Package ‘bmlm’

September 25, 2023

Title Bayesian Multilevel Mediation

Version 1.3.15

Date 2023-09-25

Description Easy estimation of Bayesian multilevel mediation models with Stan.

URL https://github.com/mvuorre/bmlm/

BugReports https://github.com/mvuorre/bmlm/issues/

License GPL (>= 3)

LazyData true

NeedsCompilation yes

Depends R (>= 3.4.0), Rcpp (>= 0.12.0)

Imports ggplot2 (>= 2.0.0), methods, RcppParallel (>= 5.0.1), rstan (>= 2.26.0), rstantools (>= 2.3.1.1)

Suggests qgraph, knitr, rmarkdown, reshape2, dplyr

LinkingTo BH (>= 1.66.0), Rcpp (>= 0.12.0), RcppEigen (>= 0.3.3.3.0), RcppParallel (>= 5.0.1), rstan (>= 2.26.0), StanHeaders (>= 2.26.0)

RoxygenNote 7.1.2

Encoding UTF-8

SystemRequirements GNU make

Biarch true

Author Matti Vuorre [aut, cre] (<https://orcid.org/0000-0001-5052-066X>)

Maintainer Matti Vuorre <m.j.vuorre@tilburguniversity.edu>

Repository CRAN

Date/Publication 2023-09-25 14:22:24 UTC
R topics documented:

- bmlm-package
- BLch9
- isolate
- MEC2010
- mlm
- mlm_pars_plot
- mlm_path_plot
- mlm_spaghetti_plot
- mlm_summary

Index

- bmlm-package
  - bmlm: Easy estimation of Bayesian multilevel mediation models with Stan.

Description


- BLch9
  - Relationship between work stressors, work dissatisfaction, and relationship dissatisfaction.

Description

Simulated data from Intensive Longitudinal Methods: An Introduction to Diary and Experience Sampling Research. (Bolger, & Laurenceau, 2013, chapter 9; [http://www.intensivelongitudinal.com/index.html](http://www.intensivelongitudinal.com/index.html)).

Usage

data(BLch9)

Format

A data frame with 2100 rows and 8 variables:

- **id** ID of study participant
- **time** Time
- **fwkstrs** Number of work stressors
- **fwkdis** Work dissatisfaction rating
- **freldis** Relationship dissatisfaction
- **x** Subject-mean deviated number of work stressors
- **m** Subject-mean deviated work dissatisfaction rating
- **y** Subject-mean deviated relationship dissatisfaction
isolate

Create isolated within- (and optionally between-) person variables.

Description

Creates variables that represent pure within- and between-person predictors.

Usage

isolate(d = NULL, by = NULL, value = NULL, z = FALSE, which = "within")

Arguments

d A data.frame.
by A vector of values in d by which the data is clustered. i.e. a vector of unique participant IDs.
value Names of columns in d to isolate. Multiple values can be given by value = c("var1", "var2", "var3")
z Should the created values be standardized (defaults to FALSE).
which Which component to return. "within" (default) returns within-person deviations only; "between" returns between-person means only; "both" returns both.

Value

A data.frame with additional columns for the within- and between-person variables. The new columns are labelled _cw for centered-within and _cb for centered-between.

Author(s)

Matti Vuorre <mv2521@columbia.edu>

Examples

# Create within-person deviations of work stressors in BLch9.
data(BLch9)
BLch9 <- isolate(BLch9, by = "id", value = "fwkstrs")
head(BLch9)  # Now has new column for within-person work stressors.
Description


Usage

data(MEC2010)

Format

A data frame with 344 rows and 4 variables:

- subj  Subject id number.
- lag   Lag condition (0 = no lag, 1 = 250ms lag).
- hr    Hit rate.
- jop   Judgment of Performance.

Source


mlm

Estimate a multilevel mediation model

Description

Estimates a Bayesian multilevel mediation model using Stan.

Usage

mlm(
    d = NULL,
    id = "id",
    x = "x",
    m = "m",
    y = "y",
    priors = NULL,
    binary_y = FALSE,
    ...
)
Arguments

d  A data.frame or a data_frame.
id  Column of participant IDs in data.
x  Column of X values in data.
m  Column of M values in data.
y  Column of Y values in data.
priors  A list of named values to be used as the prior scale parameters. See details.
binary_y  Set to TRUE if y is binary and should be modelled with logistic regression. Defaults to FALSE (y treated as continuous.) This feature is experimental.
...  Other optional parameters passed to rstan::stan().

