Package ‘BCD’

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Type Package

Title Bivariate Distributions via Conditional Specification

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Description Implementation of bivariate binomial, geometric, and Poisson distributions based on conditional specifications. The package also includes tools for data generation and goodness-of-fit testing for these three distribution families. For methodological details, see Ghosh, Marques, and Chakraborty (2025) <doi:10.1080/03610926.2024.2315294>, Ghosh, Marques, and Chakraborty (2023) <doi:10.1080/03610918.2021.2004419>, and Ghosh, Marques, and Chakraborty (2021) <doi:10.1080/02664763.2020.1793307>.

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BugReports https://github.com/mnrzrad/BCD/issues

NeedsCompilation no

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Contents

`abortflights` *Aborted Flight Counts for 109 Aircrafts*

Description

This dataset records the number of aborted flights by 109 aircrafts during two consecutive periods. The counts are cross-tabulated by the number of aborted flights in each period.

Usage

```
abortflights
```

Format

A data frame with 109 rows and 2 variables:

X Number of aborted flights in Period 1.

Y Number of aborted flights in Period 2.

References

Barbiero, A. (2019). A bivariate geometric distribution allowing for positive or negative correlation. *Communications in Statistics - Theory and Methods*, 48 (11), 2842—2861. doi:10.1080/03610926.2018.1473428.

Ghosh, I., Marques, F., & Chakraborty, S. (2023) A bivariate geometric distribution via conditional specification: properties and applications, Communications in Statistics - Simulation and Computation, 52:12, 5925–5945, doi:10.1080/03610918.2021.2004419

Examples

```
data(abortflights)
head(abortflights)
table(abortflights$X, abortflights$Y)
```

`dbinomBCD` *Joint Probability Mass Function for a Bivariate Binomial Distribution via Conditional Specification*

Description

Computes the probability mass function (p.m.f.) of the bivariate binomial conditionals distribution (BBCD) as defined by Ghosh, Marques, and Chakraborty (2025). The distribution is characterized by conditional binomial distributions for X and Y.

Usage

```
dbinomBCD(x, y, n1, n2, p1, p2, lambda)
```

Arguments

`x`	value of X, must be in $\{0, 1, ..., n_1\}$
`y`	value of Y, must be in $\{0, 1, ..., n_2\}$
`n1`	number of trials for X, must be non-negative
`n2`	number of trials for Y, must be non-negative
`p1`	base success probability for X, in $(0, 1)$
`p2`	base success probability for Y, in $(0, 1)$
`lambda`	dependence parameter, must be positive.

Details

The joint p.m.f. of the BBCD is

$$P(X = x, Y = y) = K_B(n_1, n_2, p_1, p_2, \lambda) \binom{n_1}{x} \binom{n_2}{y} p_1^x p_2^y (1 - p_1)^{n_1 - x} (1 - p_2)^{n_2 - y} \lambda^{xy},$$

where $x = 0, 1, \ldots, n_1$, $y = 0, 1, \ldots, n_2$, and $K_B(n_1, n_2, p_1, p_2, \lambda)$ is the normalizing constant.

Value

The probability $P(X = x, Y = y)$.

References

Ghosh, I., Marques, F., & Chakraborty, S. (2025). A form of bivariate binomial conditionals distributions. *Communications in Statistics - Theory and Methods*, 54(2), 534–553. doi:10.1080/03610926.2024.2315294

See Also

pbinomBCD rbinomBCD MLEbinomBCD

Examples

```
# Compute P(X = 2, Y = 1) with n1 = 5, n2 = 5, p1 = 0.5, p2 = 0.4, lambda = 0.5
dbinomBCD(x = 2, y = 1, n1 = 5, n2 = 5, p1 = 0.5, p2 = 0.4, lambda = 0.5)

# Example with independence (lambda = 1)
dbinomBCD(x = 2, y = 1, n1 = 5, n2 = 5, p1 = 0.5, p2 = 0.4, lambda = 1.0)
```

---

dgeomBCD *Joint Probability Mass Function for A Bivariate Geometric Distribution via Conditional Specification*

Description

Computes the joint probability mass function (p.m.f.) of a Bivariate Geometric Conditional Distributions (BGCD) based on Ghosh, Marques, and Chakraborty (2023). This distribution models paired count data with geometric conditionals, incorporating dependence between variables X and Y.

