bayes: meglm — Bayesian multilevel generalized linear model

Description

bayes: meglm fits a Bayesian multilevel generalized linear model to outcomes of different types such as continuous, binary, count, and so on; see [BAYES] bayes and [ME] meglm for details.

Quick start

Bayesian two-level generalized linear model of y on x1 and x2 with random intercepts by id, using the Gaussian family and log link, and using default normal priors for regression coefficients and default inverse-gamma prior for the variance of random intercepts

```
bayes: meglm y x1 x2 || id:, family(gaussian) link(log)
```

Use a standard deviation of 10 instead of 100 for the default normal priors

```
bayes, normalprior(10): meglm y x1 x2 || id:, family(gaussian) link(log)
```

Use uniform priors for the slopes and a normal prior for the intercept

```
bayes, prior({y: x1 x2}, uniform(-10,10)) ///
prior({y:_cons}, normal(0,10)): ///
meglm y x1 x2 || id:, family(gaussian) link(log)
```

Save simulation results to simdata.dta, and use a random-number seed for reproducibility

```
bayes, saving(simdata) rseed(123): ///
meglm y x1 x2 || id:, family(gaussian) link(log)
```

Specify 20,000 MCMC samples, set length of the burn-in period to 5,000, and request that a dot be displayed every 500 simulations

```
bayes, mcmcsize(20000) burnin(5000) dots(500): ///
meglm y x1 x2 || id:, family(gaussian) link(log)
```

In the above, request that the 90% HPD credible interval be displayed instead of the default 95% equal-tailed credible interval

```
bayes, clevel(90) hpd
```

Fit a logit model and display results as odds ratios

```
bayes: meglm z x1 x2 || id:, family(binomial) eform
```

Display odds ratios on replay

```
bayes, eform
```

Also see Quick start in [BAYES] bayes and Quick start in [ME] meglm.

Menu

Statistics > Multilevel mixed-effects models > Bayesian regression > Generalized linear model (GLM)
Syntax

\[
\text{bayes } [ , \text{ bayesopts} ] : \text{meglm } \text{depvar } \text{fe\_equation} \\
\quad [ \mid \mid \text{re\_equation} ] [ \mid \mid \text{re\_equation} \ldots ] [ , \text{options} ]
\]

where the syntax of \textit{fe\_equation} is

\[
\text{[indepvars]} [ \text{if} ] [ \text{in} ] [ \text{weight} ] [ , \text{fe\_options} ]
\]

and the syntax of \textit{re\_equation} is one of the following:

for random coefficients and intercepts

\[
\text{levelvar: [varlist]} [ , \text{re\_options} ]
\]

for random effects among the values of a factor variable

\[
\text{levelvar: R.varname}
\]

\textit{levelvar} either is a variable identifying the group structure for the random effects at that level or is \_all, representing one group comprising all observations.

\begin{tabular}{ll}
\hline
\textit{fe\_options} & Description \\
\hline
\textbf{Model} & \\
\textbf{noconstant} & suppress constant term from the fixed-effects equation \\
\textbf{exposure(\textit{varname}_e)} & include \text{ln(\textit{varname}_e)} in model with coefficient constrained to 1 \\
\textbf{offset(\textit{varname}_o)} & include \textit{varname}_o in model with coefficient constrained to 1 \\
\textbf{asis} & retain perfect predictor variables \\
\hline
\textbf{re\_options} & Description \\
\hline
\textbf{Model} & \\
\textbf{covariance(\textit{vartype})} & variance–covariance structure of the random effects; only structures \text{independent, identity, and unstructured} supported \\
\textbf{noconstant} & suppress constant term from the random-effects equation \\
\end{tabular}
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### Options

**Model**

- `family(family)`
  - distribution of `depvar`; default is `family(gaussian)`
- `link(link)`
  - link function; default varies per family

