

Package ‘blavaan’

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Title Bayesian Latent Variable Analysis

Version 0.1-1

Description Fit a variety of Bayesian latent variable models, including confirmatory factor analysis, structural equation models, and latent growth curve models.

Depends R(>= 3.1.0), methods, runjags, lavaan(>= 0.5-20)

Imports stats, utils, graphics, MASS, MCMCpack, mnormt, nonnest2, loo

Suggests modeest, rjags, semTools

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Author Edgar Merkle [aut, cre],
Yves Rosseel [aut]

Maintainer Edgar Merkle <merkle@missouri.edu>

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R topics documented:

bcfa	2
BF	4
bgrowth	5
blavaan	7
blav_internal	8
bsem	9
dpriors	11

Index	13
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bcfa

*Fit Confirmatory Factor Analysis Models***Description**

Fit a Confirmatory Factor Analysis (CFA) model.

Usage

```
bcfa(..., ov.cp = "srs", lv.cp = "srs",
      dp = dpriors(), n.chains = 3, burnin, sample,
      adapt, jagfile = FALSE, jagextra = list(), inits = "prior",
      jagcontrol = list())
```

Arguments

...	Default lavaan arguments. See lavaan .
ov.cp	Handling of prior distributions on covariance parameters associated with observed variables: possible values are "srs" or "fa". Option "srs" is more flexible and better from a theoretical standpoint, but it is also slower.
lv.cp	Handling of prior distributions on covariance parameters associated with latent variables; see the ov.cp argument.
dp	Default prior distributions on different types of parameters, typically the result of a call to dpriors(). See the dpriors() help file for more information.
n.chains	Number of desired MCMC chains.
burnin	Number of burnin iterations, NOT including the adaptive iterations.
sample	The total number of samples to take after burnin.
adapt	The number of adaptive iterations to use at the start of the simulation.
jagfile	If TRUE, the JAGS model will be written to file (in the lavExport directory). Can also supply a character string, which serves as the name of the directory to which files will be written.
jagextra	A list with potential names syntax and monitor. The syntax object is a text string containing extra code to insert in the JAGS model syntax, and the monitor object is a character vector containing extra JAGS parameters to sample.
inits	If it is a character string, the options are currently "simple", "Mplus", "prior" (default), and "jags". In the first two cases, parameter values are set as though they will be estimated via ML (see lavaan). The starting parameter value for each chain is then perturbed from the original values through the addition of uniform noise. If "prior" is used, the starting parameter values are obtained based on the prior distributions (while also trying to ensure that the starting values will not crash the model estimation). If "jags", no starting values are specified and JAGS will choose values on its own. If start is a fitted object of class lavaan , the estimated values of the corresponding parameters will be extracted, then perturbed in the manner described above. If it is a model list, for

example the output of the `parameterEstimates()` function, the values of the `est` or `start` or `ustart` column (whichever is found first) will be extracted.

`jagcontrol` A list containing additional parameters passed to `"run.jags"`. See the manpage of [run.jags](#) for an overview of the additional parameters that can be set. No other model estimation functions are currently available.

Details

The `bcfa` function is a wrapper for the more general [blavaan](#) function, using the following default [lavaan](#) arguments: `int.ov.free = TRUE`, `int.lv.free = FALSE`, `auto.fix.first = TRUE` (unless `std.lv = TRUE`), `auto.fix.single = TRUE`, `auto.var = TRUE`, `auto.cov.lv.x = TRUE`, `auto.th = TRUE`, `auto.delta = TRUE`, and `auto.cov.y = TRUE`.

Value

An object of class [lavaan](#), for which several methods are available, including a summary method.

References

Yves Rosseel (2012). `lavaan`: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, 48(2), 1-36. URL <http://www.jstatsoft.org/v48/i02/>.

Edgar C. Merkle & Yves Rosseel (2015). `blavaan`: Bayesian Structural Equation Models via Parameter Expansion.

See Also

[blavaan](#)

Examples

```
## Not run:
# The Holzinger and Swineford (1939) example
HS.model <- ' visual =~ x1 + x2 + x3
             textual =~ x4 + x5 + x6
             speed  =~ x7 + x8 + x9 '

fit <- bcfa(HS.model, data=HolzingerSwineford1939,
           jagcontrol=list(method="rjparallel"))
summary(fit)

## End(Not run)
```

BF *log-Bayes factor approximation*

Description

log-Bayes factor approximation.

Usage

```
BF(object1, object2, ...)
```

Arguments

object1	An object of class blavaan.
object2	A second object of class blavaan.
...	Other arguments (unused for now).

Details

This function approximates the log-Bayes factor of two candidate models using the Laplace approximation to each model's marginal log-likelihood.

