

# Package ‘TruncatedPCQM’

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**Title** Density Estimation for Point-Centered Quarter Method with Truncated Sampling

**Version** 0.1.2

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**Description** Implements a systematic methodology for estimating population density from point-centered quarter method (PCQM) surveys when distance measurements are truncated by a maximum search radius (right-censored). The package provides a unified framework for analyzing such incomplete data, addressing both completely randomly distributed (Poisson) and spatially aggregated (Negative Binomial) populations. Key features include: (1) Adjusted moment-based density estimators for censored distances; (2) Maximum likelihood estimation (MLE) of density under the Poisson (CSR) model; and (3) Simultaneous MLE of density and an aggregation parameter under the Negative Binomial model. For more details, see Huang, Shen, Xing, and Zhao (2026) <[doi:10.48550/arXiv.2603.08276](https://doi.org/10.48550/arXiv.2603.08276)>.

**License** GPL (>= 3)

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**Depends** R (>= 3.5.0)

**Suggests** testthat (>= 3.0.0), dplyr (>= 1.1.0)

**Config/testthat/edition** 3

**URL** <https://github.com/rcjhrpyt-droid/TruncatedPCQM>

**BugReports** <https://github.com/rcjhrpyt-droid/TruncatedPCQM/issues>

**NeedsCompilation** no

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adjusted_moments	<i>Adjusted Moment-based Estimators for Right-censored PCQM Data</i>
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### Description

Computes various density estimators (DK, Cottam, Pollard, Shen, Morisita) using adjusted moments to account for right-censoring in PCQM data.

### Usage

```
adjusted_moments(
  distances,
  C = 20,
  q = 4,
  l = 1,
  init_method = "Pollard_censored"
)
```

### Arguments

distances	A numeric vector, matrix, data.frame, or list of point-to-tree distances. For matrix/data.frame inputs, each row represents a sampling point and each column a sector.
C	Maximum search radius (censoring threshold). Distances exceeding C are treated as right-censored observations. Default is 20.
q	Number of sectors per sampling point. Default is 4.
l	Neighbor order. Default is 1.
init_method	Method for obtaining initial $\lambda$ estimate used in NBD-based estimators. One of: "Pollard_censored" (default), "Cottam_censored", or "DK_censored" (only for $l = 1$ ).

### Value

An object of class "pcqm\_moments" containing:

- DK\_censored: Diggle-Koedam estimator value (NA if  $l$  is not 1)
- Cottam\_censored: Cottam-type estimator value

- Pollard\_censored: Pollard-type estimator value
- Shen\_censored: Shen's NBD-based estimator value (NA if estimated  $k < 1$ )
- Morisita\_censored: Morisita's first estimator value (NA if  $l = 1$ )
- k\_hat: Estimated aggregation parameter  $k$  from Shen's estimator
- censored\_rate: Proportion of censored sectors
- n\_points: Number of sampling points
- n\_sectors: Total number of sectors analyzed
- n\_censored: Number of censored observations ( $R > C$ )
- call: Original function call

### Examples

```
distances_matrix <- matrix(c(
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 7.655136, 13.815876, 10.423496,
  6.094721, 4.135461, 7.732912, 5.454545,
  9999.000000, 9999.000000, 14.787289, 15.670821,
  9999.000000, 9.825537, 11.611850, 15.757861,
  9999.000000, 9.670381, 14.055394, 17.075678,
  11.529219, 4.464136, 7.793114, 11.309553,
  13.307828, 5.864490, 13.309636, 5.897720,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 9999.000000, 18.201084, 9999.000000,
  9999.000000, 7.809056, 12.612496, 5.601366,
  9.201294, 9999.000000, 8.353524, 9.683701,
  6.592604, 19.117869, 19.758384, 12.923507,
  15.574824, 10.643719, 9.494539, 7.382031,
  9.143077, 9999.000000, 15.551414, 5.266916,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  18.604278, 7.279454, 9.385355, 5.573127,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  11.980811, 9999.000000, 11.853695, 14.405252
), nrow = 20, ncol = 4, byrow = TRUE)
```

```
moment_result <- adjusted_moments(
  distances = distances_matrix,
  C = 20,
  q = 4,
  l = 2,
  init_method = "Pollard_censored"
)
```

```
moment_result
```

---

csr_mle	<i>CSR-based Maximum Likelihood Estimator for Right-censored PCQM Data</i>
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### Description

Computes the maximum likelihood estimate (MLE) of population density under complete spatial randomness (CSR), accounting for right-censored point-centered quarter method (PCQM) distances.