Usage

```
dgeomBCD(x, y, q1, q2, q3)
```

Arguments

x	value of X that must be non-negative integer
y	value of Y that must be non-negative integer
q1	probability parameter for X, in $(0, 1]$
q2	probability parameter for Y, in $(0, 1]$
q3	dependence parameter, in $(0, 1]$

Details

The joint p.m.f. of the BGCD is:

$$P(X = x, Y = y) = K(q_1, q_2, q_3) q_1^x q_2^y q_3^{xy},$$

where $K(q_1, q_2, q_3)$ is the normalizing constant computed by the function `normalize_constant_BGCD`.

Note that:

- $q_3 < 1$: indicates the negative correlation between X and Y

- $q_3 = 1$: indicates the independence between X and Y

Value

The probability $P(X = x, Y = y)$ for each pair of x and y.

References

Ghosh, I., Marques, F., & Chakraborty, S.(2023) A bivariate geometric distribution via conditional specification: properties and applications, Communications in Statistics - Simulation and Computation, 52:12, 5925–5945, doi:10.1080/03610918.2021.2004419

See Also

pgeomBCD rgeomBCD MLEgeomBCD

Examples

```
# Compute P(X = 1, Y = 2) with q1 = 0.5, q2 = 0.6, q3 = 0.8
dgeomBCD(x = 1, y = 2, q1 = 0.5, q2 = 0.6, q3 = 0.8)

# # Compute P(X = 0, Y = 4) with q1 = 0.5, q2 = 0.6, q3 = 0.8
dgeomBCD(x = 0, y = 4, q1 = 0.5, q2 = 0.6, q3 = 0.8)
```

---

dpoisBCD — *Joint Probability Mass Function for a Bivariate Poisson Distribution via Conditional Specification*

Description

Computes the joint probability mass function (p.m.f.) of a Bivariate Poisson Conditionals distribution (BPCD) based on Ghosh, Marques, and Chakraborty (2021).

Usage

```
dpoisBCD(x, y, lambda1, lambda2, lambda3)
```

Arguments

`x`	value of X that must be a non-negative integer
`y`	value of Y that must be a non-negative integer
`lambda1`	rate parameter for X that must be positive
`lambda2`	rate parameter for Y that must be positive
`lambda3`	dependence parameter that must be $(0, 1]$

Details

The joint p.m.f. of the BGCD is

$$P(X = x, Y = y) = K(\lambda_1, \lambda_2, \lambda_3) \frac{\lambda_1^x \lambda_2^y \lambda_3^{xy}}{x!y!},$$

where $x, y = 0, 1, 2, \ldots$, and $K(\lambda_1, \lambda_2, \lambda_3)$ is the normalizing constant computed by the function `normalize_constant_BPCD`.

Key properties of the BPCD include:

- Negative correlation for $\lambda_3 < 1$,

- Independence for $\lambda_3 = 1$.

Value

probability $P(X = x, Y = y)$ for each pair of x and y.

References

Ghosh, I., Marques, F., & Chakraborty, S. (2021). A new bivariate Poisson distribution via conditional specification: properties and applications. *Journal of Applied Statistics*, 48(16), 3025-3047. doi:10.1080/02664763.2020.1793307

See Also

`rpoisBCD`, `ppoisBCD`

Examples

```
# Compute P(X = 1, Y = 2) with lambda1 = 0.5, lambda2 = 0.5, lambda3 = 0.5
dpoisBCD(x = 1, y = 2, lambda1 = 0.5, lambda2 =  0.5, lambda3 =  0.5)

# Compute P(X = 0, Y = 1) with lambda1 = 0.5, lambda2 = 0.5, lambda3 = 0.5
dpoisBCD(x = 0, y = 1, lambda1 = 0.5, lambda2 =  0.5, lambda3 =  0.5)
```

`eplSeasonGoals` *English Premier League Goals (2014–2019)*

Description

A list of data frames for five consecutive seasons (2014/15 to 2018/19) from the English Premier League. Each data frame contains the number of full-time home (‘X‘) and away (‘Y‘) goals scored in each match of the season.