Value

The log-Bayes factor approximation, along with each model's approximate marginal log-likelihood.

References

Raftery, A. E. (1993). Bayesian model selection in structural equation models. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 163-180). Beverly Hills, CA: Sage.

Examples

```
## Not run:
hsm1 <- ' visual =~ x1 + x2 + x3 + x4
        textual =~ x4 + x5 + x6
        speed  =~ x7 + x8 + x9 '

fit1 <- bcfa(hsm1, data=HolzingerSwineford1939)

hsm2 <- ' visual =~ x1 + x2 + x3
        textual =~ x4 + x5 + x6 + x7
        speed  =~ x7 + x8 + x9 '

fit2 <- bcfa(hsm2, data=HolzingerSwineford1939)

BF(fit1, fit2)

## End(Not run)
```

bgrowth

*Fit Growth Curve Models***Description**

Fit a Growth Curve model.

Usage

```
bgrowth(..., ov.cp = "srs", lv.cp = "srs", dp = dpriors(), n.chains = 3,
burnin, sample, adapt, jagfile = FALSE, jagextra = list(),
inits = "prior", jagcontrol = list())
```

Arguments

...	Default lavaan arguments. See lavaan .
ov.cp	Handling of prior distributions on covariance parameters associated with observed variables: possible values are "srs" or "fa". Option "srs" is more flexible and better from a theoretical standpoint, but it is also slower.
lv.cp	Handling of prior distributions on covariance parameters associated with latent variables; see the ov.cp argument.
dp	Default prior distributions on different types of parameters, typically the result of a call to dpriors(). See the dpriors() help file for more information.
n.chains	Number of desired MCMC chains.
burnin	Number of burnin iterations, NOT including the adaptive iterations.
sample	The total number of samples to take after burnin.
adapt	The number of adaptive iterations to use at the start of the simulation.
jagfile	If TRUE, the JAGS model will be written to file (in the lavExport directory). Can also supply a character string, which serves as the name of the directory to which files will be written.
jagextra	A list with potential names syntax and monitor. The syntax object is a text string containing extra code to insert in the JAGS model syntax, and the monitor object is a character vector containing extra JAGS parameters to sample.
inits	If it is a character string, the options are currently "simple", "Mplus", "prior" (default), and "jags". In the first two cases, parameter values are set as though they will be estimated via ML (see lavaan). The starting parameter value for each chain is then perturbed from the original values through the addition of uniform noise. If "prior" is used, the starting parameter values are obtained based on the prior distributions (while also trying to ensure that the starting values will not crash the model estimation). If "jags", no starting values are specified and JAGS will choose values on its own. If start is a fitted object of class lavaan , the estimated values of the corresponding parameters will be extracted, then perturbed in the manner described above. If it is a model list, for example the output of the parameterEstimates() function, the values of the est or start or ustart column (whichever is found first) will be extracted.

`jagcontrol` A list containing additional parameters passed to "run.jags". See the manpage of `run.jags` for an overview of the additional parameters that can be set. No other model estimation functions are currently available.

Details

The `bgrowth` function is a wrapper for the more general `blavaan` function, using the following default `lavaan` arguments: `meanstructure = TRUE`, `int.ov.free = FALSE`, `int.lv.free = TRUE`, `auto.fix.first = TRUE` (unless `std.lv = TRUE`), `auto.fix.single = TRUE`, `auto.var = TRUE`, `auto.cov.lv.x = TRUE`, `auto.th = TRUE`, `auto.delta = TRUE`, and `auto.cov.y = TRUE`.

Value

An object of class `blavaan`, for which several methods are available, including a summary method.

References

Yves Rosseel (2012). `lavaan`: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, 48(2), 1-36. URL <http://www.jstatsoft.org/v48/i02/>.

Edgar C. Merkle & Yves Rosseel (2015). `blavaan`: Bayesian Structural Equation Models via Parameter Expansion.

See Also

[blavaan](#)

Examples

```
## Not run:
## linear growth model with a time-varying covariate
model.syntax <- '
  # intercept and slope with fixed coefficients
  i =~ 1*t1 + 1*t2 + 1*t3 + 1*t4
  s =~ 0*t1 + 1*t2 + 2*t3 + 3*t4

  # regressions
  i ~ x1 + x2
  s ~ x1 + x2

  # time-varying covariates
  t1 ~ c1
  t2 ~ c2
  t3 ~ c3
  t4 ~ c4
'

fit <- bgrowth(model.syntax, data=Demo.growth)
summary(fit)

## End(Not run)
```

lavaan

*Fit a Bayesian Latent Variable Model***Description**

Fit a Bayesian latent variable model.