### Usage

```
csr_mle(
  distances,
  C = 20,
  q = 4,
  l = 1,
  lambda_lower = 1e-04,
  lambda_upper = 1
)
```

### Arguments

distances	A numeric vector, matrix, data.frame, or list of point-to-tree distances. For matrix/data.frame inputs, each row represents a sampling point and each column a sector.
C	Maximum search radius (censoring threshold). Distances exceeding C are treated as right-censored observations. Default is 20.
q	Number of sectors per sampling point. Default is 4.
l	Neighbor order. Default is 1.
lambda_lower	Lower bound for $\lambda$ in numerical optimization. Must be positive. Default is 1e-4.
lambda_upper	Upper bound for $\lambda$ in numerical optimization. Must be positive. Default is 1.

### Value

An object of class "pcqm\_csr\_mle" containing:

- lambda: MLE of population density (individuals per unit area)
- logLik: Maximized log-likelihood value
- n\_obs: Number of fully observed (non-censored) distances
- n\_censored: Number of censored observations ( $R > C$ )
- n\_sectors: Total number of sectors analyzed
- n\_points: Inferred number of sampling points
- censored\_rate: Proportion of censored sectors
- call: Original function call

**Examples**

```

distances_matrix <- matrix(c(
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 7.655136, 13.815876, 10.423496,
  6.094721, 4.135461, 7.732912, 5.454545,
  9999.000000, 9999.000000, 14.787289, 15.670821,
  9999.000000, 9.825537, 11.611850, 15.757861,
  9999.000000, 9.670381, 14.055394, 17.075678,
  11.529219, 4.464136, 7.793114, 11.309553,
  13.307828, 5.864490, 13.309636, 5.897720,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 9999.000000, 18.201084, 9999.000000,
  9999.000000, 7.809056, 12.612496, 5.601366,
  9.201294, 9999.000000, 8.353524, 9.683701,
  6.592604, 19.117869, 19.758384, 12.923507,
  15.574824, 10.643719, 9.494539, 7.382031,
  9.143077, 9999.000000, 15.551414, 5.266916,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  18.604278, 7.279454, 9.385355, 5.573127,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  11.980811, 9999.000000, 11.853695, 14.405252
), nrow = 20, ncol = 4, byrow = TRUE)

csr_result <- csr_mle(
  distances = distances_matrix,
  C = 20,
  q = 4,
  l = 2,
  lambda_lower = 1e-4,
  lambda_upper = 1
)

csr_result

```

nbd\_mle

*NBD-based Maximum Likelihood Estimator for Right-censored  
PCQM Data*

**Description**

Computes the maximum likelihood estimate (MLE) of population density under Negative Binomial model, accounting for right-censored point-centered quarter method (PCQM) distances.

**Usage**

```
nbd_mle(
  distances,
  C = 20,
  q = 4,
  l = 1,
  init_method = "Shen_censored",
  lambda_lower = 1e-04,
  lambda_upper = 1
)
```

**Arguments**

distances	A numeric vector, matrix, data.frame, or list of point-to-tree distances. For matrix/data.frame inputs, each row represents a sampling point and each column a sector.
C	Maximum search radius (censoring threshold). Distances exceeding C are treated as right-censored observations. Default is 20.
q	Number of sectors per sampling point. Default is 4.
l	Neighbor order. Default is 1.
init_method	Method for obtaining initial parameter values. One of: "Shen_censored" (default), "Pollard_censored", "Cottam_censored", or "DK_censored" (l=1 only).
lambda_lower	Lower bound for $\lambda$ in numerical optimization. Must be positive. Default is 1e-4.
lambda_upper	Upper bound for $\lambda$ in numerical optimization. Must be positive. Default is 1.