Usage

```
data(eplSeasonGoals)
```

Format

A named list of 5 data frames:

1415 380 rows, variables: X (home goals), Y (away goals)

1516 380 rows, variables: X (home goals), Y (away goals)

1617 380 rows, variables: X (home goals), Y (away goals)

1718 380 rows, variables: X (home goals), Y (away goals)

1819 380 rows, variables: X (home goals), Y (away goals)

1920 380 rows, variables: X (home goals), Y (away goals)

2021 380 rows, variables: X (home goals), Y (away goals)

2122 380 rows, variables: X (home goals), Y (away goals)

2223 380 rows, variables: X (home goals), Y (away goals)

2324 380 rows, variables: X (home goals), Y (away goals)

2525 380 rows, variables: X (home goals), Y (away goals)

Details

Data source: English Premier League match results from https://football-data.co.uk/ (formerly hosted on datahub.io).

References

Ghosh, I., Marques, F., & Chakraborty, S. (2021). A new bivariate Poisson distribution via conditional specification: properties and applications. *Journal of Applied Statistics*, 48(16), 3025-3047. doi:10.1080/02664763.2020.1793307

Examples

```
data(eplSeasonGoals)
head(eplSeasonGoals[["1415"]])
head(eplSeasonGoals[["2425"]])
```

FTtest *Freeman–Tukey Test for Bivariate Distributions via Conditional Specification*

Description

Performs a goodness-of-fit test using the Freeman–Tukey (F–T) statistic for a given dataset and a specified bivariate distribution via Conditional Specification.

Usage

```
FTtest(data, distribution, params, num_params)
```

Arguments

`data`	a dataset or matrix with two columns.
`distribution`	a string specifying the theoretical distribution (‘"BBCD"‘, ‘"BBPD"‘, or ‘"BBGD"‘).
`params`	a named list of parameters required by the specified distribution.
`num_params`	an integer specifying the number of parameters that were estimated

Details

The Freeman–Tukey (F–T) statistic is used to assess the goodness of fit in contingency tables. It is defined as:

$$T^2 = 4\sum_{i=1}^{r}\sum_{j=1}^{c}\left(\sqrt{O_{ij}} - \sqrt{E_{ij}}\right)^2$$

where O_{ij} and E_{ij} are the observed and expected frequencies, respectively.

The statistic T^2 asymptotically follows a chi-squared distribution with $(r \cdot c - 1)$ degrees of freedom, where r is the number of rows and c is the number of columns in the contingency table.

Value

A list with components:

observed Observed frequency table

expected Expected frequency table under the specified distribution

test Result of the Freeman–Tukey test, a list with test statistic and p-value

Examples

```
samples <- rgeomBCD(n = 20, q1 = 0.5, q2 = 0.5, q3 = 0.1, seed = 123)
params <- MLEgeomBCD(samples)
result_bgcd <- FTtest(samples, "BGCD", params, num_params = 3)
result_bgcd

samples <- rpoisBCD(20, lambda1=.5, lambda2=.5, lambda3=.5)
params <- MLEpoisBCD(samples)
result_bpcd <- FTtest(samples, "BPCD", params, num_params = 3)
result_bpcd
```

lensfaults *Surface and Interior Faults in 100 Lenses*

Description

This dataset records counts of surface faults (X) and interior faults (Y) observed in 100 optical lenses

Usage

```
lensfaults
```

Format

A data frame with 100 rows and 2 variables:

X Number of surface faults in a lens.

Y Number of interior faults in the same lens.

References

Aitchison, J., & Ho, C. H. (1989). The multivariate Poisson-log normal distribution. *Biometrika*, 76(4), 643–653.
Ghosh, I., Marques, F., & Chakraborty, S. (2021). A new bivariate Poisson distribution via conditional specification: properties and applications. *Journal of Applied Statistics*, 48(16), 3025-3047. doi:10.1080/02664763.2020.1793307

MLEbinomBCD *Maximum Likelihood Estimation for a Bivariate Binomial Distribution via Conditional Specification*

Description

Estimates the parameters of a Bivariate Binomial Conditionals via Conditional Specification using maximum likelihood.

Usage

```
MLEbinomBCD(data, fixed_n1 = NULL, fixed_n2 = NULL, verbose = TRUE)
```

Arguments

data	A data frame or matrix with columns ‘X‘ and ‘Y‘
fixed_n1	known value of ‘n1‘ (NULL to estimate)
fixed_n2	known value of ‘n2‘ (NULL to estimate)
verbose	logical; print progress

Value

A list of class "MLEpoisBCD" containing:

- `n1` estimated n1
- `n2` estimated n2
- `p1` estimated p1
- `p2` estimated p2
- `lambda` estimated lambda
- `logLik` Maximum log-likelihood achieved.
- `AIC` Akaike Information Criterion.
- `BIC` Bayesian Information Criterion.
- `convergence` Convergence status from the optimizer (0 means successful).

