

Package ‘zmctp’

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Type Package

Title Zero-Modified Complex 'Tri-Parametric' Pearson Distribution for Overdispersed Count Data

Version 0.1.1

Description Implements zero-modified versions of the Complex 'Tri-Parametric' Pearson distribution for overdispersed count data. The package addresses limitations of existing implementations when the parameter b approaches zero. It provides distribution functions, maximum likelihood estimation, and diagnostic tools for modeling count data with excess zeros. The methodology is based on 'Rodriguez-Avi' and coauthors (2003) [<doi:10.1007/s00362-002-0134-7>](https://doi.org/10.1007/s00362-002-0134-7).

License GPL-3

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BugReports <https://github.com/roladoja/zmctp/issues>

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Contents

zmctp-package	2
ctp.fit	3
dctp	4
dzictp	5
mean_ctp	5
mean_zictp	6
pctp	7
plot.ctpfit	8
plot.zictpfit	8
print.ctpfit	9
print.zictpfit	9
pzip	10
qctp	11
qzip	11
rctp	12
rzictp	13
summary.ctpfit	13
summary.zictpfit	14
zictp.fit	14
Index	16

zmctp-package	<i>zmctp: Zero-Modified Complex Triparametric Pearson Distribution</i>
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Description

The zmctp package extends the Complex Triparametric Pearson (CTP) distribution with zero-modified versions for handling overdispersed count data, particularly when the parameter b approaches zero.

Details

Main functions:

- [dctp](#), [pctp](#), [qctp](#), [rctp](#) - CTP distribution functions
- [dzictp](#), [pzip](#), [qzip](#), [rzictp](#) - Zero-Modified CTP distribution functions
- [ctp.fit](#) - Fit CTP model
- [zictp.fit](#) - Fit Zero-Modified CTP model

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See Also

Useful links:

- <https://github.com/roladoja/zmctp>
- Report bugs at <https://github.com/roladoja/zmctp/issues>

 ctp.fit

Maximum Likelihood Estimation for the CTP Distribution

Description

Fits the Complex Triparametric Pearson (CTP) distribution to count data using maximum likelihood estimation.

Usage

```
ctp.fit(
  x,
  a_start = NULL,
  b_start = NULL,
  gama_start = NULL,
  method = "L-BFGS-B",
  penalty = 1e+10
)
```

Arguments

x	Numeric vector of nonnegative counts.
a_start	Optional starting value for parameter a.
b_start	Optional starting value for parameter b.
gama_start	Optional starting value for parameter gamma.
method	Optimization method (default: "L-BFGS-B").
penalty	numeric penalty added for numerical stability when $b \rightarrow 0$

Value

An object of class "ctpfir" containing:

estimates	Named vector of MLEs
se	Standard errors
vcov	Variance-covariance matrix
logLik	Log-likelihood
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion

pearson_chisq	Pearson's chi-squared statistic
wald_chisq	Wald's chi-squared statistic
fitted_freq	Data frame of observed vs expected frequencies
data	Original data
converged	Convergence status

Examples

```
set.seed(123)

x <- rctp(30, a = 1, b = 0.5, gama = 5)
fit <- ctp.fit(x)
print(fit)
plot(fit)
```

dctp

Probability Mass Function of the CTP Distribution

Description

Evaluates the probability mass function of the Complex TriParametric Pearson (CTP) distribution for nonnegative integer values.

The pmf is

$$p(x) = p(0) \frac{(a + ib)_x (a - ib)_x}{(\gamma)_x x!}, \quad x = 0, 1, \dots$$

and satisfies the recurrence

$$\frac{p(x+1)}{p(x)} = \frac{(a+x)^2 + b^2}{(\gamma+x)(x+1)}.$$

Usage

```
dctp(x, a, b, gama, log = FALSE)
```

Arguments

x	Vector of nonnegative integers.
a	Parameter a.
b	Parameter b (must satisfy $b \geq 0$).
gama	Parameter gamma.
log	Logical; if TRUE, returns log-probabilities.

