

# Package ‘Copula.Markov.survival’

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**Type** Package

**Title** Copula Markov Model with Dependent Censoring

**Version** 1.0.0

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**Description** Perform likelihood estimation and corresponding analysis under the copula-based Markov chain model for serially dependent event times with a dependent terminal event. Available are statistical methods in Huang, Wang and Emura (2020, JJSD accepted).

**License** GPL-3

**Depends** survival

**Imports** stats, graphics

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.1.1

**NeedsCompilation** no

**Repository** CRAN

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ClaytonClayton.Weibull.data

*Generate data from the Clayton copula for serial dependence and the Clayton copula for dependent censoring with the Weibull distributions*

---

### Description

The data generation process is based on the Clayton copula  $C_{\theta}$  for serial dependence and the Clayton copula  $\tilde{C}_{\alpha}$  for dependent censoring with the marginal distributions  $Weib(scale1, shape1)$  and  $Weib(scale2, shape2)$ . Censoring percentage can be controlled by constant  $b$ . This function is used when doing parametric bootstrap. The guide for using this function shall be explained by Huang (2019), and Huang, Wang and Emura (2020).

### Usage

`ClaytonClayton.Weibull.data(N, scale1, shape1, theta, scale2, shape2, alpha, b, l)`

### Arguments

<code>N</code>	sample size
<code>scale1</code>	scale parameter for $Weib(scale1, shape1)$ , $scale1 > 0$
<code>shape1</code>	shape parameter for $Weib(scale1, shape1)$ , $shape1 > 0$
<code>theta</code>	copula parameter for $C_{\theta}$ , $theta > 0$
<code>scale2</code>	scale parameter for $Weib(scale2, shape2)$ , $scale2 > 0$
<code>shape2</code>	shape parameter for $Weib(scale2, shape2)$ , $shape2 > 0$
<code>alpha</code>	copula parameter for $\tilde{C}_{\alpha}$ , $alpha > 0$
<code>b</code>	parameter of $Unif(0, b)$ for controlling censoring percentage
<code>l</code>	length for data generation (default = 300)

### Value

A list with the following elements:

<code>Subject</code>	a vector for numbers of subject
<code>T_ij</code>	a vector for event times
<code>delta_ij</code>	a vector for event indicator (=1 if recurrent; =0 if censoring)
<code>T_i_star</code>	a vector for death times
<code>delta_i_star</code>	a vector for death indicator (=1 if death; =0 if censoring)

### Author(s)

Xinwei Huang

## References

Huang XW, Wang W, Emura T (2020) A copula-based Markov chain model for serially dependent event times with a dependent terminal event. Japanese Journal of Statistics & Data Science. Accepted.

## Examples

```
Y = ClaytonClayton.Weibull.data(N = 100, scale1 = 1, shape1 = 0.5, theta = 2,
                                scale2 = 0.45, shape2 = 0.5, alpha = 2, b = 10, l = 300)
```

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ClaytonClayton.Weibull.MLE

*Parameter estimation based on the Clayton copula for serial dependence and the Clayton copula for dependent censoring with the Weibull distributions*

---

## Description

Perform two-stage estimation based on the Clayton copula  $C_\theta$  for serial dependence and the Clayton copula  $\tilde{C}_\alpha$  for dependent censoring with the marginal distributions Weib(scale1, shape1) and Weib(scale2, shape2). The jackknife method estimates the asymptotic covariance matrix. Parametric bootstrap is applied while doing Kolmogorov-Smirnov tests and Cramer-von Mises test. The guide for using this function shall be explained by Huang (2019), and Huang, Wang and Emura (2020).