Examples

```
data <- rbinomBCD(n = 10,n1 = 5, n2 = 3, p1 = 0.6, p2 = 0.4, lambda = 1.2)
MLEbinomBCD(data)
MLEbinomBCD(data, fixed_n1 = 5, fixed_n2 = 3)
```

MLEgeomBCD — *Maximum Likelihood Estimation for a Bivariate Geometric Distribution via Conditional Specification*

Description

Estimates the parameters of a bivariate geometric distribution via Conditional Specification using maximum likelihood.

Usage

```
MLEgeomBCD(data, initial_values = c(0.5, 0.5, 0.5))
```

Arguments

`data`	data frame or matrix with two columns, representing paired observations of count variables (X, Y).
`initial_values`	numeric vector of length 3 with initial values for the parameters `q1`, `q2`, and `q3`. Must be strictly between 0 and 1. Default is `c(0.5, 0.5, 0.5)`.

Details

The model estimates parameters from a joint distribution for (X, Y) with the form:

$$P(X = x, Y = y) = K(q_1, q_2, q_3) q_1^x q_2^y q_3^{xy},$$

where $K(q_1, q_2, q_3)$ is the normalizing constant.

Value

A list containing:

- `q1` estimated q1.
- `q2` estimated q2.
- `q3` estimated q3.
- `logLik` Maximum log-likelihood achieved.
- `AIC` Akaike Information Criterion.
- `BIC` Bayesian Information Criterion.
- `convergence` Convergence status from the optimizer (0 means successful).

References

Ghosh, I., Marques, F., & Chakraborty, S. (2023) A bivariate geometric distribution via conditional specification: properties and applications, Communications in Statistics - Simulation and Computation, 52:12, 5925–5945, doi:10.1080/03610918.2021.2004419

See Also

dgeomBCD pgeomBCD rgeomBCD

Examples

```
# Simulate data
samples <- rgeomBCD(n = 50, q1 = 0.2, q2 = 0.2, q3 = 0.5)
result <-MLEgeomBCD(samples)
print(result)
# For better estimation accuracy and stability, consider increasing the sample size (n = 1000)

data(abortflights)
MLEgeomBCD(abortflights)
```

MLEpoisBCD — *Maximum Likelihood Estimation for a Bivariate Poisson Distribution via Conditional Specification*

Description

Estimates the parameters of a bivariate Poisson distribution via Conditional Specification using maximum likelihood.

Usage

```
MLEpoisBCD(data, initial_values = NULL)
```

Arguments

data
: data frame or matrix with two columns, representing paired observations of count variables (X, Y).

initial_values
: optional named list with initial values for the parameters: lambda1, lambda2, and lambda3. If not provided, the function computes heuristic starting values.

Details

The model estimates parameters from a joint distribution for (X, Y) with the form:

$$P(X = x, Y = y) = K(\lambda_1, \lambda_2, \lambda_3) \frac{\lambda_1^x \lambda_2^y \lambda_3^{xy}}{x!y!},$$

where $x, y = 0, 1, 2, \ldots$, and $K(\lambda_1, \lambda_2, \lambda_3)$ is the normalizing constant.

Value

A list of class "MLEpoisBCD" containing:

lambda1 estimated lambda1.

lambda2 estimated lambda2.

lambda3 estimated dependence parameter (must be in (0, 1]).

logLik Maximum log-likelihood achieved.

AIC Akaike Information Criterion.

BIC Bayesian Information Criterion.

convergence Convergence status from the optimizer (0 means successful).

See Also

dpoisBCD ppoisBCD rpoisBCD

Examples

```
# Simulate data
data <- rpoisBCD(n = 50, lambda1 = 3, lambda2 = 5, lambda3 = 1)
result <- MLEpoisBCD(data)
print(result)

data(eplSeasonGoals)
MLEpoisBCD(eplSeasonGoals[["1819"]])

data(lensfaults)
MLEpoisBCD(lensfaults)
```

pbinomBCD — *Cumulative Distribution Function for a Bivariate Binomial Distribution via Conditional Specification*

Description

Computes the cumulative distribution function (c.d.f.) of a bivariate binomial conditionals distribution (BBCD) as defined by Ghosh, Marques, and Chakraborty (2025).