Value

A numeric vector of probabilities.

Examples

```
dctp(0:5, a = 1, b = 0.5, gama = 6)
```

dzictp

*Probability Mass Function of the ZM-CTP Distribution***Description**

The Zero-Modified CTP (ZM-CTP) distribution modifies the zero probability of the baseline CTP distribution.

Usage

```
dzictp(x, a, b, gama, omega, log = FALSE)
```

Arguments

x	Vector of nonnegative integers.
a	Parameter a.
b	Parameter b.
gama	Parameter gamma.
omega	Zero-modification parameter, with $0 < \omega < 1$.
log	Logical; if TRUE, returns log-probabilities.

Value

Numeric vector of probabilities.

Examples

```
dzictp(0:5, a = 1, b = 0.5, gama = 6, omega = 0.3)
```

mean_ctp

*Theoretical moments and mode of the CTP distribution***Description**

Theoretical moments and mode of the CTP distribution

Usage

```
mean_ctp(a, b, gama)
```

```
var_ctp(a, b, gama)
```

```
skew_ctp(a, b, gama)
```

```
mode_ctp(a, b, gama)
```

Arguments

a, b, gama CTP parameters.

Details

mode_ctp() returns the unimodal-case mode (rounded). The distribution has two consecutive modes in the knife-edge case where $((a-1)^2 + b^2) / (gama - 2*a + 1)$ is exactly an integer; this edge case is not separately flagged.

These functions do not validate that the parameter constraints required for a given moment to exist are satisfied (e.g. $gama > 2*a + 2$ for the variance, $gama > 2*a + 3$ for the skewness). Outside these regions the returned value may be Inf, NaN, or negative; see [dctp](#) for the corresponding existence warnings applied at the density level.

Examples

```
mean_ctp(a = 1, b = 0.5, gama = 6)
var_ctp(a = 1, b = 0.5, gama = 6)
skew_ctp(a = 1, b = 0.5, gama = 6)
mode_ctp(a = 1, b = 0.5, gama = 6)
```

mean_zictp

Theoretical moments and mode of the ZM-CTP distribution

Description

Theoretical moments and mode of the ZM-CTP distribution

Usage

```
mean_zictp(a, b, gama, omega)
```

```
var_zictp(a, b, gama, omega)
```

```
skew_zictp(a, b, gama, omega)
```

```
mode_zictp(a, b, gama, omega)
```

Arguments

a, b, gama	CTP parameters.
omega	Zero-modification parameter.

Details

These functions do not validate that the parameter constraints required for a given moment to exist are satisfied (e.g. $\text{gama} > 2*a+2$ for the variance, $\text{gama} > 2*a+3$ for the skewness), the same caveat documented in [mean_ctp](#).

Examples

```
# Quick illustration (fast, runs during R CMD check)
mean_zictp(a = 1, b = 0.5, gama = 6, omega = 0.3)
var_zictp(a = 1, b = 0.5, gama = 6, omega = 0.3)
skew_ctp(a = 1, b = 0.5, gama = 6)
skew_zictp(a = 1, b = 0.5, gama = 6, omega = 0.3)
mode_zictp(a = 1, b = 0.5, gama = 6, omega = 0.3)

# Empirical check against simulated data (slower, skipped on CRAN checks)
set.seed(2026)
x <- rzictp(50000, a = 1, b = 0.5, gama = 6, omega = 0.3)
skew_zictp(1, 0.5, 6, 0.3)           # theoretical
mean((x - mean(x))^3) / sd(x)^3      # empirical
```

pctp

*Cumulative Distribution Function of the CTP Distribution***Description**

Cumulative Distribution Function of the CTP Distribution

Usage

```
pctp(q, a, b, gama, lower.tail = TRUE, log.p = FALSE)
```

Arguments

q	Vector of quantiles.
a	Parameter a.
b	Parameter b.
gama	Parameter gamma.
lower.tail	Logical; if TRUE, probabilities are $P(X \leq q)$, otherwise $P(X > q)$.
log.p	Logical; if TRUE, probabilities are given on the log scale.

