Package: metaLik (via r-universe)

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Title Likelihood Inference in Meta-Analysis and Meta-Regression Models

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Contents

`albumin` *Albumin data.*

Description

Data from four experiments about the percentage of albumin in the plasma protein of the normal human subjects.

Usage

```
data(albumin)
```

Format

`y` mean albumin percentage.

`sigma2` estimated within-study variance.

Source

Meier, P. (1953). Variance of a Weighted Mean. *Biometrics* **9**, 59–73.

Examples

```
data(albumin)
```

`cholesterol` *Serum cholesterol data.*

Description

Data from 28 randomized trials about the effect of serum cholesterol reduction on the risk of ischaemic heart disease.

Usage

```
data(cholesterol)
```

Format

`heart_disease` log odds ratio of ischaemic heart disease.

`chol_reduction` average serum cholesterol reduction measured in mmol/l.

`sigma2` estimated within-study variance.

Source

Law, M.R., Wald, N.J., and Thompson, S.G. (1994). By How Much and How Quickly Does Reduction in Serum Cholesterol Concentration Lower Risk of Ischaemic Heart Disease? *British Medical Journal* **308**, 367–373.

Thompson, S.G. and Sharp, S.J. (1999). Explaining Heterogeneity in Meta-Analysis: A Comparison of Methods. *Statistics in Medicine* **18**, 2693–2708.

Examples

```
data(cholesterol)
```

`diuretics` *Diuretics data.*

Description

Data from nine randomized trials on prevention of pre-eclampsia with diuretics.

Usage

```
data(diuretics)
```

Format

`y` logarithm of the risk ratio in each study.

`sigma2` estimated within-study variance.

Source

Biggerstaff, B. and Tweedie, R. (1997). Incorporating Variability in Estimates of Heterogeneity in the Random Effects Model in Meta-Analysis. *Statistics in Medicine* **16**, 753–768.

Examples

```
data(diuretics)
```

`education` *Open education data.*

Description

Data from eleven studies on the effect of open versus traditional education on student attitude toward schools.

Usage

```
data(education)
```

Format

`y` standardized estimated mean difference in attitude according to the type of education.

`sigma2` estimated within-study variance.

Source

Hedges, L.V. and Olkin, I. (1985). *Statistical Methods for Meta-Analysis*. Academic Press, Orlando.

Examples

```
data(education)
```

`metaLik` *First- and higher-order likelihood inference in meta-analysis and meta-regression models*

Description

Implements first-order and higher-order likelihood methods for inference in meta-analysis and meta-regression models, as described in Guolo (2012). Higher-order asymptotics refer to the higher-order adjustment to the log-likelihood ratio statistic for inference on a scalar component of interest as proposed by Skovgaard (1996). See Guolo and Varin (2012) for illustrative examples about the usage of **metaLik** package.

Usage

```
metaLik(formula, data, subset, contrasts = NULL, offset, sigma2, weights=1/sigma2)
```

Arguments

`formula`	an object of class "`formula`" (or one that can be coerced to that class): a symbolic description of the model to be fitted. The details of model specification are given under 'Details'.
`data`	an optional data frame, list or environment (or object coercible by `as.data.frame` to a data frame) containing the variables in the model. If not found in `data`, the variables are taken from `environment(formula)`, typically the environment from which `metaLik` is called.
`subset`	an optional vector specifying a subset of observations to be used in the fitting process.
`contrasts`	an optional list. See the contrasts.arg of `model.matrix.default`.
`offset`	this can be used to specify an a priori known component to be included in the linear predictor during fitting. This should be `NULL` or a numeric vector of length equal to the number of cases. One or more `offset` terms can be included in the formula instead or as well, and if more than one are specified their sum is used. See `model.offset`.
`sigma2`	a vector of within-study estimated variances. The length of the vector must be the same of the number of studies.
`weights`	a vector of the inverse of within-study estimated variances. The length of the vector must be the same of the number of studies. If `sigma2` is supplied, the value of `weights` is discarded.

Details

Models for `metaLik.fit` are specified simbolically. A typical model has the form `y ~ x1 + ... + xJ`, where `y` is the continuous response term and `xj` is the j-th covariate available at the aggregated meta-analysis level for each study. The case of no covariates corresponds to the classical meta-analysis model specified as `y~1`.

Within-study variances are specified through `sigma2`: the rare case of equal within-study variances implies Skovgaard's adjustment reaching a third-order accuracy.

DerSimonian and Laird estimates (DerSimonian and Laird, 1986) are also supplied.