Usage

```
lavaan(..., ov.cp = "srs", lv.cp = "srs",
        dp = dpriors(), n.chains = 3, burnin, sample,
        adapt, jagfile = FALSE, jagextra = list(), inits = "prior",
        jagcontrol = list())
```

Arguments

...	Default lavaan arguments. See lavaan .
ov.cp	Handling of prior distributions on covariance parameters associated with observed variables: possible values are "srs" or "fa". Option "srs" is more flexible and better from a theoretical standpoint, but it is also slower.
lv.cp	Handling of prior distributions on covariance parameters associated with latent variables; see the ov.cp argument.
dp	Default prior distributions on different types of parameters, typically the result of a call to <code>dpriors()</code> . See the <code>dpriors()</code> help file for more information.
n.chains	Number of desired MCMC chains.
burnin	Number of burnin iterations, NOT including the adaptive iterations.
sample	The total number of samples to take after burnin.
adapt	The number of adaptive iterations to use at the start of the simulation.
jagfile	If TRUE, the JAGS model and data will be written to files (in the <code>lavExport</code> directory). Can also supply a character string, which serves as the name of the directory to which files will be written.
jagextra	A list with potential names <code>syntax</code> and <code>monitor</code> . The <code>syntax</code> object is a text string containing extra code to insert in the JAGS model syntax, and the <code>monitor</code> object is a character vector containing extra JAGS parameters to sample.
inits	If it is a character string, the options are currently "simple", "Mplus", "prior" (default), or "jags". In the first two cases, parameter values are set as though they will be estimated via ML (see lavaan). The starting parameter value for each chain is then perturbed from the original values through the addition of random uniform noise. If "prior" is used, the starting parameter values are obtained based on the prior distributions (while also trying to ensure that the starting values will not crash the model estimation). If "jags", no starting values are specified and JAGS will choose values on its own. If <code>start</code> is a fitted object of class lavaan , the estimated values of the corresponding parameters will be extracted, then perturbed in the manner described above. If it is a model list, for

example the output of the `parameterEstimates()` function, the values of the `est` or `start` or `ustart` column (whichever is found first) will be extracted.

`jagcontrol` A list containing additional parameters passed to "run.jags". See the manpage of [run.jags](#) for an overview of the additional parameters that can be set. No other model estimation functions are currently available.

Value

An object of class `lavaan`, for which several methods are available, including a summary method.

References

Yves Rosseel (2012). `lavaan`: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, 48(2), 1-36. URL <http://www.jstatsoft.org/v48/i02/>.

Edgar C. Merkle & Yves Rosseel (2015). `blavaan`: Bayesian Structural Equation Models via Parameter Expansion.

See Also

[bcfa](#), [bsem](#), [bgrowth](#)

Examples

```
## Not run:
# The Holzinger and Swineford (1939) example
HS.model <- ' visual =~ x1 + x2 + x3
             textual =~ x4 + x5 + x6
             speed  =~ x7 + x8 + x9 '

fit <- blavaan(HS.model, data=HolzingerSwineford1939,
              auto.var=TRUE, auto.fix.first=TRUE,
              auto.cov.lv.x=TRUE,
              jagcontrol=list(method="rjparallel"))
summary(fit)

## End(Not run)
```

blav_internal

blavaan internal functions

Description

Internal functions related to Bayesian model estimation. Not to be called by the user.

bsem *Fit Structural Equation Models*

Description

Fit a Structural Equation Model (SEM).

Usage

```
bsem(..., ov.cp = "srs", lv.cp = "srs",
      dp = dpriors(), n.chains = 3, burnin, sample,
      adapt, jagfile = FALSE, jagextra = list(), inits = "prior",
      jagcontrol = list())
```

Arguments

...	Default lavaan arguments. See lavaan .
ov.cp	Handling of prior distributions on covariance parameters associated with observed variables: possible values are "srs" or "fa". Option "srs" is more flexible and better from a theoretical standpoint, but it is also slower.
lv.cp	Handling of prior distributions on covariance parameters associated with latent variables; see the ov.cp argument.
dp	Default prior distributions on different types of parameters, typically the result of a call to dpriors(). See the dpriors() help file for more information.
n.chains	Number of desired MCMC chains.
burnin	Number of burnin iterations, NOT including the adaptive iterations.
sample	The total number of samples to take after burnin.
adapt	The number of adaptive iterations to use at the start of the simulation.
jagfile	If TRUE, the JAGS model will be written to file (in the lavExport directory). Can also supply a character string, which serves as the name of the directory to which files will be written.
jagextra	A list with potential names syntax and monitor. The syntax object is a text string containing extra code to insert in the JAGS model syntax, and the monitor object is a character vector containing extra JAGS parameters to sample.
inits	If it is a character string, the options are currently "simple", "Mplus", "prior" (default), and "jags". In the first two cases, parameter values are set as though they will be estimated via ML (see lavaan). The starting parameter value for each chain is then perturbed from the original values through the addition of uniform noise. If "prior" is used, the starting parameter values are obtained based on the prior distributions (while also trying to ensure that the starting values will not crash the model estimation). If "jags", no starting values are specified and JAGS will choose values on its own. If start is a fitted object of class lavaan , the estimated values of the corresponding parameters will be extracted, then perturbed in the manner described above. If it is a model list, for

example the output of the `parameterEstimates()` function, the values of the `est` or `start` or `ustart` column (whichever is found first) will be extracted.