Value

Numeric vector of cumulative probabilities.

Examples

```
pctp(0:5, a = 1, b = 0.5, gama = 6)
```

plot.ctpfit	<i>Plot method for ctpfit objects</i>
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Description

Plot method for ctpfit objects

Usage

```
## S3 method for class 'ctpfit'  
plot(x, type = c("frequency", "cdf", "qq"), ...)
```

Arguments

x	A ctpfit object
type	Type of plot: "frequency", "cdf", or "qq"
...	Additional graphical parameters

Value

No return value. Called for its side effect of producing a plot.

plot.zictpfit	<i>Plot method for zictpfit objects</i>
---------------	---

Description

Creates diagnostic plots for Zero-Modified CTP distribution fits, including frequency comparisons, CDF plots, and Q-Q plots.

Usage

```
## S3 method for class 'zictpfit'  
plot(x, type = c("frequency", "cdf", "qq"), ...)
```


Arguments

x	A zictpfit object from zictp.fit()
type	Type of plot: "frequency", "cdf", or "qq"
...	Additional graphical parameters

Value

No return value. Called for its side effect of producing a plot.

print.ctpfit	<i>Print method for ctpfit objects</i>
--------------	--

Description

Print method for ctpfit objects

Usage

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

Arguments

x	A ctpfit object
...	Additional arguments (ignored)

Value

Invisibly returns the original fitted model object. The function is called for its side effect of printing a model summary.

print.zictpfit	<i>Print method for zictpfit objects</i>
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Description

Print method for zictpfit objects

Usage

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

Arguments

x	A zictpfit object
...	Additional arguments (ignored)

Value

Invisibly returns the original fitted model object. The function is called for its side effect of printing a model summary.

pzictp

Cumulative Distribution Function of the ZM-CTP Distribution

Description

Cumulative Distribution Function of the ZM-CTP Distribution

Usage

```
pzictp(q, a, b, gama, omega, lower.tail = TRUE, log.p = FALSE)
```

Arguments

q	Vector of quantiles.
a	Parameter a.
b	Parameter b.
gama	Parameter gamma.
omega	Zero-modification parameter.
lower.tail	Logical.
log.p	Logical.

Value

Numeric vector of cumulative probabilities.

Examples

```
pzictp(0:5, a = 1, b = 0.5, gama = 6, omega = 0.3)
```

qctp

Quantile Function of the CTP Distribution

Description

Quantile Function of the CTP Distribution

Usage

```
qctp(p, a, b, gama, lower.tail = TRUE, log.p = FALSE, max_q = 1000)
```

Arguments

p	Vector of probabilities.
a	Parameter a.
b	Parameter b.
gama	Parameter gamma.
lower.tail	Logical.
log.p	Logical.
max_q	Maximum x to search.

Value

Numeric vector of quantiles.

Examples

```
qctp(c(0.25, 0.5, 0.75), a = 1, b = 0.5, gama = 6)
```

qzictp

Quantile Function of the ZM-CTP Distribution

Description

Quantile Function of the ZM-CTP Distribution

Usage

```
qzictp(p, a, b, gama, omega, lower.tail = TRUE, log.p = FALSE, max_q = 1000)
```

Arguments

<code>p</code>	Vector of probabilities.
<code>a</code>	Parameter a.
<code>b</code>	Parameter b.
<code>gama</code>	Parameter gamma.
<code>omega</code>	Zero-modification parameter.
<code>lower.tail</code>	Logical.
<code>log.p</code>	Logical.
<code>max_q</code>	Maximum x to search.

Value

Numeric vector of quantiles.

Examples

```
qzictp(c(0.25, 0.5, 0.75), a = 1, b = 0.5, gama = 6, omega = 0.3)
```

rctp

Random Generation from the CTP Distribution

Description

Random Generation from the CTP Distribution

Usage

```
rctp(n, a, b, gama)
```

Arguments

<code>n</code>	Number of observations.
<code>a</code>	Parameter a.
<code>b</code>	Parameter b.
<code>gama</code>	Parameter gamma.