Details

Draw samples from the joint posterior distribution of a multilevel mediation model using Stan.

Priors:
Users may pass a list of named values for the priors argument. The values will be used to define the scale parameter of the respective prior distributions. This list may specify some or all of the following parameters:
dy, dm  Regression intercepts (for Y and M as outcomes, respectively.)
a, b, cp  Regression slopes.
tau_x  Varying effects SDs for above parameters (e.g replace x with a.)
lkj_shape  Shape parameter for the LKJ prior.

See examples for specifying the following: Gaussian distributions with SD = 10 as priors for the intercepts, Gaussians with SD = 2 for the slopes, Half-Cauchy distributions with scale parameters 1 for the varying effects SDs, and an LKJ prior of 2.

Value

An object of S4 class stanfit, with all its available methods.

Author(s)

Matti Vuorre <mv2521@columbia.edu>

Examples

```r
## Not run:
## Run example from Bolger and Laurenceau (2013)
data(BLch9)
fit <- mlm(BLch9)
mlm_summary(fit)

### With priors
Priors <- list(dy = 10, dm = 10, a = 2, b = 2, cp = 2,
               tau_dy = 1, tau_dm = 1, tau_a = 1, tau_b = 1, tau_cp = 1,
mlm_pars_plot

Description

Plot estimated parameters of multilevel mediation model

Usage

mlm_pars_plot(
  mod = NULL,
  type = "hist",
  color = "black",
  p_shape = 15,
  p_size = 1.2,
  level = 0.95,
  nrow = 3,
  pars = c("a", "b", "cp", "covab", "me", "c", "pme")
)

Arguments

  mod  A Stanfit model estimated with mlm().
  type  Type of the plot, hist, coef, or violin.
  color  Color (and fill) for plots.
  p_shape  Shape of points for coefplot.
  p_size  Size of points for coefplot.
  level  X level for Credible Intervals. (Defaults to .95.)
  nrow  Number of rows for multiple histograms.
  pars  Which parameters to plot.

Details

The point estimate for the coefficient plot is the posterior mean.

Value

A ggplot2 object.

Author(s)

Matti Vuorre <mv2521@columbia.edu>
mlm_path_plot

Plot bmlm's mediation model as a path diagram

Description
Plots a path diagram for an estimated multilevel mediation model.

Usage
mlm_path_plot(
    mod = NULL,
    xlab = "X",
    ylab = "Y",
    mlab = "M",
    level = 0.95,
    random = TRUE,
    text = FALSE,
    id = NULL,
    digits = 2,
    ...
)

Arguments

mod A Stanfit model estimated with mlm().
xlab Label for X
ylab Label for Y
mlab Label for M
level "Confidence" level for credible intervals. (Defaults to .95.)
random Should the "random" effects SDs be displayed? (Default = TRUE)
text Should additional parameter values be displayed? (Defaults to FALSE.)
id Plot an individual-level path diagram by specifying ID number.
digits Number of significant digits to show on graph. (Default = 2.)
... Other arguments passed on to qgraph::qgraph().

Details
Plots a path diagram of the mediation model, with estimated parameter values and credible intervals. Can also be used to draw a template diagram of the mediation model by not specifying input to the mod argument.

To modify various settings of the underlying qgraph object, see qgraph.

Value
A qgraph object.
Author(s)
Matti Vuorre <mv2521@columbia.edu>

Examples

# Draw a template path diagram of the mediation model
mlm_path_plot()

---

**mlm_spaghetti_plot**  
*Plot fitted values of M and Y from multilevel mediation model*

Description

Plot population-level fitted values and X values, for M and Y.

Usage