## Usage

```
ClaytonClayton.Weibull.MLE(subject, t.event, event, t.death, death, stageI, Weibull.plot,
                             jackknife, plot, GOF, GOF.plot, rep.GOF, digit)
```

## Arguments

subject	a vector for numbers of subject
t.event	a vector for event times
event	a vector for event indicator (=1 if recurrent; =0 if censoring)
t.death	a vector for death times
death	a vector for death indicator (=1 if death; =0 if censoring)
stageI	an option to select MLE or LSE method for the 1st-stage optimization
Weibull.plot	if TRUE, show the Weibull probability plot
jackknife	if TRUE, the jackknife method is used for estimate covariance matrix (default = TRUE)
plot	if TRUE, the plots for marginal distributions are shown (default = FALSE)
GOF	if TRUE, show the p-values for KS-test and CvM-test
GOF.plot	if TRUE, show the model diagnostic plot
rep.GOF	repetition number of parametric bootstrap
digit	accurate to some decimal places



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 ClaytonFrank.Weibull.data

*Generate data from the Clayton copula for serial dependence and the Frank copula for dependent censoring with the Weibull distributions*

---

### Description

The data generation process is based on the Clayton copula  $C_{\theta}$  for serial dependence and the Frank copula  $\tilde{C}_{\alpha}$  for dependent censoring with the marginal distributions  $Weib(scale1, shape1)$  and  $Weib(scale2, shape2)$ . Censoring percentage can be controlled by constant  $b$ . This function is used when doing parametric bootstrap. The guide for using this function shall be explained by Huang (2019), and Huang, Wang and Emura (2020).

### Usage

```
ClaytonFrank.Weibull.data(N, scale1, shape1, theta, scale2, shape2, alpha, b, l)
```

### Arguments

N	sample size
scale1	scale parameter for $Weib(scale1, shape1)$ , $scale1 > 0$
shape1	shape parameter for $Weib(scale1, shape1)$ , $shape1 > 0$
theta	copula parameter for $C_{\theta}$ , $\theta > 0$
scale2	scale parameter for $Weib(scale2, shape2)$ , $scale2 > 0$
shape2	shape parameter for $Weib(scale2, shape2)$ , $shape2 > 0$
alpha	copula parameter for $\tilde{C}_{\alpha}$ , $\alpha \neq 0$
b	parameter of $Unif(0, b)$ for controlling censoring percentage
l	length for data generation (default = 300)

### Value

A list with the following elements:

Subject	a vector for numbers of subject
T_ij	a vector for event times
delta_ij	a vector for event indicator (=1 if recurrent; =0 if censoring)
T_i_star	a vector for death times
delta_i_star	a vector for death indicator (=1 if death; =0 if censoring)

### Author(s)

Xinwei Huang

## References

Huang XW, Wang W, Emura T (2020) A copula-based Markov chain model for serially dependent event times with a dependent terminal event. Japanese Journal of Statistics & Data Science. Accepted.

## Examples

```
Y = ClaytonFrank.Weibull.data(N = 100, scale1 = 1, shape1 = 0.5, theta = 2,
                              scale2 = 0.45, shape2 = 0.5, alpha = 2, b = 10, l = 300)
```

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ClaytonFrank.Weibull.MLE

*Parameter estimation based on the Clayton copula for serial dependence and the Frank copula for dependent censoring with the Weibull distributions*

---

## Description

Perform two-stage estimation based on the Clayton copula  $C_\theta$  for serial dependence and the Frank copula  $\tilde{C}_\alpha$  for dependent censoring with the marginal distributions  $Weib(scale1, shape1)$  and  $Weib(scale2, shape2)$ . The jackknife method estimates the asymptotic covariance matrix. Parametric bootstrap is applied while doing Kolmogorov-Smirnov tests and Cramer-von Mises test. The guide for using this function shall be explained by Huang (2019) and Huang, Wang and Emura (2020).

