Package ‘altmeta’

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Title Alternative Meta-Analysis Methods
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Description Provides alternative statistical methods for meta-analysis, including new heterogeneity tests and measures that are robust to outliers.
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**Description**

This meta-analysis serves as an example to illustrate the function usage in the package `altmeta`.

**Usage**

data("aex")

**Format**

A data frame containing 29 studies with the observed effect sizes and their within-study variances.

- `y` The observed effect size for each collected study in the meta-analysis.
- `s2` The within-study variance for each study.

**Source**


**Description**

This meta-analysis serves as an example to illustrate the function usage in the package `altmeta`.

**Usage**

data("ha")

**Format**

A data frame containing 109 studies with the observed effect sizes and their within-study variances.

- `y` The observed effect size for each collected study in the meta-analysis.
- `s2` The within-study variance for each study.

**Source**

hipfrac

A Meta-Analysis for Investigating the Magnitude and Duration of Excess Mortality After Hip Fracture Among Older Men

Description

This meta-analysis serves as an example to illustrate the function usage in the package \texttt{altmeta}.

Usage

\begin{verbatim}
data("hipfrac")
\end{verbatim}

Format

A data frame containing 17 studies with the observed effect sizes and their within-study variances.

\begin{description}
\item[y] The observed effect size for each collected study in the meta-analysis.
\item[s2] The within-study variance for each study.
\end{description}

Source


lcj

A Meta-Analysis for Evaluating the Effect of Progressive Resistance Strength Training Exercise Versus Control

Description

This meta-analysis serves as an example to illustrate the function usage in the package \texttt{altmeta}.

Usage

\begin{verbatim}
data("lcj")
\end{verbatim}

Format

A data frame containing 33 studies with the observed effect sizes and their within-study variances.

\begin{description}
\item[y] The observed effect size for each collected study in the meta-analysis.
\item[s2] The within-study variance for each study.
\end{description}
metahet

Meta-Analysis Heterogeneity Measures

Description

Calculates various between-study heterogeneity measures in meta-analysis, including the conventional measures (e.g., $I^2$) and the alternative measures (e.g., $I^2_r$) which are robust to outlying studies; p-values of various tests are also calculated.

Usage

metahet(y, s2, n.resam = 1000)

Arguments

- **y**: a numeric vector indicating the observed effect sizes in the collected studies; they are assumed to be normally distributed.
- **s2**: a numeric vector indicating the within-study variances.
- **n.resam**: a positive integer indicating the number of resampling iterations for calculating p-values of test statistics and 95% confidence interval of heterogeneity measures.

Details

Suppose that a meta-analysis collects $n$ studies. The observed effect size in study $i$ is $y_i$ and its within-study variance is $s_i^2$. Also, the inverse-variance weight is $w_i = 1/s_i^2$. The fixed-effect estimate of overall effect size is $\bar{\mu} = \sum_{i=1}^{n} w_i y_i / \sum_{i=1}^{n} w_i$. The conventional test statistic for heterogeneity is

$$Q = \sum_{i=1}^{n} w_i (y_i - \bar{\mu})^2.$$ 

Based on the $Q$ statistic, the method-of-moments estimate of the between-study variance $\tau^2_{DL}$ is (DerSimonian and Laird, 1986)

$$\tau^2_{DL} = \max \left\{ 0, \frac{Q - (n - 1)}{\sum_{i=1}^{n} w_i - (\sum_{i=1}^{n} w_i^2) / (\sum_{i=1}^{n} w_i)} \right\}.$$

Also, the $H$ and $I^2$ statistics (Higgins and Thompson, 2002; Higgins et al., 2003) are widely used in practice because they do not depend on the number of collected studies $n$ and the effect size scale; these two statistics are defined as

$$H = \sqrt{Q/(n - 1)};$$
\[ I^2 = \frac{Q - (n - 1)}{Q}. \]

Specifically, the \( H \) statistic reflects the ratio of the standard deviation of the underlying mean from a random-effects meta-analysis compared to the standard deviation from a fixed-effect meta-analysis; the \( I^2 \) statistic describes the proportion of total variance across studies that is due to heterogeneity rather than sampling error.

Outliers are frequently present in meta-analysis, and they may have great impact on the above heterogeneity measures. Alternatively, to be more robust to outliers, the test statistic may be modified as (Lin et al., 2016+):

\[ Q_r = \sum_{i=1}^{n} \sqrt{w_i} |y_i - \bar{\mu}|. \]

Based on the \( Q_r \) statistic, the method-of-moments estimate of between-study variance \( \hat{\tau}^2 \) is defined as the solution to

\[ Q_r \sqrt{\frac{\pi}{2}} = \sum_{i=1}^{n} \left\{ 1 - \frac{w_i}{\sum_{j=1}^{n} w_j} + \tau^2 \left[ w_i - \frac{2w_i^2}{\sum_{j=1}^{n} w_j} + \frac{w_i \sum_{j=1}^{n} w_j^2}{(\sum_{j=1}^{n} w_j)^2} \right] \right\}. \]

If no positive solution exists to the equation above, set \( \hat{\tau}^2 = 0 \). The counterparts of the \( H \) and \( I^2 \) statistics are defined as

\[ H_r = Q_r \sqrt{\pi/[2n(n - 1)]}; \]
\[ I_r^2 = \frac{Q_r^2 - 2n(n - 1)/\pi}{Q_r^2}. \]

