Package 'DepDoubleTruncKS'

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Type Package

Title Kolmogorov-Smirnov Test for Dependently Double-Truncated Durations

Version 0.1.0

Description Performs the Kolmogorov-Smirnov-type goodness-of-fit test for exponential duration models under independent or dependently double-truncated sampling scheme using Farlie-Gumbel-Morgenstern ('FGM') copulas, as proposed by Toparkus and Weissbach (2026) <doi:10.1007/s10985-026-09722-0>. Provides functions for profile maximum likelihood estimation / score equation solving, computation of the two-dimensional Kolmogorov-Smirnov test statistic over the double-truncation parallelogram, simulation of the asymptotic Gaussian process limit distribution for critical values and p-value calculation, and synthetic dataset generation.

License GPL (>= 3)

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`calc_alpha_fgm` *Calculate Observation Probability for FGM-Dependent Double Truncation*

Description

Computes the observation probability alpha_theta and its gradient vector with respect to (theta, vtheta) for an exponentially distributed lifespan and uniformly distributed age under Farlie-Gumbel-Morgenstern (FGM) copula dependence.

Usage

```
calc_alpha_fgm(theta, vtheta, s, G)
```

Arguments

`theta`	Rate parameter of the exponential lifespan distribution (theta > 0).
`vtheta`	FGM copula dependence parameter (vtheta in [-1, 1]).
`s`	Duration of the study (s > 0).
`G`	Upper bound of the foundation age distribution (G > 0).

Value

A list containing:

`alpha`	Observation probability alpha_theta_vtheta.
`dalpha_theta`	Partial derivative of alpha with respect to theta.
`dalpha_vtheta`	Partial derivative of alpha with respect to vtheta.
`grad`	Gradient vector c(dalpha_theta, dalpha_vtheta).

Examples

```
calc_alpha_fgm(theta = 0.082, vtheta = 0.103, s = 3, G = 24)
```

`calc_alpha_ind` *Calculate Observation Probability for Independent Double Truncation*

Description

Computes the observation probability alpha_theta and its derivative with respect to theta for an exponentially distributed lifespan and uniformly distributed age at study start under independent double truncation.

Usage

```
calc_alpha_ind(theta, s, G)
```

Arguments

`theta`	Rate parameter of the exponential lifespan distribution (theta > 0).
`s`	Duration of the study (s > 0).
`G`	Upper bound of the foundation age distribution (G > 0).

Value

A list containing:

`alpha`	Observation probability alpha_theta.
`dalpha`	Derivative of alpha_theta with respect to theta.

Examples

```
calc_alpha_ind(theta = 0.082, s = 3, G = 24)
```

`calc_critical_values` *Calculate Asymptotic Critical Values and P-Value*

Description

Implements Algorithm 2 from Toparkus & Weissbach (2026) to compute critical values (90 on a 2D grid over the double-truncation region D.

Usage

```
calc_critical_values(
  ks_stat,
  theta,
  vtheta = 0,
  s,
  G,
  model = c("fgm", "ind"),
  grid_dim = 25,
  n_sim = 500
)
```

Arguments

`ks_stat`	Observed Kolmogorov-Smirnov test statistic value.
`theta`	Rate parameter theta.
`vtheta`	Dependence parameter vtheta (0 for model="ind").
`s`	Duration of the study (s > 0).
`G`	Upper bound of foundation age (G > 0).
`model`	Model type: ‘"fgm"‘ or ‘"ind"‘.
`grid_dim`	Discretization grid dimension (default 25 x 25 grid).
`n_sim`	Number of Monte Carlo simulation repetitions (default 500).

Value

A list containing:

`crit_90`	Critical value at 10 percent significance level (alpha = 0.10).
`crit_95`	Critical value at 5 percent significance level (alpha = 0.05).
`crit_99`	Critical value at 1 percent significance level (alpha = 0.01).
`p_value`	Empirical p-value.
`sim_suprema`	Vector of simulated suprema.

Examples

```
set.seed(123)
res <- calc_critical_values(ks_stat = 1.2, theta = 0.08, vtheta = 0,
                            s = 3, G = 24, model = "ind", grid_dim = 15, n_sim = 100)
res$crit_95
```

`calc_E_fgm` *Region Integral E_theta(g_x,t,D) for FGM-Dependent Model*

Description

Computes the expectation E_theta(g_x,t,D) = P_theta((X,T) in [0,x] x [0,t] intersect D) and its derivatives with respect to theta and vtheta under the FGM copula.