`jagcontrol` A list containing additional parameters passed to "run.jags". See the manpage of `run.jags` for an overview of the additional parameters that can be set. No other model estimation functions are currently available.

Details

The `bsem` function is a wrapper for the more general `blavaan` function, using the following default `lavaan` arguments: `int.ov.free = TRUE`, `int.lv.free = FALSE`, `auto.fix.first = TRUE` (unless `std.lv = TRUE`), `auto.fix.single = TRUE`, `auto.var = TRUE`, `auto.cov.lv.x = TRUE`, `auto.th = TRUE`, `auto.delta = TRUE`, and `auto.cov.y = TRUE`.

Value

An object of class `lavaan`, for which several methods are available, including a summary method.

References

Yves Rosseel (2012). `lavaan`: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, 48(2), 1-36. URL <http://www.jstatsoft.org/v48/i02/>.

Edgar C. Merkle & Yves Rosseel (2015). `blavaan`: Bayesian Structural Equation Models via Parameter Expansion.

See Also

`blavaan`

Examples

```
## Not run:
## The industrialization and Political Democracy Example
## Bollen (1989), page 332
model <- '
  # latent variable definitions
  ind60 =~ x1 + x2 + x3
  dem60 =~ y1 + a*y2 + b*y3 + c*y4
  dem65 =~ y5 + a*y6 + b*y7 + c*y8

  # regressions
  dem60 ~ ind60
  dem65 ~ ind60 + dem60

  # residual correlations
  y1 ~~ y5
  y2 ~~ y4 + y6
  y3 ~~ y7
  y4 ~~ y8
  y6 ~~ y8
'
```

```
## unique priors for mv intercepts; parallel chains
fit <- bsem(model, data=PoliticalDemocracy,
           dp=dpriors(nu="dnorm(5,1e-2)"),
           jagcontrol=list(method="rjparallel"))
summary(fit)

## End(Not run)
```

dpriors *Specify default prior distributions*

Description

Specify "default" prior distributions for classes of model parameters.

Usage

```
dpriors(nu = "dnorm(0,1e-3)", alpha = "dnorm(0,1e-2)",
       lambda = "dnorm(0,1e-2)", beta = "dnorm(0,1e-2)",
       itheta = "dgamma(1,.5)", ipsi = "dgamma(1,.5)",
       rho = "dbeta(1,1)", ibpsi = "dwish(iden,3)")
```

Arguments

nu	Prior distribution for nu (observed variable intercept) parameters.
alpha	Prior distribution for alpha (latent variable intercept) parameters.
lambda	Prior distribution for lambda (loading) parameters.
beta	Prior distribution for regression parameters.
itheta	Prior distribution for observed variable precision parameters.
ipsi	Prior distribution for latent variable precision parameters.
rho	Prior distribution for correlation parameters (only used under srs approach).
ibpsi	Prior distribution for inverse covariance matrix of blocks of latent variables.

Details

User-specified prior distributions for specific parameters (using the `prior()` operator within the model syntax) always override prior distributions set using `dpriors()`.

Value

A character vector containing the prior distribution for each type of parameter.

References

Edgar C. Merkle & Yves Rosseel (2015). *blavaan: Bayesian Structural Equation Models via Parameter Expansion*.

See Also

[bcfa](#), [bsem](#), [bgrowth](#)

Examples

```
dpriors(nu = "dunif(0,10)", lambda = "dnorm(0,1e-2) T(0,)", itheta = "dexp(1)")
```

Index

bcfa, [2](#), [8](#), [12](#)
BF, [4](#)
bgrowth, [5](#), [8](#), [12](#)
blav_internal, [8](#)
blav_model_test (blav_internal), [8](#)
lavaan, [3](#), [6](#), [7](#), [10](#)
bsem, [8](#), [9](#), [12](#)

coefffun (blav_internal), [8](#)

dpriors, [11](#)

lavaan, [2](#), [3](#), [5–10](#)

run.jags, [3](#), [6](#), [8](#), [10](#)

set_inits (blav_internal), [8](#)
set_phantoms (blav_internal), [8](#)
set_priors (blav_internal), [8](#)