Package 'PTLENKies'

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Type Package

Title Computation of PTLENKies Distribution Properties

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Description Implements statistical tools for analyzing, simulating, and computing properties of the Power Topp Leone Exponential Negative Kies Burr (PTLENKBurr). See Atchadé M, Otodji T, and Djibril A (2024) <doi:10.1063/5.0179458> and Atchadé M, Otodji T, Djibril A, and N'bouké M (2023) <doi:10.1515/phys-2023-0151> for details.

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Contents

`C_PTLENKBurr` *Cumulative Distribution Function (CDF) of the PTLENKBurr Distribution*

Description

This function calculates the Cumulative Distribution Function (CDF) of the PTLENKBurr distribution.

Usage

```
C_PTLENKBurr(x, m, n, p, lambda, beta, c, k)
```

Arguments

`x`	Value or vector of positive values up to which to calculate the CDF.
`m`	Parameter m of the distribution (m > 0).
`n`	Parameter n of the distribution (n > 0).
`p`	Parameter p of the distribution (p > 0).
`lambda`	Parameter lambda of the distribution (lambda > 0).
`beta`	Parameter beta of the distribution (beta > 0).
`c`	Parameter c of the Burr XII baseline component (c > 0).
`k`	Parameter k of the Burr XII baseline component (k > 0).

Details

It takes parameters x, m, n, p, lambda, beta, c, and k, and returns the CDF value at x based on these parameters.

The Cumulative Distribution Function (CDF) of the PTLENKBurr distribution is defined as:

$$F(x; m, n, p, \lambda, \beta, c, k) = \exp\left(mn\left(1 - \frac{1}{K(x)^p}\right)\right)\left[2 - \exp\left(n\left(1 - \frac{1}{K(x)^p}\right)\right)\right]^m$$

where

$$K(x) = 1 - \exp\left(-\lambda\left(\frac{1-(1+x^c)^{-k}}{(1+x^c)^{-k}}\right)^\beta\right)$$

and $m, n, p, \lambda, \beta, c, k > 0$, $x > 0$.

Value

A numeric vector containing the values of the CDF evaluated at `x`.

Examples

```
C_PTLENKBurr(
  x = c(0.5, 1.0, 1.5),
  m = 1, n = 1, p = 1,
  lambda = 0.5, beta = 1.5, c = 2, k = 1
)
```

`E_PTLENKBurr` *Maximum Likelihood Estimation (MLE) of the PTLENKBurr Distribution*

Description

Estimates the parameters of the Power Transformed Lindley Extended Modified Kies Burr XII (PTLENKBurr) distribution using maximum likelihood estimation (MLE) via constrained optimization with `nlminb`.

Usage

```
E_PTLENKBurr(data, start_params = NULL, lower = 1e-05)
```

Arguments

`data`	Numeric vector of positive observations.
`start_params`	Optional numeric vector of length 7 containing initial parameter values for `c(m, n, p, lambda, beta, c, k)`. Default is `c(1, 1, 1, 1, 1, 1, 1)`.
`lower`	Lower bounds for parameters. Default is `1e-5` for all 7 parameters.

Details

Optimization is performed using `nlminb`. Infeasible iterations returning non-positive densities, `NA`, or `NaN` values are assigned a high penalty.

Value

A named numeric vector of estimated parameters: `m`, `n`, `p`, `lambda`, `beta`, `c`, and `k`.

Examples

```
data_sample <- c(0.5, 1.2, 0.8, 2.1, 0.3, 1.5, 0.9)
E_PTLENKBurr(data_sample)
```

GlassFibers *Dataset: GlassFibers*

Description

The dataset contains observations collected at the UK National Physical Laboratory regarding the breaking strengths of 1.5 cm glass fibers, previously reported in Atchade (2023).

Usage

```
data(GlassFibers)
```

Format

A numeric vector of breaking strengths.

Details

This dataset contains measurements corresponding to the breaking strengths of 1.5 cm glass fibers. The data are presented as a numeric vector.

References

Atchade, N. (2023). Statistical modeling of lifetime data and probability distributions.

Plot_CPTLENKBurr *Plot the Cumulative Distribution Function (CDF) of the PTLENKBurr Distribution*

Description

Generates an enhanced plot of the Cumulative Distribution Function (CDF) of the PTLENKBurr distribution over [0, +Inf), automatically calculating and displaying the numerical median.