Usage

```
calc_E_fgm(x, t, s, G, theta, vtheta)
```

Arguments

`x`	Vector of duration evaluation points (x > 0).
`t`	Vector of truncation evaluation points (0 <= t <= G).
`s`	Duration of the study.
`G`	Upper bound of foundation age.
`theta`	Exponential rate parameter.
`vtheta`	FGM copula dependence parameter.

Value

A list containing:

`val`	Value of E_theta(g_x,t,D).
`dval_theta`	Partial derivative wrt theta.
`dval_vtheta`	Partial derivative wrt vtheta.

calc_E_ind — *Region Integral E_theta(g_x,t,D) for Independent Model*

Description

Computes the expectation E_theta(g_x,t,D) = P_theta((X,T) in [0,x] x [0,t] intersect D) and its derivative with respect to theta for independent truncation.

Usage

```
calc_E_ind(x, t, s, G, theta)
```

Arguments

x	Vector of duration evaluation points (x > 0).
t	Vector of truncation evaluation points (0 <= t <= G).
s	Duration of the study.
G	Upper bound of foundation age.
theta	Exponential rate parameter.

Value

A list containing:

val	Value of E_theta(g_x,t,D).
dval	Derivative wrt theta.

calc_ks_stat — *Compute 2D Kolmogorov-Smirnov Test Statistic for Truncated Data*

Description

Implements Algorithm 1 from Toparkus & Weissbach (2026) to compute the 2D Kolmogorov-Smirnov test statistic comparing the empirical CDF and the parametric CDF over the double-truncation region D.

Usage

```
calc_ks_stat(x, t, s, G, theta, vtheta = 0, model = c("fgm", "ind"))
```

Arguments

x	Vector of observed durations (x > 0).
t	Vector of observed ages at study start (0 <= t <= G).
s	Duration of the study (s > 0).
G	Upper bound of foundation age (G > 0).
theta	Estimated rate parameter theta.
vtheta	Estimated dependence parameter vtheta (0 for model="ind").
model	Model type: ‘"fgm"‘ or ‘"ind"‘.

Value

A list containing:

ks_stat	Composite KS test statistic value.
max_diff	Maximum absolute difference between empirical and parametric CDFs.
delta_plus	Maximum positive difference delta_plus.
delta_minus	Maximum negative difference delta_minus.
n_eval_points	Total number of evaluated candidate points.

Examples

```
set.seed(123)
dat <- sim_double_trunc(n = 300, theta = 0.08, G = 24, s = 3, model = "ind")
fit <- fit_double_trunc(dat$x, dat$t, s = 3, G = 24, model = "ind")
ks_res <- calc_ks_stat(dat$x, dat$t, s = 3, G = 24, theta = fit$theta, model = "ind")
ks_res$ks_stat
```

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enterprise_data *Synthetic Enterprise Lifespans under Double Truncation*

Description

A synthetic dataset containing 500 observed enterprise durations and age at study start under double truncation, constructed to mimic German enterprise lifespan data described in Toparkus & Weissbach (2026).

Usage

```
enterprise_data
```

Format

A data frame with 500 rows and 2 variables:

x Observed enterprise duration (lifespan in years).

t Observed age at study start (truncation age in years, between 0 and G=24).

Source

Simulated based on parameters from Toparkus & Weissbach (2026).

References

Toparkus, A.-M. and Weissbach, R. (2026). Kolmogorov-Smirnov-type test for dependently double-truncated durations: A copula approach. *Lifetime Data Analysis*, 32, 41. doi:10.1007/s10985-026097220.

Examples

```
data(enterprise_data)
head(enterprise_data)
```

`fit_double_trunc` *Fit Double-Truncated Exponential Duration Model*

Description

Estimates the parameters of an exponential duration model under independent or dependently double-truncated sampling using Z-estimation / maximum likelihood.

Usage

```
fit_double_trunc(x, t, s, G, model = c("fgm", "ind"))
```

Arguments

`x`	Vector of observed durations (x > 0).
`t`	Vector of observed ages at study start (0 <= t <= G).
`s`	Duration of the study (s > 0).
`G`	Upper bound of foundation age (G > 0).
`model`	Model specification: ‘"fgm"‘ for FGM copula dependent truncation or ‘"ind"‘ for independent truncation.

Value

A list of class ‘"fit_double_trunc"‘ containing:

`theta`	Estimated exponential rate parameter theta.
`vtheta`	Estimated FGM dependence parameter vtheta (if model="fgm").
`alpha`	Estimated observation probability alpha.
`model`	Model type ("ind" or "fgm").
`s`	Study length.
`G`	Maximum truncation age.
`mn`	Number of observed units.
`n_hat`	Estimated latent sample size mn / alpha.