Value

An object of class "`metaLik`" with the following components:

`y`	the y vector used.
`X`	the model matrix used.
`fitted.values`	the fitted values.
`sigma2`	the within-study variances used.
`K`	the number of studies.
`mle`	the vector of the maximum likelihood parameter estimates.
`vcov`	the variance-covariance matrix of the parameter estimates.
`max.lik`	the maximum log-likelihood value.

`beta.mle`	the vector of fixed-effects parameters estimated according to maximum likelihood.
`tau2.mle`	the maximum likelihood estimate of τ^2.
`DL`	the vector of fixed-effects parameters estimated according to DerSimonian and Laird's pproach.
`tau2.DL`	the method of moments estimate of the heterogeneity parameter τ^2.
`vcov.DL`	the variance-covariance matrix of the DL parameter estimates.
`call`	the matched call.
`formula`	the `formula` used.
`terms`	the `terms` object used.
`offset`	the offset used.
`contrasts`	(only where relevant) the `contrasts` specified.
`xlevels`	(only where relevant) a record of the levels of the factors used in fitting.
`model`	the model frame used.

Generic functions `coefficients`, `vcov`, `logLik`, `fitted`, `residuals` can be used to extract fitted model quantities.

Author(s)

Annamaria Guolo and Cristiano Varin.

References

DerSimonian, R. and Laird, N. (1986). Meta-Analysis in Clinical Trials. *Controlled Clinical Trials* **7**, 177–188.

Guolo, A. (2012). Higher-Order Likelihood Inference in Meta-Analysis and Meta-Regression. *Statistics in Medicine* **31**, 313–327.

Guolo, A. and Varin, C. (2012). The R Package metaLik for Likelihood Inference in Meta-Analysis. *Journal of Statistical Software* **50** (7), 1–14. `https://www.jstatsoft.org/v50/i07/`.

Skovgaard, I. M. (1996). An Explicit Large-Deviation Approximation to One-Parameter Tests. *Bernoulli* **2**, 145–165.

See Also

Function `summary.metaLik` for summaries.

Function `test.metaLik` for hypothesis testing.

Examples

```
## meta-analysis
data(education)
m <- metaLik(y~1, data=education, sigma2=sigma2)
summary(m)
## meta-analysis
data(albumin)
```

```
m <- metaLik(y~1, data=albumin, sigma2=sigma2)
summary(m)
## meta-regression
data(vaccine)
m <- metaLik(y~latitude, data=vaccine, sigma2=sigma2)
summary(m)
## meta-regression
data(cholesterol)
m <- metaLik(heart_disease~chol_reduction, data=cholesterol, weights=1/sigma2)
summary(m)
```

`simulate.metaLik` *Simulate meta-analysis outcomes*

Description

Simulate one or more meta-analysis outcomes from a fitted `metaLik` object.

Usage

```
## S3 method for class 'metaLik'
simulate(object, nsim=1, seed=NULL, ...)
```

Arguments

`object`	an object of class "`metaLik`".
`nsim`	number of outcome vectors to simulate. Default is `1`.
`seed`	an object specifying if and how the random number generator should be initialized, see `simulate` for details.
`...`	additional optional arguments.

Value

A dataframe containing the simulated meta-analysis outcomes.

Author(s)

Annamaria Guolo and Cristiano Varin.

References

DerSimonian, R. and Laird, N. (1986). Meta-Analysis in Clinical Trials. *Controlled Clinical Trials* **7**, 177–188.

Examples

```
data(vaccine)
m <- metaLik(y~latitude, data=vaccine, sigma2=sigma2)
sim <- simulate(m, nsim=2)
sim
```

`summary.metaLik` *Summarizing meta-analysis and meta-regression model fits*

Description

Summary method for class "`metaLik`".

Usage

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

Arguments

`object`	an object of class "metaLik", usually a result of a call to "`metaLik`".
`...`	additional arguments

Details

`summary.metaLik` prints summary information about within-study heterogeneity, parameter estimates, standard errors, first- and higher-order log-likelihood ratio statistics. See `test.metaLik` for more details about the first- and higher-order statistics.

Value

The function `summary.metaLik` returns the `metaLik` object from which `summary.metaLik` is called.

See Also

The generic functions `coefficients`, `confint` and `vcov`.

Function `test.metaLik` allows for hypothesis testing.