```r
mlm_spaghetti_plot(
  mod = NULL,
  d = NULL,
  id = "id",
  x = "x",
  m = "m",
  y = "y",
  level = 0.95,
  n = 12,
  binary_y = FALSE,
  mx = "fitted",
  fixed = TRUE,
  random = TRUE,
  h_jitter = 0,
  v_jitter = 0,
  bar_width = 0.2,
  bar_size = 0.75,
  n_samples = NA
)
```

Arguments

- `mod` A multilevel mediation model estimated with `mlm()`.
- `d` A `data.frame` or a `data_frame` used in fitting model.
- `id` Name of id variable (identifying subjects) in data (`d`).
- `x` Name of X variable in data.
- `m` Name of M variable in data.
- `y` Name of Y variable in data.
mlm_summary

level  X level for Credible Intervals. (Defaults to .95.)
n    Number of points along X to evaluate fitted values on. See details.
binary_y  Set to TRUE if the outcome variable (Y) is 0/1.
mx  Should the X axis of the M-Y figure be "fitted" values, or "data" values. Defaults to "fitted".
fixed  Should the population-level ("fixed") fitted values be shown?
random  Should the subject-level ("random") fitted values be shown?
h_jitter  Horizontal jitter of points. Defaults to 0.
v_jitter  Vertical jitter of points. Defaults to 0.
bar_width  Width of the error bars. Defaults to 0.2.
bar_size  Thickness of the error bars. Defaults to 0.75.
n_samples  Number of MCMC samples to use in calculating fitted values. See details.

Details

If n = 2, the fitted values will be represented as points with X line with a Confidence Ribbon instead. If a very large model is fitted with a large number of MCMC iterations, the function might take a long time to run. In these cases, users can set n_samples to a smaller value (e.g. 1000), in which case the fitted values (and the CIs) will be based on a random subset of n_samples MCMC samples. The default value is NA, meaning that all MCMC samples are used.

Value

A list of two ggplot2 objects.

Author(s)

Matti Vuorre <mv2521@columbia.edu>

mlm_summary  Print a summary of the estimated multilevel mediation model

Description

Prints the estimated parameters (numerical summaries of the marginal posterior distributions).

Usage

mlm_summary(
  mod = NULL,
  level = 0.95,
  pars = c("a", "b", "cp", "me", "c", "pme"),
  digits = 2
)
mlm_summary

Arguments

- **mod**: A stanfit object obtained from `mlm()`
- **level**: "Confidence" level; Defines the limits of the credible intervals. Defaults to .95 (i.e. displays 95% CIs.)
- **pars**: Parameters to summarize. Defaults to main average-level parameters. See Details for more information.
- **digits**: How many decimal points to display in the output. Defaults to 2.

Details

After estimating a model (drawing samples from the joint posterior probability distribution) with `mlm()`, show the estimated results by using `mlm_summary(fit)`, where `fit` is an object containing the fitted model.

The function shows, for each parameter specified with `pars`, the posterior mean, and limits of the Credible Interval as specified by `level`. For example, `level = .91` shows a 91% Credible Interval, which summarizes the central 91% mass of the marginal posterior distribution.

**Parameters**: By default, `mlm()` estimates and returns a large number of parameters, including the varying effects, and their associated standard deviations. However, `mlm_summary()` by default only displays a subset of the estimated parameters:

- **a**: Regression slope of the X -> M relationship.
- **b**: Regression slope of the M -> Y relationship.
- **cp**: Regression slope of the X -> Y relationship. (Direct effect.)
- **me**: Mediated effect ($a \cdot b + \sigma_{a_j}b_j$).
- **c**: Total effect of X on Y. ($cp + me$)
- **pme**: Percent mediated effect.

The user may specify `pars = NULL` to display all estimated parameters. Other options include e.g. `pars = "tau"` to display the varying effects’ standard deviations. To display all the group-level parameters (also known as random effects) only, specify `pars = "random"`. With this argument, `mlm_summary()` prints the following parameters:

- **tau_a**: Standard deviation of subject-level $a_{-j}$s.
- **tau_b**: Standard deviation of subject-level $b_{-j}$s.
- **tau_cp**: Standard deviation of subject-level $c_{-j}$s.
- **covab**: Estimated covariance of $a_{-j}$ and $b_{-j}$s.
- **corrab**: Estimated correlation of $a_{-j}$ and $b_{-j}$s.

To learn more about the additional parameters, refer to the Stan code (`cat(get_stancode(fit))`).

Value

A data.frame summarizing the estimated multilevel mediation model:

- **Parameter**: Name of parameter
- **Mean**: Mean of parameter’s posterior distribution.
- **Median**: Median of parameter’s posterior distribution.
SE  Standard deviation of parameter’s posterior distribution.

.ci_lwr  The lower limit of Credible Intervals.

.ci_upr  The upper limit of Credible Intervals.

.n_eff  Number of efficient samples.

.Rhat  Should be 1.00.

Author(s)

Matti Vuorre <mv2521@columbia.edu>
Index

* datasets
  BLch9, 2
  MEC2010, 4

BLch9, 2
bmlm (bmlm-package), 2
bmlm-package, 2
isolate, 3
MEC2010, 4
mlm, 4
mlm_pars_plot, 6
mlm_path_plot, 7
mlm_spaghetti_plot, 8
mlm_summary, 9
qgraph, 7