Examples

```
set.seed(123)
sim_dat <- sim_double_trunc(n = 500, theta = 0.08, G = 24, s = 3, model = "ind")
fit <- fit_double_trunc(sim_dat$x, sim_dat$t, s = 3, G = 24, model = "ind")
fit$theta
```

`ks_dep_trunc` *Kolmogorov-Smirnov-type Test for Dependently Double-Truncated Data*

Description

Performs the 2D Kolmogorov-Smirnov goodness-of-fit test for exponential lifespan distributions under independent or Farlie-Gumbel-Morgenstern (FGM) copula dependent double truncation, as proposed by Toparkus & Weissbach (2026).

Usage

```
ks_dep_trunc(x, t, s, G, model = c("fgm", "ind"), grid_dim = 25, n_sim = 500)
```

Arguments

`x`	Vector of observed durations (x > 0).
`t`	Vector of observed ages at study start (0 <= t <= G).
`s`	Duration of the study (s > 0).
`G`	Upper bound of foundation age (G > 0).
`model`	Model specification: ‘"fgm"‘ for FGM copula dependent truncation (default) or ‘"ind"‘ for independent truncation.
`grid_dim`	Discretization grid dimension for critical value calculation (default 25).
`n_sim`	Number of Monte Carlo simulation repetitions for critical value calculation (default 500).

Value

An object of class `"ks_dep_trunc"` containing:

`ks_stat`	Composite KS test statistic value.
`fit`	Parameter estimates object from fit_double_trunc.
`crit_values`	Critical values at 90, 95, 99 percent significance levels.
`p_value`	Empirical p-value of the test.
`decision`	Statistical decision at alpha = 0.05 ("Reject H0" or "Fail to reject H0").
`x`	Observed durations.
`t`	Observed truncation ages.
`s`	Study length.
`G`	Maximum truncation age.
`model`	Model type.

References

Toparkus, A.-M. and Weissbach, R. (2026). Kolmogorov-Smirnov-type test for dependently double-truncated durations: A copula approach. *Lifetime Data Analysis*, 32, 41. doi:10.1007/s10985-026097220.

Examples

```
set.seed(42)
dat <- sim_double_trunc(n = 300, theta = 0.082, G = 24, s = 3, model = "ind")
res <- ks_dep_trunc(dat$x, dat$t, s = 3, G = 24, model = "ind", grid_dim = 15, n_sim = 100)
print(res)
```

---

plot.ks_dep_trunc *Plot S3 Method for ks_dep_trunc*

Description

Scatter plot of observed durations and truncation ages inside the truncation parallelogram D, along with theoretical boundaries.

Usage

```
## S3 method for class 'ks_dep_trunc'
plot(x, ...)
```

Arguments

x	Object of class ‘"ks_dep_trunc"‘.
...	Additional graphical parameters.

Value

No return value, called for side effects.

---

print.ks_dep_trunc *Print S3 Method for ks_dep_trunc*

Description

Print S3 Method for ks_dep_trunc

Usage

```
## S3 method for class 'ks_dep_trunc'
print(x, ...)
```

Arguments

x	Object of class ‘"ks_dep_trunc"‘.
...	Additional arguments passed to print.

Value

Invisibly returns the input object x.

---

sim_double_trunc *Simulate Double-Truncated Duration Data*

Description

Generates double-truncated duration data (X, T) under independent or Farlie-Gumbel-Morgenstern (FGM) copula dependence according to Algorithms 4 & 5 from Toparkus & Weissbach (2026).

Usage

```
sim_double_trunc(n, theta, G, s, vtheta = 0, model = c("fgm", "ind"))
```

Arguments

n	Latent sample size (n > 0).
theta	Rate parameter of the exponential lifespan distribution (theta > 0).
G	Upper bound of the foundation age distribution (G > 0).
s	Duration of the study (s > 0).
vtheta	FGM copula dependence parameter in [-1, 1] (0 for model="ind").
model	Model specification: ‘"fgm"‘ or ‘"ind"‘.

Value

A list containing:

x	Vector of observed durations inside parallelogram D.
t	Vector of observed truncation ages inside parallelogram D.
mn	Number of observed units mn.
n	Latent sample size n.
alpha_true	True observation probability.
model	Model type.

Examples

```
set.seed(123)
dat <- sim_double_trunc(n = 1000, theta = 0.082, G = 24, s = 3, model = "ind")
head(dat$x)
dat$mn
```

`summary.ks_dep_trunc` *Summary S3 Method for ks_dep_trunc*

Description

Summary S3 Method for ks_dep_trunc

Usage

```
## S3 method for class 'ks_dep_trunc'
summary(object, ...)
```

Arguments

`object`	Object of class ‘"ks_dep_trunc"‘.
`...`	Additional arguments passed to summary.

Value

Invisibly returns the input object `object`.

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