Usage

```
Plot_CPTLENKBurr(
  m,
  n,
  p,
  lambda,
  beta,
  c,
  k,
  max_x = NULL,
  show_median = TRUE,
```

```
  col_line = "deepskyblue4",
  col_median = "firebrick3",
  legend_pos = "right",
  ...
)
```

Arguments

m	Parameter m of the distribution (m > 0).
n	Parameter n of the distribution (n > 0).
p	Parameter p of the distribution (p > 0).
lambda	Parameter lambda of the distribution (lambda > 0).
beta	Parameter beta of the distribution (beta > 0).
c	Parameter c of the Burr XII baseline component (c > 0).
k	Parameter k of the Burr XII baseline component (k > 0).
max_x	Optional maximum x-axis value. If NULL (default), it is automatically computed using the CDF.
show_median	Logical. If TRUE (default), calculates and plots the median.
col_line	Color of the CDF curve. Default is "deepskyblue4".
col_median	Color of the median lines and point. Default is "firebrick3".
legend_pos	Position of the legend. Default is "right".
...	Additional graphical parameters passed to plot.

Details

The median is numerically calculated by finding the root of $F(x) - 0.5 = 0$ using uniroot.

Value

A plot of the CDF and an invisible list containing the evaluation grid data frame and the numerical value of the median.

Examples

```
Plot_CPTLENKBurr(
  m = 1, n = 1, p = 1, lambda = 0.5,
  beta = 1.5, c = 2, k = 1
)
```

`Plot_PPTLENKBurr` *Plot the Probability Density Function (PDF) of the PTLENKBurr Distribution*

Description

Generates an enhanced plot of the Probability Density Function (PDF) of the PTLENKBurr distribution over [0, +Inf), automatically calculating and displaying the numerical mode and median.

Usage

```
Plot_PPTLENKBurr(
  m,
  n,
  p,
  lambda,
  beta,
  c,
  k,
  max_x = NULL,
  show_mode = TRUE,
  show_median = TRUE,
  col_line = "deepskyblue4",
  col_mode = "darkorange2",
  col_median = "firebrick3",
  legend_pos = "topright",
  ...
)
```

Arguments

`m`	Parameter m of the distribution (m > 0).
`n`	Parameter n of the distribution (n > 0).
`p`	Parameter p of the distribution (p > 0).
`lambda`	Parameter lambda of the distribution (lambda > 0).
`beta`	Parameter beta of the distribution (beta > 0).
`c`	Parameter c of the Burr XII baseline component (c > 0).
`k`	Parameter k of the Burr XII baseline component (k > 0).
`max_x`	Optional maximum x-axis value. If NULL (default), it is automatically computed using the CDF.
`show_mode`	Logical. If TRUE (default), calculates and plots the mode.
`show_median`	Logical. If TRUE (default), calculates and plots the median.
`col_line`	Color of the PDF curve. Default is `"deepskyblue4"`.
`col_mode`	Color of the mode marker. Default is `"darkorange2"`.

col_median	Color of the median marker. Default is "firebrick3".
legend_pos	Position of the legend. Default is "topright".
...	Additional graphical parameters passed to plot.

Details

The upper bound max_x is determined automatically by finding where $F(x) \geq 0.999$. The mode is calculated numerically by maximizing the PDF via optimize, and the median is found via uniroot on the CDF (C_PTLENKBurr).

Value

A plot of the PDF and an invisible list containing the evaluation grid data frame, calculated mode, and median.

Examples

```
Plot_PPTLENKBurr(
  m = 1, n = 1, p = 1, lambda = 0.5,
  beta = 1.5, c = 2, k = 1
)
```

P_PTLENKBurr *Probability Density Function (PDF) of the PTLENKBurr Distribution*

Description

This function calculates the Probability Density Function (PDF) of the PTLENKBurr distribution.

Usage

```
P_PTLENKBurr(x, m, n, p, lambda, beta, c, k)
```

Arguments

x	Value or vector of positive values to evaluate the PDF at.
m	Parameter m of the distribution (m > 0).
n	Parameter n of the distribution (n > 0).
p	Parameter p of the distribution (p > 0).
lambda	Parameter lambda of the distribution (lambda > 0).
beta	Parameter beta of the distribution (beta > 0).
c	Parameter c of the Burr XII baseline component (c > 0).
k	Parameter k of the Burr XII baseline component (k > 0).

Details

$$f(x;m,n,p,\lambda,\beta,c,k) = 2mnp\lambda\beta ckx^{c-1}(1+x^c)^{-(k+1)}\frac{\left(1-(1+x^c)^{-k}\right)^{\beta-1}}{\left((1+x^c)^{-k}\right)^{\beta+1}}\frac{1-K(x)}{K(x)^{p+1}}\exp\left(mn\left(1-\frac{1}{K(x)^p}\right)\right)\left(1-$$

where

$$K(x) = 1-\exp\left(-\lambda\left(\frac{1-(1+x^c)^{-k}}{(1+x^c)^{-k}}\right)^{\beta}\right)$$

and $m, n, p, \lambda, \beta, c, k > 0$, $x > 0$.

