# Package 'leiv'

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**Type** Package

**Title** Bivariate Linear Errors-In-Variables Estimation

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**Depends** R (>= 2.9.0)

**Imports** methods, stats, graphics

**Suggests** grDevices

**Description** Estimate the slope and intercept of a bivariate linear relationship by calculating a posterior density that is invariant to interchange and scaling of the coordinates.

**License** GPL (>= 2)

**URL** http://www.r-project.org

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**NeedsCompilation** no

**Repository** CRAN

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## Contents

leiv *Bivariate Linear Errors-In-Variables Estimation*

## Description

Generates a linear errors-in-variables object.

## Usage

```
leiv(formula, data, subset, prior = NULL,
      n = NULL, cor = NULL, sdRatio = NULL, xMean = 0, yMean = 0,
      probIntCalc = FALSE, level = 0.95, subdivisions = 100,
      rel.tol = .Machine$double.eps^0.25, abs.tol = 0.1*rel.tol, ...)

## S4 method for signature 'leiv'
print(x, digits = max(3, getOption("digits") - 3), ...)
## S4 method for signature 'leiv,missing'
plot(x, plotType = "density", xlim = NULL, ylim = NULL,
     xlab = NULL, ylab = NULL, col = NULL, lwd = NULL, ...)
```

## Arguments

| | |
|---|---|
| formula | an optional 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 in the 'Details' section of the documentation for lm. An intercept is always included and integrated out as a nuisance parameter: y ~ x, y ~ 0 + x, and y ~ x - 1 are equivalent. If not provided, the sufficient statistics n, cor, and sdRatio must be provided. |
| data | an optional data frame (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 leiv is called. |
| subset | an optional vector specifying a subset of observations to be used in the fitting process. |
| prior | an optional object of class leiv to use as the prior density of the scale invariant slope; otherwise the rotationally invariant Cauchy density is used. |
| n | an optional sample size (if formula is missing). |
| cor, sdRatio | optional sample correlation cor(x,y) and ratio sd(y)/sd(x) (if formula is missing). |
| xMean, yMean | optional sample means mean(x) and mean(y) (if formula is missing). |
| probIntCalc | logical; if TRUE returns the shortest (100*level)% probability intervals; if FALSE (the default) no probability intervals are returned. |
| level | the probability level requested (if probIntCalc = TRUE). |
| subdivisions | the maximum number of subintervals (see integrate). |

| | |
|---|---|
| rel.tol | the relative accuracy requested (see integrate). |
| abs.tol | the absolute accuracy requested (see integrate). |
| x | a leiv object. |
| digits | controls formating of numeric objects. |
| plotType | specifies the type of plot; if plotType = "density" (the default) then the posterior density of the slope is plotted; if plotType = "scatter" then a scatter plot with the fitted line. |
| xlim, ylim | $x$ limits c(x1,x2) and $y$ limits c(y1,y2) of the plot. |
| xlab, ylab | labels for the $x$ and $y$ axes of the plot. |
| col, lwd | color and width of plotted lines. |
| ... | additional argument(s) for generic methods. |

## Details

Use leiv to estimate the slope and intercept of a bivariate linear relationship when both variables are observed with error. The method is exact when the true values and the errors are normally distributed. The posterior density depends on the data only through the correlation coefficient and ratio of standard deviations; it is invariant to interchange and scaling of the coordinates.

## Value

leiv returns an object of class "leiv" with the following components:

| | |
|---|---|
| slope | the (posterior median) slope estimate. |
| intercept | the (maximum likelihood) intercept estimate. |
| slopeInt | the shortest (100*level)% probability interval of the slope. |
| interceptInt | the shortest (100*level)% probability interval of the intercept. |
| density | the posterior probability density function. |
| n | the number of ($x$,$y$) pairs. |
| cor | the sample correlation cor(x,y). |
| sdRatio | the ratio sd(y)/sd(x). |
| xMean | the sample mean mean(x). |
| yMean | the sample mean mean(y). |
| call | the matched call. |
| probIntCalc | the logical probability interval request. |
| level | the probability level of the probability interval. |
| x | the $x$ data. |
| y | the $y$ data. |

## Note

Numerical integration is used to normalize the posterior density. When the data is nearly linear, normalization using the default tolerance parameters may fail. Specifying `abs.tol = 1e-6` (or smaller) may help, but expect a longer run time. In general, `rel.tol` cannot be less than `max(50*.Machine$double.eps, 0.5e-28)` if `abs.tol <= 0`. In addition, when using a sharply peaked `leiv` object as a prior density, normalization may fail. In this case, an alternative is to first fit using the default Cauchy prior, then multiply by the appropriate ratio of prior densities and tackle the normalization outside of the `leiv` environment.

## Author(s)

David Leonard

## References

Leonard, David. (2011). "Estimating a Bivariate Linear Relationship." *Bayesian Analysis*, 6:727-754. DOI:10.1214/11-BA627.

Zellner, Arnold. (1971). *An Introduction to Bayesian Inference in Econometrics*, Chapter 5. John Wiley & Sons.

## See Also

`lm` for formula syntax; `integrate` for control parameters.

## Examples

```
## generate artificial data
set.seed(1123)
n <- 20
X <- rnorm(n, mean=5, sd=4) # true x
x <- X + rnorm(n, mean=0, sd=5) # observed x
Y <- 2 + X # true y
y <- Y + rnorm(n, mean=0, sd=3) # observed y

## fit with default options
fit <- leiv(y ~ x)
print(fit)
plot(fit) # density plot
dev.new()
plot(fit,plotType="scatter")

## calculate a density to use as an informative prior density of
## the scale invariant slope in a subsequent fit
fit0 <- leiv(n=10, cor=0.5, sdRatio=1.0)
print(fit0)

## refit the data using the informative prior density
fit1 <- leiv(y ~ x, prior=fit0, abs.tol=1e-6)
print(fit1)
```

leiv-internal *Probability Density Utilities*

## Description

p50 calculates the median of the leiv posterior probability density. probInt calculates the shortest probability interval of the leiv posterior probability density for a given probability level.

## Usage

```
p50(p, interval, subdivisions = 100,
      rel.tol = .Machine$double.eps^0.25,
      abs.tol = rel.tol)

probInt(p, interval, level, subdivisions = 100,
      rel.tol = .Machine$double.eps^0.25,
      abs.tol = rel.tol)
```

## Arguments

| | |
|---|---|
| p | a normalized probability density function. |
| interval | a vector containing the endpoints of the interval to be searched. |
| level | the probability level requested. |
| subdivisions | the maximum number of subintervals (see integrate). |
| rel.tol | the relative accuracy requested (see integrate). |
| abs.tol | the absolute accuracy requested (see integrate, optimize and uniroot). |

## Details

Internal functions for integrating the posterior density returned by the function leiv. These functions are not meant to be called by the user.

## Value

p50 returns a numeric scalar. probInt returns a 2-dimensional numeric vector of interval endpoints.

## Note

p must accept a vector of inputs and produce a vector of function evaluations at those points. rel.tol cannot be less than max(50*.Machine$double.eps, 0.5e-28) if abs.tol <= 0.

## See Also

leiv for general information; integrate for control parameters.

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