

# Package ‘gigg’

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**Type** Package

**Title** Group Inverse-Gamma Gamma Shrinkage for Sparse Regression with Grouping Structure

**Version** 0.2.1

**Description** A Gibbs sampler corresponding to a Group Inverse-Gamma Gamma (GIGG) regression model with adjustment covariates. Hyperparameters in the GIGG prior specification can either be fixed by the user or can be estimated via Marginal Maximum Likelihood Estimation. Jonathan Boss, Jyotishka Datta, Xin Wang, Sung Kyun Park, Jian Kang, Bhramar Mukherjee (2021) <arXiv:2102.10670>.

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**BugReports** <https://github.com/umich-cphds/gigg/issues>

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**R topics documented:**

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chol_solve	<i>Solve function with Cholesky decomposition.</i>
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**Description**

An Rcpp function that solves  $M*U = V$ .

**Usage**

```
chol_solve(M, V)
```

**Arguments**

M	A (M x M) symmetric positive definite matrix.
V	A (M x 1) vector.

**Value**

The solution to  $M*U = V$ .

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concentrated	<i>Example data set</i>
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**Description**

Contains a list with data and parameters to run the package examples. Please see ?gigg\_fixed and ?grouped\_igg\_mmle pages for use.

**Usage**

```
concentrated
```

**Format**

An object of class list of length 15.

**Examples**

```
concentrated
names(concentrated)
```

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digamma_inv	<i>Inverse digamma function.</i>
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**Description**

Evaluate the inverse digamma function.

**Usage**

```
digamma_inv(y, precision = 1e-08)
```

**Arguments**

y	value to evaluate the inverse digamma function at.
precision	default = 1e-08.

**Value**

Numeric inverse digamma value.

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distributed	<i>Example data set</i>
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**Description**

Contains a list with data and parameters to run the package examples. Please see ?gigg\_fixed and ?grouped\_igg\_mmle pages for use.

**Usage**

```
distributed
```

**Format**

An object of class list of length 15.

**Examples**

```
distributed
names(distributed)
```

gigg

*GIGG regression***Description**

Perform GIGG (Group Inverse-Gamma Gamma) regression. This package implements a Gibbs sampler corresponding to a Group Inverse-Gamma Gamma (GIGG) regression model with adjustment covariates. Hyperparameters in the GIGG prior specification can either be fixed by the user or can be estimated via Marginal Maximum Likelihood Estimation.

**Usage**

```
gigg(
  X,
  C,
  Y,
  method = "mmle",
  grp_idx,
  alpha_inits = rep(0, ncol(C)),
  beta_inits = rep(0, ncol(X)),
  a = rep(0.5, length(unique(grp_idx))),
  b = rep(0.5, length(unique(grp_idx))),
  sigma_sq_init = 1,
  tau_sq_init = 1,
  n_burn_in = 500,
  n_samples = 1000,
  n_thin = 1,
  verbose = TRUE,
  btrick = FALSE,
  stable_solve = TRUE
)
```

**Arguments**

X	A (n x p) matrix of covariates that to apply GIGG shrinkage on.
C	A (n x k) matrix of covariates that to apply no shrinkage on (typically intercept + adjustment covariates).
Y	A length n vector of responses.
method	Either fixed for GIGG regression with fixed hyperparameters or mmle for GIGG regression with MMLE. Defaults to method = "mmle".
grp_idx	A length p integer vector indicating which group of the G groups the p covariates in X belong to. The grp_idx vector must be a sequence from 1 to G with no skips. A valid example is 1,1,1,2,2,3,3,3,4,5,5.
alpha_inits	A length k vector containing initial values for the regression coefficients corresponding to C.

beta_inits	A length $p$ vector containing initial values for the regression coefficients corresponding to $X$ .
a	A length $G$ vector of shape parameters for the prior on the group shrinkage parameters. The $a$ parameter is only used if the user selects <code>method = 'fixed'</code> . If <code>method = 'mmle'</code> , then $a = \text{rep}(1/n, \text{length}(\text{unique}(\text{grp\_idx})))$ .
b	A length $G$ vector of shape parameters for the prior on the individual shrinkage parameters. If <code>method = 'mmle'</code> , then the $b$ is used as an initial value for the MMLE procedure.
sigma_sq_init	Initial value for the residual error variance (double).
tau_sq_init	Initial value for the global shrinkage parameter (double).
n_burn_in	The number of burn-in samples (integer).
n_samples	The number of posterior draws (integer).
n_thin	The thinning interval (integer).
verbose	Boolean value which indicates whether or not to print the progress of the Gibbs sampler.
btrick	Boolean value which indicates whether or not to use the computational trick in Bhattacharya et al. (2016). Only recommended if number of covariates is much larger than the number of observations.
stable_solve	Boolean value which indicates whether or not to use Cholesky decomposition during the update of the regression coefficients corresponding to $X$ . In our experience, <code>stable_solve = TRUE</code> is slightly slower, but more stable.