Value

A numeric vector containing the values of the PDF evaluated at `x`.

Examples

```
P_PTLENKBurr(
  x = c(0.5, 1.0, 1.5),
  m = 1, n = 1, p = 1,
  lambda = 0.5, beta = 1.5, c = 2, k = 1
)
```

Q_PTLENKBurr *Quantile Function of the PTLENKBurr Distribution*

Description

Calculates the quantile value (inverse CDF) of the PTLENKBurr distribution for a given probability `u` or a vector of probabilities.

Usage

```
Q_PTLENKBurr(u, m, n, p, lambda, beta, c, k, tol = 1e-08)
```

Arguments

`u`	Numeric vector of probabilities ($0 \leq u \leq 1$).
`m`	Parameter m of the distribution (m > 0).
`n`	Parameter n of the distribution (n > 0).
`p`	Parameter p of the distribution (p > 0).
`lambda`	Parameter lambda of the distribution (lambda > 0).
`beta`	Parameter beta of the distribution (beta > 0).
`c`	Parameter c of the Burr XII baseline component (c > 0).
`k`	Parameter k of the Burr XII baseline component (k > 0).
`tol`	Tolerance level for numerical root finding via `uniroot`. Default is `1e-8`.

Details

The quantile function $Q(u)$ is obtained by numerically solving $F(x) - u = 0$ using `uniroot`. The probability argument is named `u` to avoid name collision with the distribution parameter `p`.

Value

A numeric vector of quantiles corresponding to the probabilities in `u`.

Examples

```
# Calculate quartiles (25%, 50%, 75%)
Q_PTLENKBurr(
  u = c(0.25, 0.5, 0.75),
  m = 1, n = 1, p = 1,
  lambda = 0.5, beta = 1.5, c = 2, k = 1
)
```

R_PTLENKBurr *Random Generation for the PTLENKBurr Distribution*

Description

Generates random samples from the PTLENKBurr distribution using inverse transform sampling (quantile method).

Usage

```
R_PTLENKBurr(n_samples, m, n, p, lambda, beta, c, k)
```

Arguments

`n_samples`	Number of random samples to generate (must be a positive integer).
`m`	Parameter m of the distribution (m > 0).
`n`	Parameter n of the distribution (n > 0).
`p`	Parameter p of the distribution (p > 0).
`lambda`	Parameter lambda of the distribution (lambda > 0).
`beta`	Parameter beta of the distribution (beta > 0).
`c`	Parameter c of the Burr XII baseline component (c > 0).
`k`	Parameter k of the Burr XII baseline component (k > 0).

Details

The parameter for the sample size is named `n_samples` to avoid naming conflicts with the distribution parameter `n`. Random variates are generated by applying the quantile function `Q_PTLENKBurr` to uniform random variables: $X = Q(U)$ where $U \sim \text{Uniform}(0, 1)$.

Value

A numeric vector of `n_samples` random values generated from the PTLENKBurr distribution.

Examples

```
set.seed(123)
sim_data <- R_PTLENKBurr(
  n_samples = 100,
  m = 1, n = 1, p = 1,
  lambda = 0.5, beta = 1.5, c = 2, k = 1
)
head(sim_data)
```

Sim_PTLENKBurr *Histogram and Fitted Density Function (PDF) of the PTLENKBurr Distribution*

Description

Generates a histogram of the provided dataset and overlays the fitted Probability Density Function (PDF) of the PTLENKBurr distribution with parameters estimated via Maximum Likelihood Estimation using `E_PTLENKBurr`.

Usage

```
Sim_PTLENKBurr(
  data,
  breaks = 15,
  col_hist = "lightblue",
  col_line = "firebrick3",
  ...
)
```

Arguments

`data`	Numeric vector of positive data values.
`breaks`	Number of breaks or break specification for the histogram. Default is `15`.
`col_hist`	Fill color for the histogram bars. Default is `"lightblue"`.
`col_line`	Color for the fitted PDF curve. Default is `"firebrick3"`.
`...`	Additional graphical parameters passed to `hist`.

Details

The function uses `E_PTLENKBurr` to estimate distribution parameters and evaluates `P_PTLENKBurr` over a sequence from near zero to 1.2 times the maximum data value.

Value

An invisible named numeric vector containing the 7 estimated parameters `c(m, n, p, lambda, beta, c, k)`.

Examples

```
sample_data <- c(0.5, 1.2, 0.8, 2.1, 0.3, 1.5, 0.9)
Sim_PTLENKBurr(sample_data)
```

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