2,3,4,5)
y.obs=c(2,1,4,5,6)
dx=c(1,1,1,1,1)
dy=c(1,1,1,1,1)
U2.Gumbel(x.obs,y.obs,dx,dy)
```

`Weib.reg.BB1` *Weibull regression under the BB1 copula*

Description

See Section 2.6.3 of Emura et al. (2019).

Usage

```
Weib.reg.BB1(x.obs,y.obs,dx,dy,zx,zy,convergence.par=FALSE)
```

Arguments

x.obs	censored times for X
y.obs	censored times for Y
dx	censoring indicators for X
dy	censoring indicators for Y
zx	matrix of covariates for X
zy	matrix of covariates for Y
convergence.par	if TRUE, show the details

Details

Details are seen from the references.

Value

`beta_x`	regression coefficients for X
`beta_y`	regression coefficients for Y
`alpha`	copula parameter
`delta`	copula parameter
`tau`	Kendall's tau

Author(s)

Takeshi Emura

References

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
#TBA
```

`Weib.reg.BB1.0` *Weibull regression under the BB1 copula with known "delta"*

Description

See Section 2.6.3 of Emura et al. (2019).

Usage

```
Weib.reg.BB1.0(x.obs,y.obs,dx,dy,zx,zy,delta=0,convergence.par=FALSE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`zx`	matrix of covariates for X
`zy`	matrix of covariates for Y
`delta`	known copula parameter (d>=0)
`convergence.par`	if TRUE, show the details

Details

Details are seen from the references.

Value

`beta_x`	regression coefficients for X
`beta_y`	regression coefficients for Y
`alpha`	copula parameter
`tau`	Kendall's tau

Author(s)

Takeshi Emura

References

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
#TBA
```

`Weib.reg.cBB1` *Weibull regression under the conditional BB1 copula*

Description

See Section 2.6.3 of Emura et al. (2019).

Usage

```
Weib.reg.cBB1(x.obs,y.obs,dx,dy,zx,zy,zxy,convergence.par=FALSE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`zx`	matrix of covariates for X
`zy`	matrix of covariates for Y
`zxy`	matrix of covariates for copula
`convergence.par`	if TRUE, show the details

Details

Details are seen from the references.

Value

`beta_x`	regression coefficients for X
`beta_y`	regression coefficients for Y
`beta_xy`	regression coefficients for copula
`alpha`	copula parameter
`delta`	copula parameter
`tau`	Kendall's tau given beta_xy=0

Author(s)

Takeshi Emura

References

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
#TBA
```

`Weib.reg.cBB1.0` *Weibull regression under the conditional BB1 copula with known "delta"*

Description

See Section 2.6.3 of Emura et al. (2019).

Usage

```
Weib.reg.cBB1.0(x.obs,y.obs,dx,dy,zx,zy,zxy,delta=0,convergence.par=FALSE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`zx`	matrix of covariates for X
`zy`	matrix of covariates for Y

zxy	matrix of covariates for copula
delta	known copula parameter (d>=0)
convergence.par	if TRUE, show the details

Details

Details are seen from the references.

Value

beta_x	regression coefficients for X
beta_y	regression coefficients for Y
beta_xy	regression coefficients for copula
alpha	copula parameter
tau	Kendall's tau given beta_xy=0

Author(s)

Takeshi Emura

References

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
#TBA
```

Weib.reg.Clayton *Weibull regression under the Clayton copula*

Description

See Section 2.6.3 of Emura et al. (2019).

Usage

```
Weib.reg.Clayton(x.obs,y.obs,dx,dy,zx,zy,convergence.par=FALSE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`zx`	matrix of covariates for X
`zy`	matrix of covariates for Y
`convergence.par`	if TRUE, show the details

Details

Details are seen from the references.

Value

`beta_x`	regression coefficients for X
`beta_y`	regression coefficients for Y

Author(s)

Takeshi Emura

References

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
#TBA
```

`Weib.reg.Frank` *Weibull regression under the Frank copula*

Description

See Section 2.6.3 of Emura et al. (2019).

Usage

```
Weib.reg.Frank(x.obs,y.obs,dx,dy,zx,zy,convergence.par=FALSE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`zx`	matrix of covariates for X
`zy`	matrix of covariates for Y
`convergence.par`	if TRUE, show the details

Details

Details are seen from the references.

Value

`beta_x`	regression coefficients for X
`beta_y`	regression coefficients for Y

Author(s)

Takeshi Emura

References

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
#TBA
```

`Weib.reg.Gumbel` *Weibull regression under the Gumbel copula*

Description

See Section 2.6.3 of Emura et al. (2019).

Usage

```
Weib.reg.Gumbel(x.obs,y.obs,dx,dy,zx,zy,convergence.par=FALSE)
```

Arguments

`x.obs`	censored times for X
`y.obs`	censored times for Y
`dx`	censoring indicators for X
`dy`	censoring indicators for Y
`zx`	matrix of covariates for X
`zy`	matrix of covariates for Y
`convergence.par`	if TRUE, show the details

Details

Details are seen from the references.

Value

`beta_x`	regression coefficients for X
`beta_y`	regression coefficients for Y

Author(s)

Takeshi Emura

References

Emura T, Matsui S, Rondeau V (2019), Survival Analysis with Correlated Endpoints, Joint Frailty-Copula Models, JSS Research Series in Statistics, Springer

Examples

```
#TBA
```

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