## Usage

```
ClaytonFrank.Weibull.MLE(subject, t.event, event, t.death, death, stageI, Weibull.plot,
                          jackknife, plot, GOF, GOF.plot, rep.GOF, digit)
```

## Arguments

subject	a vector for numbers of subject
t.event	a vector for event times
event	a vector for event indicator (=1 if recurrent; =0 if censoring)
t.death	a vector for death times
death	a vector for death indicator (=1 if death; =0 if censoring)
stageI	an option to select MLE or LSE method for the 1st-stage optimization
Weibull.plot	if TRUE, show the Weibull probability plot
jackknife	if TRUE, the jackknife method is used for estimate covariance matrix (default = TRUE)
plot	if TRUE, the plots for marginal distributions are shown (default = FALSE)
GOF	if TRUE, show the p-values for KS-test and CvM-test
GOF.plot	if TRUE, show the model diagnostic plot
rep.GOF	repetition number of parametric bootstrap
digit	accurate to some decimal places



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Copula.Markov.survival

*Copula.Markov.survival*

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### Description

Perform likelihood estimation and corresponding analysis under the copula-based Markov chain model for serially dependent event times with a dependent terminal event. A two stage estimation method is applied for estimating model parameters. Two copula functions are used for measuring dependence. One is used for modeling serial dependence in recurrent event times. The other one is for modeling dependent censoring. The baseline hazard functions are modeled by the Weibull distributions. See Huang (2019) <<https://etd.lib.nctu.edu.tw/cgi-bin/gs32/ncugsweb.cgi?o=dncucdr&s=id=>

### Author(s)

Xinwei Huang <xinweihuang@hotmail.com>

### References

Huang, X.-W. (2019). Likelihood-based inference for copula-based Markov chain models for continuous, discrete, and survival data. NCU library.

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FrankClayton.Weibull.data

*Generate data from the Frank copula for serial dependence and the Clayton copula for dependent censoring with the Weibull distributions*

---

### Description

The data generation process is based on the Frank copula  $C_{\theta}$  for serial dependence and the Clayton copula  $\tilde{C}_{\alpha}$  for dependent censoring with the marginal distributions  $Weib(scale1, shape1)$  and  $Weib(scale2, shape2)$ . Censoring percentage can be controlled by constant  $c$ . This function is used when doing parametric bootstrap. The guide for using this function shall be explained by Huang (2019), and Huang, Wang and Emura (2020).

### Usage

FrankClayton.Weibull.data(N, scale1, shape1, theta, scale2, shape2, alpha, b, l)

### Arguments

N	sample size
scale1	scale parameter for $Weib(scale1, shape1)$ , $scale1 > 0$
shape1	shape parameter for $Weib(scale1, shape1)$ , $shape1 > 0$



theta	copula parameter for C_theta, theta $\neq$ 0
scale2	scale parameter for Weib(scale2, shape2), scale2 > 0
shape2	shape parameter for Weib(scale2, shape2), shape2 > 0
alpha	copula parameter for tilde(C)_alpha, alpha > 0
b	parameter of Unif(0, b) for controlling censoring percentage
l	length for data generation (default = 300)

**Value**

A list with the following elements:

Subject	a vector for numbers of subject
T_ij	a vector for event times
delta_ij	a vector for event indicator (=1 if recurrent; =0 if censoring)
T_i_star	a vector for death times
delta_i_star	a vector for death indicator (=1 if death; =0 if censoring)

**Author(s)**

Xinwei Huang

**References**

Huang XW, Wang W, Emura T (2020) A copula-based Markov chain model for serially dependent event times with a dependent terminal event. Japanese Journal of Statistics & Data Science. Accepted.

**Examples**

```
Y = FrankClayton.Weibull.data(N = 100, scale1 = 1, shape1 = 0.5, theta = 2,
                             scale2 = 0.45, shape2 = 0.5, alpha = 2, b = 10, l = 300)
```

---

FrankClayton.Weibull.MLE

*Parameter estimation based on the Frank copula for serial dependence and the Clayton copula for dependent censoring with the Weibull distributions*

---

**Description**

Perform two-stage estimation based on the Frank copula C\_theta for serial dependence and the Clayton copula tilde(C)\_alpha for dependent censoring with the marginal distributions Weib(scale1, shape1) and Weib(scale2, shape2). The jackknife method estimates the asymptotic covariance matrix. Parametric bootstrap is applied while doing Kolmogorov-Smirnov tests and Cramer-von Mises test. The guide for using this function shall be explained by Huang (2019), and Huang, Wang and Emura (2020).