Usage

```
pbinomBCD(x, y, n1, n2, p1, p2, lambda)
```

Arguments

`x`	value at which the c.d.f. is evaluated
`y`	value at which the c.d.f. is evaluated
`n1`	number of trials for X, must be non-negative.
`n2`	number of trials for Y, must be non-negative.
`p1`	base success probability for X, in (0, 1).
`p2`	base success probability for Y, in (0, 1).
`lambda`	dependence parameter, must be positive.

Value

The probability $P(X \le x, Y \le y)$.

References

Ghosh, I., Marques, F., & Chakraborty, S. (2025). A form of bivariate binomial conditionals distributions. *Communications in Statistics - Theory and Methods*m 54(2), 534–553. doi:10.1080/03610926.2024.2315294

See Also

`dbinomBCD` `rbinomBCD`

Examples

```
# Compute P(X \le 2, Y \le 1) with n1 = 5, n2 = 5, p1 = 0.5, p2 = 0.4, lambda = 0.5
pbinomBCD(x = 2, y = 5, n1 = 5, n2 = 5, p1 = 0.5, p2 = 0.4, lambda = 0.5)

# Example with independence (lambda = 1)
pbinomBCD(x = 1, y = 1, n1 = 10, n2 = 10, p1 = 0.3, p2 = 0.6, lambda = 1)
```

pgeomBCD — *Cumulative Distribution Function for a Bivariate Geometric Distribution via Conditional Specification*

Description

Computes the cumulative distribution function (c.d.f.) of a bivariate geometric conditionals distribution (BGCD) based on Ghosh, Marques, and Chakraborty (2023).

Usage

```
pgeomBCD(x, y, q1, q2, q3)
```

Arguments

x	value at which the c.d.f. is evaluated
y	value at which the c.d.f. is evaluated
q1	probability parameter for X, in (0, 1]
q2	probability parameter for Y, in (0, 1]
q3	dependence parameter, in (0, 1]

Value

The probability $P(X \le x, Y \le y)$.

References

Ghosh, I., Marques, F., & Chakraborty, S. (2023) A bivariate geometric distribution via conditional specification: properties and applications, Communications in Statistics - Simulation and Computation, 52:12, 5925–5945, doi:10.1080/03610918.2021.2004419

See Also

dgeomBCD rgeomBCD

Examples

```
# Compute P(X \le 1, Y \le 2) with q1 = 0.5, q2 = 0.6, q3 = 0.8
pgeomBCD(x = 1, y = 2, q1 = 0.5, q2 = 0.6, q3 = 0.8)

# Example with small values
pgeomBCD(x = 0, y = 0, q1 = 0.4, q2 = 0.3, q3 = 0.9)
```

ppoisBCD *Cumulative Distribution Function for a Bivariate Poisson Distribution via Conditional Specification*

Description

Computes the cumulative distribution function (c.d.f.) of a bivariate Poisson distribution (BPD) with conditional specification, as described by Ghosh, Marques, and Chakraborty (2021).

Usage

```
ppoisBCD(x, y, lambda1, lambda2, lambda3)
```

Arguments

x	value at which the c.d.f. is evaluated
y	value at which the c.d.f. is evaluated
lambda1	rate parameter for X that must be positive
lambda2	rate parameter for Y that must be positive
lambda3	dependence parameter that must be (0, 1]

Value

The probability $P(X \le x, Y \le y)$.

References

Ghosh, I., Marques, F., & Chakraborty, S. (2021). A new bivariate Poisson distribution via conditional specification: properties and applications. *Journal of Applied Statistics*, 48(16), 3025-3047. doi:10.1080/02664763.2020.1793307

See Also

dpoisBCD rpoisBCD

Examples

```
# Compute P(X \le 1, Y \le 1) with lambda1 = 0.5, lambda2 = 0.5, lambda3 = 0.5
ppoisBCD(x = 1, y = 1, lambda1 = 0.5, lambda2 = 0.5, lambda3 = 0.5)

# Example with larger values
ppoisBCD(x = 2, y = 2, lambda1 = 1.0, lambda2 = 1.0, lambda3 = 0.8)
```

rbinomBCD — *Random Sampling from a Bivariate Binomial Distribution via Conditional Specification*

Description

Generates random samples from a bivariate binomial conditionals distribution (BBCD).