Examples

```
## meta-analysis
data(education)
m <- metaLik(y~1, data=education, sigma2=sigma2)
summary(m)
## meta-analysis
data(albumin)
m <- metaLik(y~1, data=albumin, sigma2=sigma2)
summary(m)
## meta-regression
data(vaccine)
m <- metaLik(y~latitude, data=vaccine, sigma2=sigma2)
summary(m)
## meta-regression
data(cholesterol)
```

```
m <- metaLik(heart_disease~chol_reduction, data=cholesterol, weights=1/sigma2)
summary(m)
```

`test.metaLik` *Hypothesis testing on a scalar fixed-effect component in meta-analysis and meta-regression models*

Description

Performs hypothesis testing on a scalar component of the fixed-effects vector in meta-analysis and meta-regression models, using the signed profile log-likelihood ratio test and its higher-order Skovgaard's adjustment (Skovgaard, 1996), as described in Guolo (2012). See Guolo and Varin (2012) for illustrative examples about the usage of **metaLik** package.

Usage

```
test.metaLik(object, param=1, value=0, alternative=c("two.sided", "less", "greater"),
print=TRUE)
```

Arguments

`object`	an object of class `"metaLik"`.
`param`	a specification of which parameter is to be given confidence interval, either a number or a name. Default is `1` corresponding to the intercept.
`value`	a single number indicating the value of the fixed-effect parameter under the null hypothesis. Default is 0.
`alternative`	a character string specifying the alternative hypothesis, must be one of "two.sided" (default), "greater" or "less". Just the initial letter can be specified.
`print`	logical, whether output information should be printed or not; default is `TRUE`.

Details

`test.metaLik` allows hypothesis testing on a scalar component of interest in the fixed-effects vector. The signed profile log-likelihood ratio statistic for inference on scalar component β of θ is

$$r(\beta) = sign(\hat{\beta} - \beta)\sqrt{2\{l(\hat{\theta}) - l(\theta)\}},$$

where l is the log-likelihood function and $\hat{\theta}$ is the maximum likelihood estimate of θ. The Skovgaard's adjustment is defined as

$$\bar{r}(\beta) = r(\beta) + \frac{1}{r(\beta)} \log \frac{u(\beta)}{r(\beta)},$$

where $u(\beta)$ is a correction term involving the observed and the expected information matrix and covariances of likelihood quantities, as described in Guolo (2012). Skovgaard's statistic has a second-order accuracy in approximating the standard normal distribution. In the rare case of equal within-study variances, Skovgaard's statistic reaches third-order accuracy.

Value

A list with the following components:

`r`	the value of the signed profile log-likelihood ratio statistic.
`pvalue.r`	the p-value of the signed profile log-likelihood ratio test.
`rskov`	the value of the Skovgaard's statistic.
`pvalue.rskov`	the p-value of the Skovgaard's test.

Author(s)

Annamaria Guolo and Cristiano Varin.

References

Guolo, A. (2012). Higher-Order Likelihood Inference in Meta-Analysis and Meta-Regression. *Statistics in Medicine* **31**, 313–327.

Guolo, A. and Varin, C. (2012). The R Package metaLik for Likelihood Inference in Meta-Analysis. *Journal of Statistical Software* **50** (7), 1–14. `https://www.jstatsoft.org/v50/i07/`.

Skovgaard, I. M. (1996). An Explicit Large-Deviation Approximation to One-Parameter Tests. *Bernoulli* **2**, 145–165.

See Also

Function `metaLik` for fitting meta-analysis and meta-regression models. Function `summary.metaLik` for summaries.

Examples

```
data(vaccine)
m <- metaLik(y~latitude, data=vaccine, sigma2=sigma2)
## significance test for the intercept coefficient
test.metaLik(m)
## significance test for the 'latitude' coefficient
test.metaLik(m, param=2)
## testing for the 'latitude' coefficient less than 0
test.metaLik(m, param=2, value=0, alternative='less')
```

`vaccine` *Data for Bacillus Calmette-Guerin (BCG) vaccine studies.*

Description

Data from thirteen clinical studies evaluating the efficacy of the BCG vaccine for the prevention of tuberculosis.

Usage

```
data(vaccine)
```

Format

`y` log odds ratio in each study.

`latitude` latitude, distance of each study from the equator, surrogate for the presence of environmental mycobacteria providing a level of natural immunity against tuberculosis.

`year` year of the study.

`sigma2` estimated within-study variance.

Source

Berkey, C.S., Hoaglin, D.C., Mosteller, F. and Colditz, G.A. (1995). A random-effects regression model for meta-analysis. *Statistics in Medicine* **14**, 395–411.

Examples

```
data(vaccine)
```

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