**Usage**

```
FrankClayton.Weibull.MLE(subject, t.event, event, t.death, death, stageI, Weibull.plot,
                        jackknife, plot, GOF, GOF.plot, rep.GOF, digit)
```

**Arguments**

subject	a vector for numbers of subject
t.event	a vector for event times
event	a vector for event indicator (=1 if recurrent; =0 if censoring)
t.death	a vector for death times
death	a vector for death indicator (=1 if death; =0 if censoring)
stageI	an option to select MLE or LSE method for the 1st-stage optimization
Weibull.plot	if TRUE, show the Weibull probability plot
jackknife	if TRUE, the jackknife method is used for estimate covariance matrix (default = TRUE)
plot	if TRUE, the plots for marginal distributions are shown (default = FALSE)
GOF	if TRUE, show the p-values for KS-test and CvM-test
GOF.plot	if TRUE, show the model diagnostic plot
rep.GOF	repetition number of parametric bootstrap
digit	accurate to some decimal places

**Details**

When jackknife=FALSE, the corresponding standard error and confidence interval values are shown as NA.

**Value**

A list with the following elements:

Sample_size	Sample size N
Case	Count for event occurrences
scale1	Scale parameter for Weib(scale1, shape1)
shape1	Shape parameter for Weib(scale1, shape1)
scale2	Scale parameter for Weib(scale2, shape2)
shape2	Shape parameter for Weib(scale2, shape2)
theta	Copula parameter for the Frank copula C_theta
alpha	Copula parameter for the Clayton copula tilde(C)_alpha
COV	Asymptotic covariance estimated by the jackknife method
KS	Kolmogorov-Smirnov test statistics
p.KS	P-values for Kolmogorov-Smirnov tests
CM	Cramer-von Mises test statistics

p.CM	P-values for Cramer-von Mises tests
Convergence	Convergence results for each stage
Jackknife_error	Count for error in jackknife repetitions
Log_likelihood	Log-likelihood values

**Author(s)**

Xinwei Huang

**Examples**

```
data = FrankClayton.Weibull.data(N = 30, scale1 = 1, shape1 = 0.5, theta = 2,
                                scale2 = 0.45, shape2 = 0.5, alpha = 2, b = 10, l = 300)

FrankClayton.Weibull.MLE(subject = data$Subject,
                          t.event = data$T_ij, event = data$delta_ij,
                          t.death = data$T_i_star, death = data$delta_i_star,
                          jackknife= TRUE, plot = TRUE)
```

---

FrankFrank.Weibull.data

*Generate data from the Frank copula for serial dependence and the Frank copula for dependent censoring with the Weibull distributions*

---

**Description**

The data generation process is based on the Frank copula  $C_{\theta}$  for serial dependence and the Frank copula  $\tilde{C}_{\alpha}$  for dependent censoring with the marginal distributions  $Weib(scale1, shape1)$  and  $Weib(scale2, shape2)$ . Censoring percentage can be controlled by constant  $c$ . This function is used when doing parametric bootstrap. The guide for using this function shall be explained by Huang (2019), and Huang, Wang and Emura (2020).

**Usage**

```
FrankFrank.Weibull.data(N, scale1, shape1, theta, scale2, shape2, alpha, b, l)
```

**Arguments**

N	sample size
scale1	scale parameter for $Weib(scale1, shape1)$ , $scale1 > 0$
shape1	shape parameter for $Weib(scale1, shape1)$ , $shape1 > 0$
theta	copula parameter for $C_{\theta}$ , $\theta \neq 0$

scale2	scale parameter for Weib(scale2, shape2), scale2 > 0
shape2	shape parameter for Weib(scale2, shape2), shape2 > 0
alpha	copula parameter for tilde(C)_alpha, alpha ≠ 0
b	parameter of Unif(0, b) for controlling censoring percentage
l	length for data generation (default = 300)

**Value**

A list with the following elements:

Subject	a vector for numbers of subject
T_ij	a vector for event times
delta_ij	a vector for event indicator (=1 if recurrent; =0 if censoring)
T_i_star	a vector for death times
delta_i_star	a vector for death indicator (=1 if death; =0 if censoring)

**Author(s)**

Xinwei Huang

**References**

Huang XW, Wang W, Emura T (2020) A copula-based Markov chain model for serially dependent event times with a dependent terminal event. *Japanese Journal of Statistics & Data Science*. Accepted.