Usage

```
rbinomBCD(n, n1, n2, p1, p2, lambda, seed = 123, verbose = TRUE)
```

Arguments

`n`	number of samples to generate.
`n1`	number of trials for X, must be non-negative.
`n2`	number of trials for Y, must be non-negative.
`p1`	base success probability for X, in (0, 1).
`p2`	base success probability for Y, in (0, 1).
`lambda`	dependence parameter, must be positive.
`seed`	seed for random number generation (default = 123).
`verbose`	logical; if TRUE (default), prints progress updates and a summary.

Value

A data frame with columns ‘X‘ and ‘Y‘, containing the sampled values.

Examples

```
samples <- rbinomBCD(n = 100, n1 = 10, n2 = 10, p1 = 0.5, p2 = 0.4, lambda = 1.2)
head(samples)
```

rgeomBCD — *Random Sampling from a Bivariate Geometric Distribution via Conditional Specification*

Description

Generates random samples from a bivariate geometric distribution (BGCD)

Usage

```
rgeomBCD(n, q1, q2, q3, seed = 123)
```

Arguments

n	number of samples to generate
q1	probability parameter for X, in $(0, 1]$
q2	probability parameter for Y, in$(0, 1]$
q3	dependence parameter, in $(0, 1]$
seed	seed for random number generation (default = 123)

Value

A data frame with two columns: ‘X‘ and ‘Y‘, containing the sampled values.

Examples

```
# Generate 100 samples
samples <- rgeomBCD(n = 100, q1 = 0.5, q2 = 0.5, q3 = 0.00001)
head(samples)
cor(samples$X, samples$Y)  # Should be negative
```

`rpoisBCD` *Random Sampling from a Bivariate Poisson Distribution via Conditional Specification*

Description

Generates random samples from a bivariate Poisson distribution (BPD).

Usage

```
rpoisBCD(n, lambda1, lambda2, lambda3, seed = 123)
```

Arguments

n	number of samples to generate
lambda1	rate parameter for X that must be positive
lambda2	rate parameter for Y that must be positive
lambda3	dependence parameter that must be (0, 1]
seed	seed for random number generation (default = 123)

Value

A data frame with columns ‘X‘ and ‘Y‘, containing the sampled values.

Examples

```
samples <- rpoisBCD(n = 100, lambda1 = 0.5, lambda2 = 0.5, lambda3 = 0.5)
cor(samples$X, samples$Y) # Should be negative
```

seedplant *Seed and Plant Count Data*

Description

This dataset records the number of seeds sown and the number of resulting plants grown over plots of fixed area (5 square feet).

Usage

```
seedplant
```

Format

A data frame with *n* rows and 2 variables:

X Number of seeds sown.

Y Number of plants grown.

#' @references Lakshminarayana, J., S. N. N. Pandit, and K. Srinivasa Rao. 1999. On a bivariate poisson distribution. *Communications in Statistics - Theory and Methods*, 28 (2), 267–276. doi:10.1080/03610929908832297

Ghosh, I., Marques, F., & Chakraborty, S. (2025). A form of bivariate binomial conditionals distributions. *Communications in Statistics - Theory and Methods*, 54(2), 534–553. doi:10.1080/03610926.2024.2315294

Examples

```
data(seedplant)
head(seedplant)
plot(seedplant$X, seedplant$Y,
     xlab = "Seeds Sown",
     ylab = "Plants Grown",
     main = "Seed vs. Plant Count per Plot")
```

shacc *Railway Shunter Accident Data (1937–1947)*

Description

Accident records for 122 experienced railway shunters across two historical periods.

Usage

```
shacc
```

Format

A data frame with 122 rows and 2 variables:

X Number of accidents during the 6-year period from 1937 to 1942.

Y Number of accidents during the 5-year period from 1943 to 1947.

This dataset is useful for analyzing accident rates before and after possible policy or operational changes.

References

Arbous, A. G., & Kerrich, J. E. (1951). Accident statistics and the concept of accident-proneness. *Biometrics*, 7(4), 340. doi:10.2307/3001656

Ghosh, I., Marques, F., & Chakraborty, S. (2025). A form of bivariate binomial conditionals distributions. *Communications in Statistics - Theory and Methods*, 54(2), 534–553. doi:10.1080/03610926.2024.2315294

Examples

```
data(shacc)
head(shacc)
plot(shacc$X, shacc$Y, xlab = "Accidents 1937-42", ylab = "Accidents 1943-47")
```

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