To further improve the robustness of heterogeneity assessment, the weighted mean in the \( Q_r \) statistic may be replaced by the weighted median \( \hat{\mu}_m \), which is the solution to \( \sum_{i=1}^{n} w_i [I(\theta \geq y_i) - 0.5] = 0 \) with respect to \( \theta \). The new test statistic is

\[ Q_m = \sum_{i=1}^{n} \sqrt{w_i} |y_i - \hat{\mu}_m|. \]

Based on \( Q_m \), the new estimator of between-study variance \( \hat{\tau}^2_m \) is the solution to

\[ Q_m \sqrt{\pi/2} = \sum_{i=1}^{n} \sqrt{(s_i^2 + \tau^2)/s_i^2}. \]

The counterparts of the \( H \) and \( I^2 \) statistics are

\[ H_m = \frac{Q_m}{n} \sqrt{\pi/2}; \]
\[ I_m^2 = \frac{Q_m^2 - 2n^2/\pi}{Q_m^2}. \]

Value

This function returns a list containing p-values of various heterogeneity tests and various heterogeneity measures with 95% confidence intervals.
References


Examples

data("aex")
set.seed(1234)
attach(aex)
metahet(y, s2, 100)
#metahet(y, s2, 1000)
detach(aex)

data("hipfrac")
set.seed(1234)
attach(hipfrac)
metahet(y, s2, 100)
#metahet(y, s2, 1000)
detach(hipfrac)

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metaoutliers

Outlier Detection in Meta-Analysis

Description

Calculates the standardized residual for each study in meta-analysis using the methods described in Hedges and Olkin (1985) Chapter 12 and Viechtbauer and Cheung (2010). A study is considered as an outlier if its standardized residual is greater than 3 in absolute magnitude.

Usage

metaoutliers(y, s2, model)

Arguments

y a numeric vector indicating the observed effect sizes in the collected studies; they are assumed to be normally distributed.

s2 a numeric vector indicating the within-study variances.
model a character string specified as either "FE" or "RE". If model = "FE", this function uses the outlier detection procedure for fixed-effect meta-analysis described in Hedges and Olkin (1985) Chapter 12; If model = "RE", the procedure for random-effects meta-analysis described in Viechtbauer and Cheung (2010) is used. See Details for the two approaches. If the argument model is not specified, this function sets model = "FE" if $I^2 < 30\%$ and sets model = "RE" if $I^2 \geq 30\%$.

Details
Suppose that a meta-analysis collects $n$ studies. The observed effect size in study $i$ is $y_i$ and its within-study variance is $s_i^2$. Also, the inverse-variance weight is $w_i = 1/s_i^2$.

Hedges and Olkin (1985) Chapter 12 describes the outlier detection procedure for fixed-effect meta-analysis (model = "FE"). Using the studies except study $i$, the pooled estimate of overall effect size is $\overline{\mu}(-i) = \sum_{j \neq i} w_j y_j / \sum_{j \neq i} w_j$. The residual of study $i$ is $e_i = y_i - \overline{\mu}(-i)$. The variance of $e_i$ is $v_i = s_i^2 + (\sum_{j \neq i} w_j)^{-1}$, so the standardized residual of study $i$ is $\epsilon_i = e_i / \sqrt{v_i}$.

Viechtbauer and Cheung (2010) describes the outlier detection procedure for random-effects meta-analysis (model = "RE"). Using the studies except study $i$, let the method-of-moments estimate of between-study variance be $\hat{\tau}^2(-i)$. The pooled estimate of overall effect size is $\tilde{\mu}(-i) = \sum_{j \neq i} \tilde{w}(-i)_{ij} y_j / \sum_{j \neq i} \tilde{w}(-i)_{ij}$, where $\tilde{w}(-i)_{ij} = 1/(s_i^2 + \hat{\tau}^2(-i))$. The residual of study $i$ is $e_i = y_i - \tilde{\mu}(-i)$, and its variance is $v_i = s_i^2 + \hat{\tau}^2(-i) + (\sum_{j \neq i} \tilde{w}(-i)_{ij})^{-1}$. Then, the standardized residual of study $i$ is $\epsilon_i = e_i / \sqrt{v_i}$.

Value
This functions returns a list which contains standardized residuals and identified outliers. A study is considered as an outlier if its standardized residual is greater than 3 in absolute magnitude.

References


Examples
```r
data("aex")
attach(aex)
metaoutliers(y, sR, model = "FE")
metaoutliers(y, sR, model = "RE")
detach(aex)

data("hipfrac")
attach(hipfrac)
metaoutliers(y, sR)
detach(hipfrac)
```
Description

Draws a plot showing study-specific standardized residuals.

Usage

## S3 method for class 'metaoutliers'
plot(x, xtick.cex = 1, ytick.cex = 0.5, ...)

Arguments

x an object created by the function metaoutliers().
xtick.cex a numerical value indicating the magnification to be used for ticks on x-axis.
ytick.cex a numerical value indicating the magnification to be used for ticks on y-axis.
... Other arguments can be passed to plot() function.

See Also

metaoutliers

Examples

data("aex")
attach(aex)
out.aex <- metaoutliers(y, s2, model = "FE")
detach(aex)
plot(out.aex)

data("hipfrac")
attach(hipfrac)
out.hipfrac <- metaoutliers(y, s2, model = "RE")
detach(hipfrac)
plot(out.hipfrac)

Description

This meta-analysis serves as an example to illustrate the function usage in the package altmeta.
Usage

data("slf")

Format

A data frame containing 56 studies with the observed effect sizes and their within-study variances.

y  The observed effect size for each collected study in the meta-analysis.
s2  The within-study variance for each study.

Source

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