Package 'zmctp'

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

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Description Provides probability, distribution, quantile and random-generation functions for the complex three-parameter Pearson distribution and its zero-inflated extension. Maximum likelihood fitting uses analytic profiling of the mixing probability, multiple starting points and numerical boundary diagnostics. The parent family is described in the 2003 study <doi:10.1007/s00362-002-0134-7>.

License GPL-3

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`zmctp-package` *zmctp: Zero-Modified Complex Triparametric Pearson Distribution*

Description

The zmctp package extends the Complex Triparametric Pearson (CTP) distribution with a zero-inflated mixture. It provides distribution functions, likelihood fitting and numerical boundary diagnostics.

Details

Main functions:

- `dctp`, `pctp`, `qctp`, `rctp` - CTP distribution functions
- `dzictp`, `pzictp`, `qzictp`, `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 fitting for CTP*

Description

Fit an independent-observation CTP model in the finite-variance domain.

Usage

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

Arguments

`x`	Nonempty numeric vector of finite nonnegative integer counts, with at least one positive count and maximum at most 1,000,000.
`a_start`, `b_start`, `gama_start`	Optional finite scalar starting values. A supplied triple must have `b_start > 0`, `gama_start > 0`, and `gama_start > 2*a_start+2`. A partial triple supplements safe defaults. An inconsistent gamma margin is replaced with a safe margin with a warning, as in version 0.1.3.
`method`	An `optim` method used to supplement the default multistart Nelder-Mead search and `nlminb` polishing. Supported values are `"L-BFGS-B"`, `"BFGS"`, `"Nelder-Mead"`, and `"CG"`.
`penalty`	Positive finite objective penalty, retained for compatibility. Values too small to exceed the initial feasible objectives are increased.

Details

Coordinates are $(a, \log b, \log(\gamma - 2a - 2))$. The final transformed coordinates are retained. Six fixed starting triples are used, with a user-supplied start added when present. The two best finite Nelder-Mead solutions are polished with `nlminb` and the requested supplementary method. Convergence requires a successful optimiser within `1e-4` log-likelihood units of the best finite point.

Wald standard errors require convergence, `b >= 1e-6`, variance margin at least `1e-3`, and a positive definite observed Hessian with minimum eigenvalue greater than `1e-10` times its maximum. Missing uncertainty is reported as `NULL`, with an explanation in `diagnostics`. No Hessian jitter or negative-variance clipping is used.

The frequency table includes unobserved counts through the sample maximum and a final upper-tail bin. Pearson and the historically named `wald_chisq` statistics are descriptive discrepancies, not calibrated tests. The latter is the sum of squared standardised observations.

Value

An object of class `ctpfit`, retaining fields `estimates`, `se`, `vcov`, `logLik`, `AIC`, `BIC`, `pearson_chisq`, `wald_chisq`, `fitted_freq`, `data`, `converged`, `near_boundary`, `method`, and `raw_optim`. Additional fields `theta`, `attempts`, and `diagnostics` record transformed coordinates, search outcomes and numerical flags. The `raw_optim$par` coordinates are now `a`, `log_b`, and `log_margin`; they should not be interpreted as natural parameters.

Examples

```
x <- rep(0:4, c(30, 16, 8, 3, 1))
fit <- ctp.fit(x)
fit$estimates
fit$diagnostics
```

`dctp` *CTP distribution*

Description

Density, distribution, quantile and random-generation functions for the complex triparametric Pearson distribution.

Usage

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

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

qctp(
  p,
  a,
  b,
  gama,
  lower.tail = TRUE,
  log.p = FALSE,
  max_q = 1000,
  max_count = 1000000L
)

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

Arguments

x	Numeric vector of counts. Nonintegers and negative values have probability zero; missing values propagate.
a, b, gama	Finite scalar parent parameters, with b >= 0 and gama > max(0, 2*a). The spelling gama is retained.
log	Return log probabilities.
q	Numeric vector of quantiles; values are rounded down.
lower.tail	Return $P(X \leq q)$ if true and $P(X > q)$ otherwise.
log.p	Probabilities are on the log scale.
p	Numeric vector of probabilities. Missing values propagate.
max_q	Initial search endpoint, retained for compatibility. It is expanded as needed, rather than returned as a capped quantile.
max_count	Maximum search endpoint, at most 1,000,000. Failure to bracket a requested quantile raises an error.
n	Number of draws, a nonnegative integer.

Details

The probability at zero is evaluated from a shifted log-gamma expansion. Subsequent log probabilities use the recurrence

$$p(k+1)/p(k) = ((a+k)^2 + b^2)/((gama+k)(k+1)).$$

Probabilities are not renormalised on the requested support. Moment existence is checked by moment functions, not by density functions. Recurrences have a work limit of 1,000,000 counts and signal an error when that limit is insufficient. At b = 0, nonpositive integer a gives a terminating distribution.

Value

Numeric vector of probabilities, cumulative probabilities, quantiles, or integer random draws. Quantiles return Inf at probability one for an infinite-support distribution.

Examples

```
dctp(0:5, 1, 0.5, 6)
pctp(c(-Inf, 0, 2, Inf), 1, 0.5, 6)
qctp(c(0, 0.5, 0.99, 1), 1, 0.5, 6)
set.seed(123)
rctp(10, 1, 0.5, 6)
```

dzictp *Zero-inflated CTP distribution*

Description

A mixture of a point mass at zero and a CTP parent. The historical package name uses "zero-modified"; this nonnegative mixing-probability model adds zeros relative to the same parent distribution.