## Value

A list containing

- "draws" - A list containing the posterior draws of
  - (1) the regression coefficients (alphas and betas)
  - (2) the individual shrinkage parameters (`lambda_sqs`)
  - (3) the group shrinkage parameters (`gamma_sqs`)
  - (4) the global shrinkage parameter (`tau_sqs`) and
  - (5) the residual error variance (`sigma_sqs`).
 The list also contains details regarding the dataset ( $X$ ,  $C$ ,  $Y$ , `grp_idx`) and Gibbs sampler details (`n_burn_in`, `n_samples`, and `n_thin`).
- "beta.hat" - Posterior mean of betas
- "beta.lcl.95" - 95% credible interval lower bound of betas
- "beta.ucl.95" - 95% credible interval upper bound of betas
- "alpha.hat" - Posterior mean of alpha
- "alpha.lcl.95" - 95% credible interval lower bound of alphas
- "alpha.ucl.95" - 95% credible interval upper bound of alphas
- "sigma\_sq.hat" - Posterior mean of sigma squared
- "sigma\_sq.lcl.95" - 95% credible interval lower bound of sigma sq.
- "sigma\_sq.ucl.95" - 95% credible interval upper bound of sigma sq.

**References**

Boss, J., Datta, J., Wang, X., Park, S.K., Kang, J., & Mukherjee, B. (2021). Group Inverse-Gamma Gamma Shrinkage for Sparse Regression with Block-Correlated Predictors. [arXiv](#)

**Examples**

```
X = concentrated$X
C = concentrated$C
Y = as.vector(concentrated$Y)
grp_idx = concentrated$grps
alpha_inits = concentrated$alpha
beta_inits = concentrated$beta

gf = gigg(X, C, Y, method = "fixed", grp_idx, alpha_inits, beta_inits,
          n_burn_in = 200, n_samples = 500, n_thin = 1,
          verbose = TRUE, btrick = FALSE, stable_solve = FALSE)

gf_mmle = gigg(X, C, Y, method = "mmle", grp_idx, alpha_inits, beta_inits,
              n_burn_in = 200, n_samples = 500, n_thin = 1,
              verbose = TRUE, btrick = FALSE,
              stable_solve = FALSE)
```

---

`gigg_fixed_gibbs_sampler`

*Gibbs sampler for GIGG regression with fixed hyperparameters.*

---

**Description**

An Rcpp function that implements a Gibbs sampler for GIGG regression with fixed hyperparameters.

**Usage**

```
gigg_fixed_gibbs_sampler(
  X,
  C,
  Y,
  grp_idx,
  grp_size,
  grp_size_cs,
  alpha_inits,
  beta_inits,
  lambda_sq_inits,
  gamma_sq_inits,
  eta_inits,
  p,
```

```

q,
tau_sq_init = 1,
sigma_sq_init = 1,
nu_init = 1,
n_burn_in = 500L,
n_samples = 1000L,
n_thin = 1L,
stable_const = 1e-07,
verbose = TRUE,
btrick = FALSE,
stable_solve = FALSE
)

```

### Arguments

X	A (n x M) matrix of covariates that we want to apply GIGG shrinkage on.
C	A (n x K) matrix of covariates that we want to apply no shrinkage on (typically intercept + adjustment covariates).
Y	A (n x 1) column vector of responses.
grp_idx	A (1 x M) row vector indicating which group of the J groups the M covariates in X belong to.
grp_size	A (1 x J) row vector indicating the number of covariates in each group.
grp_size_cs	A (1 x J) row vector that is the cumulative sum of grp_size (indicating the indices where each group ends).
alpha_inits	A (K x 1) column vector containing initial values for the regression coefficients corresponding to C.
beta_inits	A (M x 1) column vector containing initial values for the regression coefficients corresponding to X.
lambda_sq_inits	A (M x 1) column vector containing initial values for the local shrinkage parameters.
gamma_sq_inits	A (J x 1) column vector containing initial values for the group shrinkage parameters.
eta_inits	A (J x 1) column vector containing initial values for the mixing parameters.
p	A (J x 1) column vector of shape parameter for the prior on the group shrinkage parameters.
q	A (J x 1) column vector of shape parameter for the prior on the individual shrinkage parameters.
tau_sq_init	Initial value for the global shrinkage parameter (double).
sigma_sq_init	Initial value for the residual variance (double).
nu_init	Initial value for the augmentation variable (double).
n_burn_in	The number of burn-in samples (integer).
n_samples	The number of posterior draws (integer).