Value

Integer vector of random draws.

Examples

```
set.seed(123)
rctp(10, a = 1, b = 0.5, gama = 6)
```

 rzictp

Random Generation from the ZM-CTP Distribution

Description

Random Generation from the ZM-CTP Distribution

Usage

```
rzictp(n, a, b, gama, omega)
```

Arguments

n	Number of observations.
a	Parameter a.
b	Parameter b.
gama	Parameter gamma.
omega	Zero-modification parameter.

Value

Integer vector of random draws.

Examples

```
set.seed(123)
rzictp(10, a = 1, b = 0.5, gama = 6, omega = 0.3)
```

 summary.ctpfit

Summary method for ctpfit objects

Description

Summary method for ctpfit objects

Usage

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

Arguments

object	A ctpfit object
...	Additional arguments (ignored)

Value

Invisibly returns the original fitted model object. The function is called for its side effects, producing a formatted summary of parameter estimates, moments, and goodness-of-fit diagnostics.

summary.zictpfit	<i>Summary method for zictpfit objects</i>
------------------	--

Description

Summary method for zictpfit objects

Usage

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

Arguments

object	A zictpfit object
...	Additional arguments (ignored)

Value

Invisibly returns the original fitted model object. The function is called for its side effects, producing a formatted summary of parameter estimates, moments, and goodness-of-fit diagnostics.

zictp.fit	<i>Maximum Likelihood Estimation for the Zero-Modified CTP Distribution</i>
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Description

Fits the Zero-Modified Complex TriParametric Pearson (ZM-CTP) distribution to count data using maximum likelihood estimation.

A logit reparameterization is used for omega to ensure $0 < \omega < 1$, and a log reparameterization is used for gamma so that $\gamma = 2^a + 2 + \exp(\eta)$, which guarantees variance existence throughout optimization.

Usage

```
zictp.fit(
  x,
  a_start = NULL,
  b_start = NULL,
  gama_start = NULL,
  omega_start = NULL,
  method = "BFGS"
)
```

Arguments

<code>x</code>	Numeric vector of nonnegative counts.
<code>a_start</code>	Optional starting value for parameter a.
<code>b_start</code>	Optional starting value for parameter b.
<code>gama_start</code>	Optional starting value for parameter gamma.
<code>omega_start</code>	Optional starting value for omega ($0 < \text{omega} < 1$).
<code>method</code>	Optimization method (default: "BFGS").

Value

An object of class `"zictpfit"`.

Examples

```
set.seed(123)
x <- rzictp(30, a = 1, b = 0.5, gama = 5, omega = 0.3)
fit <- zictp.fit(x)
fit$estimates
```

Index

`ctp.fit`, [2](#), [3](#)

`dctp`, [2](#), [4](#), [6](#)

`dzictp`, [2](#), [5](#)

`mean_ctp`, [5](#), [7](#)

`mean_zictp`, [6](#)

`mode_ctp (mean_ctp)`, [5](#)

`mode_zictp (mean_zictp)`, [6](#)

`pctp`, [2](#), [7](#)

`plot.ctpfit`, [8](#)

`plot.zictpfit`, [8](#)

`print.ctpfit`, [9](#)

`print.zictpfit`, [9](#)

`pzipct`, [2](#), [10](#)

`qctp`, [2](#), [11](#)

`qzipct`, [2](#), [11](#)

`rctp`, [2](#), [12](#)

`rzipct`, [2](#), [13](#)

`skew_ctp (mean_ctp)`, [5](#)

`skew_zictp (mean_zictp)`, [6](#)

`summary.ctpfit`, [13](#)

`summary.zictpfit`, [14](#)

`var_ctp (mean_ctp)`, [5](#)

`var_zictp (mean_zictp)`, [6](#)

`zipct.fit`, [2](#), [14](#)

`zmctp (zmctp-package)`, [2](#)

`zmctp-package`, [2](#)