Usage

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

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

qzictp(
  p,
  a,
  b,
  gama,
  omega,
  lower.tail = TRUE,
  log.p = FALSE,
  max_q = 1000,
  max_count = 1000000L
)

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

Arguments

x	Numeric vector of counts. Nonintegers and negative values have probability zero; missing values propagate.
a, b, gama	Finite scalar parent parameters, with b >= 0 and gama > max(0, 2*a). The spelling gama is retained.
omega	Scalar mixing probability in [0, 1]. Zero gives the parent distribution; one gives a point mass at zero. Positive values increase the zero probability whenever the parent is nondegenerate.
log	Return log probabilities.
q	Numeric vector of quantiles; values are rounded down.
lower.tail	Return $P(X \leq q)$ if true and $P(X > q)$ otherwise.
log.p	Probabilities are on the log scale.
p	Numeric vector of probabilities. Missing values propagate.
max_q	Initial search endpoint, retained for compatibility. It is expanded as needed, rather than returned as a capped quantile.

max_count	Maximum search endpoint, at most 1,000,000. Failure to bracket a requested quantile raises an error.
n	Number of draws, a nonnegative integer.

Details

$P(Y = 0) = omega + (1 - omega)P(X = 0)$ and $P(Y = k) = (1 - omega)P(X = k)$ for $k > 0$. Quantile search limits and endpoint conventions are as in dctp.

Value

Numeric vector of probabilities, cumulative probabilities or quantiles, or integer random draws.

Examples

```
dzictp(0:5, 1, 0.5, 6, 0.3)
pzictp(0:5, 1, 0.5, 6, 0.3)
qzictp(c(0.1, 0.5, 0.9), 1, 0.5, 6, 0.3)
rzictp(10, 1, 0.5, 6, 0.3)
```

---

mean_ctp *Moments of the CTP distribution*

Description

Moments of the CTP distribution

Usage

```
mean_ctp(a, b, gama)

var_ctp(a, b, gama)

skew_ctp(a, b, gama)
```

Arguments

a, b, gama	Scalar parent parameters; see dctp.

Details

For an infinite-support parent the mean, variance and third moment require gama > 2*a+1, gama > 2*a+2, and gama > 2*a+3, respectively. A nonexisting mean or variance returns Inf with a warning; nonexisting skewness returns NaN with a warning. Terminating parents are handled separately.

Value

A scalar mean, variance or skewness.

Examples

```
mean_ctp(1, 0.5, 6)
var_ctp(1, 0.5, 6)
skew_ctp(1, 0.5, 6)
```

`mean_zictp` *Moments of the zero-inflated CTP distribution*

Description

Moments of the zero-inflated CTP distribution

Usage

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

var_zictp(a, b, gama, omega)

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

Arguments

a, b, gama	Scalar parent parameters; see dctp.
omega	Scalar mixing probability in [0, 1].

Details

Moment domains are the same as for the parent, except that omega = 1 gives mean and variance zero. Skewness of a degenerate distribution is undefined and returns NaN.

Value

A scalar mean, variance or skewness.

Examples

```
mean_zictp(1, 0.5, 6, 0.3)
var_zictp(1, 0.5, 6, 0.3)
skew_zictp(1, 0.5, 6, 0.3)
```

mode_ctp *Mode of the CTP distribution*

Description

Mode of the CTP distribution

Usage

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

Arguments

a, b, gama	Scalar parent parameters; see dctp.

Details

Ties are detected to relative tolerance 1e-10. The recurrence minus one changes sign at most once in the valid domain.

Value

The modal integer, or both adjacent integers in a numerical tie.

Examples

```
mode_ctp(-1.5, 1.8, 3.8)
```

mode_zictp *Mode of the zero-inflated CTP distribution*

Description

Mode of the zero-inflated CTP distribution

Usage

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

Arguments

a, b, gama	Scalar parent parameters; see dctp.
omega	Scalar mixing probability in [0, 1].

Value

The smallest modal integer; ties are resolved to the smallest value.

Examples

```
mode_zictp(-1.5, 1.8, 3.8, 0.3)
```

`plot.ctpfit` *Plot method for ctpfit objects*

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` *Plot method for zictpfit objects*

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 *Print method for ctpfit objects*

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 *Print method for zictpfit objects*

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.

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 *Summary method for zictpfit objects*

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` *Maximum likelihood fitting for zero-inflated CTP*

Description

Fits the zero-inflated model while profiling the mixing probability analytically. The exact parent boundary `omega = 0` is permitted.

Usage

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

Arguments

`x`	Nonempty numeric vector of finite nonnegative integer counts, with at least one positive count and maximum at most 1,000,000.
`a_start`, `b_start`, `gama_start`	Optional finite scalar starting values. A supplied triple must have `b_start > 0`, `gama_start > 0`, and `gama_start > 2*a_start+2`. A partial triple supplements safe defaults. An inconsistent gamma margin is replaced with a safe margin with a warning, as in version 0.1.3.
`omega_start`	Retained for call compatibility. If supplied it must be a scalar in `[0, 1)`. It does not affect the analytic profile.
`method`	An `optim` method used to supplement the default multistart Nelder-Mead search and `nlminb` polishing. Supported values are `"L-BFGS-B"`, `"BFGS"`, `"Nelder-Mead"`, and `"CG"`.

Details

For a fixed parent with zero probability f_0 and observed zero fraction q, the profile estimate is zero when $q \leq f_0$ and $(q - f_0)/(1 - f_0)$ otherwise. A parent fit is included as a feasible nested point. All-zero samples are rejected because the parent parameters are unidentified. In addition to the checks in `ctp.fit`, Wald uncertainty is withheld within `1e-5` of an omega endpoint. Bootstrap tests remain in the research supplement in this release.

Value

An object of class `zictpfit` with the fields described in `ctp.fit`, plus `diagnostics$parent_logLik`.

Examples

```
x <- rep(0:4, c(40, 12, 6, 2, 1))
fit <- zictp.fit(x)
fit$estimates
```

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