**Value**

An object of class "pcqm\_nbd\_mle" containing:

- lambda: MLE of population density (individuals per unit area)
- k: MLE of aggregation parameter (smaller values indicate stronger aggregation)
- logLik: Maximized log-likelihood value
- n\_obs: Number of fully observed (non-censored) distances
- n\_censored: Number of censored observations ( $R > C$ )
- n\_sectors: Total number of sectors analyzed
- n\_points: Inferred number of sampling points
- censored\_rate: Proportion of censored sectors
- call: Original function call

**Examples**

```
distances_matrix <- matrix(c(
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 7.655136, 13.815876, 10.423496,
  6.094721, 4.135461, 7.732912, 5.454545,
```

```

9999.000000, 9999.000000, 14.787289, 15.670821,
9999.000000, 9.825537, 11.611850, 15.757861,
9999.000000, 9.670381, 14.055394, 17.075678,
11.529219, 4.464136, 7.793114, 11.309553,
13.307828, 5.864490, 13.309636, 5.897720,
9999.000000, 9999.000000, 9999.000000, 9999.000000,
9999.000000, 9999.000000, 18.201084, 9999.000000,
9999.000000, 7.809056, 12.612496, 5.601366,
9.201294, 9999.000000, 8.353524, 9.683701,
6.592604, 19.117869, 19.758384, 12.923507,
15.574824, 10.643719, 9.494539, 7.382031,
9.143077, 9999.000000, 15.551414, 5.266916,
9999.000000, 9999.000000, 9999.000000, 9999.000000,
18.604278, 7.279454, 9.385355, 5.573127,
9999.000000, 9999.000000, 9999.000000, 9999.000000,
9999.000000, 9999.000000, 9999.000000, 9999.000000,
11.980811, 9999.000000, 11.853695, 14.405252
), nrow = 20, ncol = 4, byrow = TRUE)

nbd_result <- nbd_mle(
  distances = distances_matrix,
  C = 20,
  q = 4,
  l = 2,
  init_method = "Pollard_censored",
  lambda_lower = 1e-4,
  lambda_upper = 10
)

nbd_result

```

print

*Print Methods for PCQM Density Estimation Objects***Description**

Provides formatted console output for fitted PCQM (Point-Centered Quarter Method) density estimation results under different model assumptions. The following specialized print methods for S3 classes are supported:

- `print.pcqm_csr_mle` – display CSR-based PCQM maximum likelihood estimation results.
- `print.pcqm_moments` – display adjusted moment-based PCQM density estimators.
- `print.pcqm_nbd_mle` – display NBD-based PCQM maximum likelihood estimation results.

**Usage**

```
## S3 method for class 'pcqm_csr_mle'
print(x, digits = 6, ...)

## S3 method for class 'pcqm_moments'
print(x, digits = 6, ...)

## S3 method for class 'pcqm_nbd_mle'
print(x, digits = 6, ...)
```

**Arguments**

**x** An object of class "pcqm\_csr\_mle", "pcqm\_moments", or "pcqm\_nbd\_mle", returned by [csr\\_mle](#), [adjusted\\_moments](#), or [nbd\\_mle](#), respectively.

**digits** Number of decimal places to display for numeric estimates. Default is 6.

**...** Additional arguments passed to the generic print method (currently unused; included for S3 consistency).

**Value**

The input model object *x*, invisibly. These functions are called primarily for their side effect of printing a formatted summary of the PCQM density estimation results to the R console.

**See Also**

[csr\\_mle](#) for CSR-based MLE estimation; [adjusted\\_moments](#) for adjusted moment estimators; [nbd\\_mle](#) for NBD-based MLE estimation.