**Reporting**

- `eform`
  - report exponentiated coefficients
- `irr`
  - report incidence-rate ratios
- `or`
  - report odds ratios
- `notable`
  - suppress coefficient table
- `noheader`
  - suppress output header
- `nogroup`
  - suppress table summarizing groups
- `display_options`
  - control spacing, line width, and base and empty cells
- `level(#)`
  - set credible level; default is `level(95)`

**bayesopts**

**Priors**

- `normalprior(#)`
  - specify standard deviation of default normal priors for regression coefficients; default is `normalprior(100)`
- `igammaprior(# #)`
  - specify shape and scale of default inverse-gamma prior for variance components; default is `igammaprior(0.01 0.01)`
- `iwishartprior(# [...])`
  - specify degrees of freedom and, optionally, scale matrix of default inverse-Wishart prior for unstructured random-effects covariance
- `prior(priorspec)`
  - prior for model parameters; this option may be repeated
- `dryrun`
  - show model summary without estimation

**Simulation**

- `nchains(#)`
  - number of chains; default is to simulate one chain
- `mcmcsize(#)`
  - MCMC sample size; default is `mcmcsize(10000)`
- `burnin(#)`
  - burn-in period; default is `burnin(2500)`
- `thinning(#)`
  - thinning interval; default is `thinning(1)`
- `rseed(#)`
  - random-number seed
- `exclude(paramref)`
  - specify model parameters to be excluded from the simulation results
- `restubs(restub1 restub2 ...)`
  - specify stubs for random-effects parameters for all levels

**Blocking**

- `blocksize(#)`
  - maximum block size; default is `blocksize(50)`
- `block(paramref[, blockopts])`
  - specify a block of model parameters; this option may be repeated
- `blocksummary`
  - display block summary
- `noblocking`
  - do not block parameters by default

---

`indevars` may contain factor variables; see [U] 11.4.3 Factor variables.

`depvar`, `indevars`, and `varlist` may contain time-series operators; see [U] 11.4.4 Time-series varlists.

`fweights` are allowed; see [U] 11.1.6 weight.

`bayes: meglm, level()` is equivalent to `bayes, clevel(): meglm`.

For a detailed description of options, see `Options` in [ME] `meglm`. 
 Initialization

 - **initial)**: specify initial values for model parameters with a single chain
 - **init#**: specify initial values for #th chain; requires nchains()
 - **initall**: specify initial values for all chains; requires nchains()
 - **nomleinitial**: suppress the use of maximum likelihood estimates as starting values
 - **initrandom**: specify random initial values
 - **initsummary**: display initial values used for simulation
 - ***noisily**: display output from the estimation command during initialization

 Adaptation

 - **adaptation**,(adaptopts): control the adaptive MCMC procedure
 - **scale(#)**: initial multiplier for scale factor; default is scale(2.38)
 - **covariance(cov)**: initial proposal covariance; default is the identity matrix

 Reporting

 - **clevel(#)**: set credible interval level; default is clevel(95)
 - **hpd**: display HPD credible intervals instead of the default equal-tailed credible intervals
 - ***irr**: report incidence-rate ratios
 - ***or**: report odds ratios
 - **eform[ (string)]**: report exponentiated coefficients and, optionally, label as string
 - **remargl**: compute log marginal-likelihood
 - **batch(#)**: specify length of block for batch-means calculations; default is batch(0)
 - **saving(filename[, replace])**: save simulation results to filename.dta
 - **nomodelsummary**: suppress model summary
 - **nomesummary**: suppress multilevel-structure summary
 - **chainsdetail**: display detailed simulation summary for each chain
 - **[no]dots**: suppress dots or display dots every 100 iterations and iteration numbers every 1,000 iterations; default is dots
 - **dots(#[, every(#)])**: display dots as simulation is performed
 - **[no]show(paramref)**: specify model parameters to be excluded from or included in the output
 - **showeffects[(reref)]**: specify that all or a subset of random-effects parameters be included in the output