**Examples**

```
Y = FrankFrank.Weibull.data(N = 100, scale1 = 1, shape1 = 0.5, theta = 2,
                             scale2 = 0.45, shape2 = 0.5, alpha = 2, b = 10, l = 300)
```

---

FrankFrank.Weibull.MLE

*Parameter estimation based on the Frank copula for serial dependence and the Frank copula for dependent censoring with the Weibull distributions*

---

**Description**

Perform two-stage estimation based on the Frank copula  $C_\theta$  for serial dependence and the Frank copula  $\tilde{C}_\alpha$  for dependent censoring with the marginal distributions Weib(scale1, shape1) and Weib(scale2, shape2). The jackknife method estimates the asymptotic covariance matrix. Parametric bootstrap is applied while doing Kolmogorov-Smirnov tests and Cramer-von Mises test. The guide for using this function shall be explained by Huang (2019), and Huang, Wang and Emura (2020).

**Usage**

```
FrankFrank.Weibull.MLE(subject, t.event, event, t.death, death, stageI, Weibull.plot,
                        jackknife, plot, GOF, GOF.plot, rep.GOF, digit)
```

**Arguments**

subject	a vector for numbers of subject
t.event	a vector for event times
event	a vector for event indicator (=1 if recurrent; =0 if censoring)
t.death	a vector for death times
death	a vector for death vindicator (=1 if death; =0 if censoring)
stageI	an option to select MLE or LSE method for the 1st-stage optimization
Weibull.plot	if TRUE, show the Weibull probability plot
jackknife	if TRUE, the jackknife method is used for estimate covariance matrix (default = TRUE)
plot	if TRUE, the plots for marginal distributions are shown (default = FALSE)
GOF	if TRUE, show the p-values for KS-test and CvM-test
GOF.plot	if TRUE, show the model diagnostic plot
rep.GOF	repetition number of parametric bootstrap
digit	accurate to some decimal places

**Details**

When jackknife=FALSE, the corresponding standard error and confidence interval values are shown as NA.

**Value**

A list with the following elements:

Sample_size	Sample size N
Case	Count for event occurrences
scale1	Scale parameter for Weib(scale1, shape1)
shape1	Shape parameter for Weib(scale1, shape1)
scale2	Scale parameter for Weib(scale2, shape2)
shape2	Shape parameter for Weib(scale2, shape2)
theta	Copula parameter for the Frank copula $C_{\theta}$
alpha	Copula parameter for the Frank copula $\tilde{C}_{\alpha}$
COV	Asymptotic covariance estimated by the jackknife method
KS	Kolmogorov-Smirnov test statistics
p.KS	P-values for Kolmogorov-Smirnov tests
CM	Cramer-von Mises test statistics

p.CM	P-values for Cramer-von Mises tests
Convergence	Convergence results for each stage
Jackknife_error	Count for error in jackknife repetitions
Log_likelihood	Log-likelihood values

**Author(s)**

Xinwei Huang

**Examples**

```
data = FrankFrank.Weibull.data(N = 300, scale1 = 1, shape1 = 0.5, theta = 2,  
                               scale2 = 0.45, shape2 = 0.5, alpha = 2, b = 10, l = 300)
```

```
FrankFrank.Weibull.MLE(subject = data$Subject,  
                        t.event = data$T_ij, event = data$delta_ij,  
                        t.death = data$T_i_star, death = data$delta_i_star,  
                        jackknife = TRUE, plot = TRUE)
```

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