**Examples**

```
distances_matrix <- matrix(c(
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 7.655136, 13.815876, 10.423496,
  6.094721, 4.135461, 7.732912, 5.454545,
  9999.000000, 9999.000000, 14.787289, 15.670821,
  9999.000000, 9.825537, 11.611850, 15.757861,
  9999.000000, 9.670381, 14.055394, 17.075678,
  11.529219, 4.464136, 7.793114, 11.309553,
  13.307828, 5.864490, 13.309636, 5.897720,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 9999.000000, 18.201084, 9999.000000,
  9999.000000, 7.809056, 12.612496, 5.601366,
  9.201294, 9999.000000, 8.353524, 9.683701,
  6.592604, 19.117869, 19.758384, 12.923507,
  15.574824, 10.643719, 9.494539, 7.382031,
  9.143077, 9999.000000, 15.551414, 5.266916,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  18.604278, 7.279454, 9.385355, 5.573127,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
  9999.000000, 9999.000000, 9999.000000, 9999.000000,
```

```

      11.980811, 9999.000000, 11.853695, 14.405252
    ), nrow = 20, ncol = 4, byrow = TRUE)

# CSR-based MLE
csr_result <- csr_mle(
  distances = distances_matrix,
  C = 20,
  q = 4,
  l = 2,
  lambda_lower = 1e-4,
  lambda_upper = 1
)
print(csr_result)

# Adjusted Moment Estimators
moment_result <- adjusted_moments(
  distances = distances_matrix,
  C = 20,
  q = 4,
  l = 2,
  init_method = "Pollard_censored"
)
print(moment_result)

# NBD-based MLE
nbd_result <- nbd_mle(
  distances = distances_matrix,
  C = 20,
  q = 4,
  l = 2,
  init_method = "Pollard_censored",
  lambda_lower = 1e-4,
  lambda_upper = 10
)
print(nbd_result)

```

---

summary

*Summary Methods for PCQM Density Estimation Objects*


---

## Description

Generate structured summary objects and formatted console output for PCQM (Point-Centered Quarter Method) density estimation results under different model assumptions.

Supported S3 methods:

- `summary.pcqm_csr_mle`
- `summary.pcqm_moments`
- `summary.pcqm_nbd_mle`
- `print.summary.pcqm_*`

**Usage**

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

## S3 method for class 'summary.pcqm_csr_mle'
print(x, digits = 6, ...)

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

## S3 method for class 'summary.pcqm_moments'
print(x, digits = 6, ...)

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

## S3 method for class 'summary.pcqm_nbd_mle'
print(x, digits = 6, ...)
```

**Arguments**

object	Model object returned by <code>csr_mle</code> , <code>adjusted_moments</code> , or <code>nbd_mle</code> .
...	Additional arguments (unused).
x	Summary object returned by corresponding <code>summary()</code> method.
digits	Number of digits to display.

**Value**

An object of class "summary.pcqm\_csr\_mle", a named list with components:

**model** Character string: "csr\_mle".

**lambda** Estimated population density (intensity parameter  $\lambda$ ). NA if estimation failed.

**logLik** Maximized log-likelihood evaluated at  $\hat{\lambda}$ .

**n\_points** Number of focal sampling points.

**n\_sectors** Total number of sectors.

**n\_censored** Number of censored sectors.

**censored\_rate** Proportion of censored sectors.

An object of class "summary.pcqm\_moments", a named list with components:

**model** Character string: "moments".

**estimators** Named numeric vector of valid adjusted moment estimators (NA removed).

**k\_hat** Estimated aggregation (dispersion) parameter  $\hat{k}$ .

**n\_points** Number of focal sampling points.

**n\_sectors** Total number of sectors.

**n\_censored** Number of censored sectors.

**censored\_rate** Proportion of censored sectors.

An object of class "summary.pcq\_m\_nbd\_mle", a named list with components:

**model** Character string: "nbd\_mle".

**lambda** Estimated population density (intensity parameter  $\lambda$ ). NA if estimation failed.

**k** Estimated aggregation (dispersion) parameter of the Negative Binomial distribution. NA if estimation failed.

**logLik** Maximized log-likelihood evaluated at  $(\hat{\lambda}, \hat{k})$ .

**n\_points** Number of focal sampling points.

**n\_sectors** Total number of sectors.

**n\_censored** Number of censored sectors.

**censored\_rate** Proportion of censored sectors.

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