<code>n_thin</code>	The thinning interval (integer).
<code>stable_const</code>	Parameter that controls numerical stability of the algorithm (double).
<code>verbose</code>	Boolean value which indicates whether or not to print the progress of the Gibbs sampler.
<code>btrick</code>	Boolean value which indicates whether or not to use the computational trick in Bhattacharya et al. (2016). Only recommended if number of covariates is much larger than the number of observations.
<code>stable_solve</code>	default to FALSE

**Value**

A list containing the posterior draws of (1) the regression coefficients (alphas and betas) (2) the individual shrinkage parameters (`lambda_sqs`) (3) the group shrinkage parameters (`gamma_sqs`) (4) the global shrinkage parameter (`tau_sqs`) and (5) the residual error variance (`sigma_sqs`). The list also contains details regarding the dataset (`X`, `C`, `Y`, `grp_idx`) and Gibbs sampler details (`n_burn_in`, `n_samples`, and `n_thin`).

---

`gigg_mmle_gibbs_sampler`

*Gibbs sampler for GIGG regression with hyperparameters estimated via MMLE.*

---

**Description**

An Rcpp function that implements a Gibbs sampler for GIGG regression with hyperparameters estimated via MMLE.

**Usage**

```
gigg_mmle_gibbs_sampler(
  X,
  C,
  Y,
  grp_idx,
  grp_size,
  grp_size_cs,
  alpha_inits,
  beta_inits,
  lambda_sq_inits,
  gamma_sq_inits,
  eta_inits,
  p_inits,
  q_inits,
  tau_sq_init = 1,
  sigma_sq_init = 1,
  nu_init = 1,
```

```

    n_burn_in = 500L,
    n_samples = 1000L,
    n_thin = 1L,
    stable_const = 1e-07,
    verbose = TRUE,
    btrick = FALSE,
    stable_solve = FALSE
)

```

### Arguments

X	A (n x M) matrix of covariates that we want to apply GIGG shrinkage on.
C	A (n x K) matrix of covariates that we want to apply no shrinkage on (typically intercept + adjustment covariates).
Y	A (n x 1) column vector of responses.
grp_idx	A (1 x M) row vector indicating which group of the J groups the M covariates in X belong to.
grp_size	A (1 x J) row vector indicating the number of covariates in each group.
grp_size_cs	A (1 x J) row vector that is the cumulative sum of grp_size (indicating the indices where each group ends).
alpha_inits	A (K x 1) column vector containing initial values for the regression coefficients corresponding to C.
beta_inits	A (M x 1) column vector containing initial values for the regression coefficients corresponding to X.
lambda_sq_inits	A (M x 1) column vector containing initial values for the local shrinkage parameters.
gamma_sq_inits	A (J x 1) column vector containing initial values for the group shrinkage parameters.
eta_inits	A (J x 1) column vector containing initial values for the mixing parameters.
p_inits	A (J x 1) column vector of initial shape parameter for the prior on the group shrinkage parameters.
q_inits	A (J x 1) column vector of initial shape parameter for the prior on the individual shrinkage parameters.
tau_sq_init	Initial value for the global shrinkage parameter (double).
sigma_sq_init	Initial value for the residual variance (double).
nu_init	Initial value for the augmentation variable (double).
n_burn_in	The number of burn-in samples (integer).
n_samples	The number of posterior draws (integer).
n_thin	The thinning interval (integer).
stable_const	Parameter that controls numerical stability of the algorithm (double).
verbose	Boolean value which indicates whether or not to print the progress of the Gibbs sampler.

btrick	Boolean value which indicates whether or not to use the computational trick in Bhattacharya et al. (2016). Only recommended if number of covariates is much larger than the number of observations.
stable_solve	default to FALSE

**Value**

A list containing the posterior draws of (1) the regression coefficients (alphas and betas) (2) the individual shrinkage parameters (lambda\_sqs) (3) the group shrinkage parameters (gamma\_sqs) (4) the global shrinkage parameter (tau\_sqs) and (5) the residual error variance (sigma\_sqs). The list also contains details regarding the dataset (X, C, Y, grp\_idx) and Gibbs sampler details (n\_burn\_in, n\_samples, and n\_thin).

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quick_solve	<i>Iterative one rank update for matrix inverse.</i>
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**Description**

An Rcpp function that computes the matrix inverse of  $XtX + D_{pos}$ .

**Usage**

```
quick_solve(XtX_inv, D_pos, vec_draw)
```

**Arguments**

XtX_inv	A precomputed (M x M) matrix inverse.
D_pos	A (M x 1) vector of the square root of the diagonal entries in the D matrix.
vec_draw	A (M x 1) vector drawn from a multivariate normal distribution.

**Value**

The solution to  $(XtX + D)*U = vec\_draw$ .

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rgig_cpp	<i>Randomly generate a generalized inverse gaussian random variable.</i>
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---

**Description**

Randomly generates one draw from a generalized inverse gaussian distribution.

**Usage**

```
rgig_cpp(chi, psi, lambda)
```

**Arguments**

<code>chi</code>	A positive double.
<code>psi</code>	A positive double.
<code>lambda</code>	A non-negative double.

**Value**

A random draw from the generalized inverse gaussian distribution with parameters `chi`, `psi`, and `lambda` (double).

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