 Advanced

 - **melabel**: display estimation table using the same row labels as megilm
 - **nogroup**: suppress table summarizing groups
 - **notable**: suppress estimation table
 - **noheader**: suppress output header
 - **title(string)**: display string as title above the table of parameter estimates
 - **display_options**: control spacing, line width, and base and empty cells

 Advanced

 - **search(search_options)**: control the search for feasible initial values
 - **corrlag(#)**: specify maximum autocorrelation lag; default varies
 - **corrtol(#)**: specify autocorrelation tolerance; default is corrtol(0.01)
*Starred options are specific to the `bayes` prefix; other options are common between `bayes` and `bayesmh`.
Options `prior()` and `block()` may be repeated.
`priorspec` and `paramref` are defined in [BAYES] `bayesmh`.
`paramref` may contain factor variables; see [U] 11.4.3 Factor variables.
See [U] 20 Estimation and postestimation commands for more capabilities of estimation commands.
Model parameters are regression coefficients `{depvar:indepvars}`, parameters as described in Additional model parameters, random effects `{rename}`, and either variance components `{rename:sigma2}` or, if option covariance(unstructured) is specified, matrix parameter `{restub:Sigma,matrix}`; see Likelihood model in [BAYES] `bayes` for how `renames` and `restub` are defined. Use the `dryrun` option to see the definitions of model parameters prior to estimation.
For a detailed description of `bayesopts`, see Options in [BAYES] `bayes`.

Remarks and examples

For a general introduction to Bayesian analysis, see [BAYES] Intro. For a general introduction to Bayesian estimation using an adaptive Metropolis–Hastings algorithm, see [BAYES] `bayesmh`. For remarks and examples specific to the `bayes` prefix, see [BAYES] `bayes`. For details about the estimation command, see [ME] `meglm`.

For a simple example of the `bayes` prefix, see Introductory example in [BAYES] `bayes`. For multilevel examples, see Multilevel models in [BAYES] `bayes`. Also see Crossed-effects model in [BAYES] `bayes`.

Additional model parameters

In addition to regression coefficients `{depvar:indepvars}`, `bayes: meglm` defines extra parameters that depend on the chosen family; see table 1 below.

Table 1. Additional model parameters defined by `bayes: meglm`

<table>
<thead>
<tr>
<th>Family</th>
<th>Parameter</th>
<th>Model parameter</th>
<th>Default prior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaussian</td>
<td>Error variance</td>
<td><code>{e.depvar:sigma2}</code></td>
<td>InvGamma(0.01, 0.01)</td>
</tr>
<tr>
<td>Bernoulli/Binomial</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ordinal</td>
<td>Cutpoints</td>
<td><code>{cut1},{cut2},...</code></td>
<td>Flat</td>
</tr>
<tr>
<td>Poisson</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Negative binomial</td>
<td>Log-overdispersion</td>
<td><code>{lnalpha} (mean disp.)</code></td>
<td>N(0, 10000)</td>
</tr>
<tr>
<td>Gamma</td>
<td>Log-scale</td>
<td><code>{lnscale}</code></td>
<td>N(0, 10000)</td>
</tr>
</tbody>
</table>

Use the `dryrun` option with the `bayes` prefix to see the definitions of model parameters prior to estimation.

Stored results

See Stored results in [BAYES] `bayes`.
Methods and formulas

See Methods and formulas in [BAYES] bayesmh.

Also see

[BAYES] bayes — Bayesian regression models using the bayes prefix
[ME] meglm — Multilevel mixed-effects generalized linear model
[BAYES] Bayesian postestimation — Postestimation tools for bayesmh and the bayes prefix
[BAYES] Bayesian estimation — Bayesian estimation commands
[BAYES] Bayesian commands — Introduction to commands for Bayesian analysis
[BAYES] Intro — Introduction to Bayesian analysis
[BAYES] Glossary