

# Package ‘BoomSpikeSlab’

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**Title** MCMC for Spike and Slab Regression

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**Description** Spike and slab regression a la McCulloch and George (1997).

**Depends** Boom ( $\geq 0.8$ ) , R ( $\geq 3.1.0$ )

**LinkingTo** BH ( $\geq 1.65.0$ )

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```
scale.by.residual.variance = FALSE,
sigma.upper.limit = Inf)
```

### Arguments

<code>x</code>	The design matrix for the regression problem. Missing data is not allowed.
<code>y</code>	The vector of responses for the regression. Missing data is not allowed.
<code>expected.r2</code>	The expected R-square for the regression. The spike and slab prior requires an inverse gamma prior on the residual variance of the regression. The prior can be parameterized in terms of a guess at the residual variance, and a "degrees of freedom" representing the number of observations that the guess should weigh. The guess at $\sigma^2$ is set to $(1 - \text{expected.r2}) * \text{var}(y)$ .
<code>prior.df</code>	A positive scalar representing the prior 'degrees of freedom' for estimating the residual variance. This can be thought of as the amount of weight (expressed as an observation count) given to the <code>expected.r2</code> argument.
<code>expected.model.size</code>	A positive number less than $\text{ncol}(x)$ , representing a guess at the number of significant predictor $p$ variables. Used to obtain the 'spike' portion of the spike and slab prior.
<code>prior.beta.sd</code>	A vector of positive numbers giving the prior standard deviation of each model coefficient, conditional on inclusion. If NULL it will be set to $10 * \text{ratio of } \text{sd}_y / \text{sd}_x$ .
<code>optional.coefficient.estimate</code>	If desired, an estimate of the regression coefficients can be supplied. In most cases this will be a difficult parameter to specify. If omitted then a prior mean of zero will be used for all coordinates except the intercept, which will be set to $\text{mean}(y)$ .
<code>mean.y</code>	The mean of the response vector, for use in cases when specifying the response vector is undesirable.
<code>sd_y</code>	The standard deviation of the response vector, for use in cases when specifying the response vector is undesirable.
<code>sd_x</code>	The standard deviations to use when scaling the prior sd of each coefficient.
<code>prior.inclusion.probabilities</code>	A vector giving the prior probability of inclusion for each variable.
<code>number.of.observations</code>	The number of observations in the data to be modeled.
<code>number.of.variables</code>	The number of potential predictor variables in the data to be modeled.
<code>scale.by.residual.variance</code>	If TRUE the prior variance is $\text{sigma\_sq} * V$ , where $\text{sigma\_sq}$ is the residual variance of the linear regression modeled by this prior. Otherwise the prior variance is $V$ , unscaled.
<code>sigma.upper.limit</code>	The largest acceptable value for the residual standard deviation. A non-positive number is interpreted as Inf.

**Value**

A list with with the components necessary to run `lm.spike` with method "DA".

**Author(s)**

Steven L. Scott

**References**

Ghosh and Clyde (2011) "Rao-Blackwellization for Bayesian variable selection and model averaging in linear and binary regression: A novel data augmentation approach", *Journal of the American Statistical Association*, **106** 1041-1052. [http://homepage.stat.uiowa.edu/~jghsh/ghosh\\_clyde\\_2011\\_jasa.pdf](http://homepage.stat.uiowa.edu/~jghsh/ghosh_clyde_2011_jasa.pdf)

**Examples**

```
x <- cbind(1, matrix(rnorm(900), ncol = 9))
beta <- rep(0, 10)
beta[1] <- 3
beta[5] <- -4
beta[8] <- 2
y <- rnorm(100, x %>% beta)
## x has 10 columns, including the intercept
prior <- IndependentSpikeSlabPrior(x, y,
  expected.model.size = 3, # expect 3 nonzero predictors
  prior.df = .01, # weaker prior than the default
  optional.coefficient.estimate = rep(0, 10) # shrink to zero
)
## now 'prior' can be fed to 'lm.spike'
x <- x[, -1]
model <- lm.spike(y ~ x, niter = 1000, prior = prior, method = "DA")
```

---

independent.student.spike.slab.prior

*Spike and Slab Prior for Regressions with Student T Errors*

---

**Description**

A spike and slab prior on the parameters of a regression model with Student T errors. The prior assumes independence among the regression coefficients.

**Usage**

```
StudentIndependentSpikeSlabPrior(
  predictor.matrix = NULL,
  response.vector = NULL,
  expected.r2 = .5,
```

```

prior.df = .01,
expected.model.size = 1,
prior.beta.sd = NULL,
optional.coefficient.estimate = NULL,
mean.y = mean(response.vector, na.rm = TRUE),
sdy = sd(as.numeric(response.vector), na.rm = TRUE),
sdx = apply(as.matrix(predictor.matrix), 2, sd, na.rm = TRUE),
prior.inclusion.proBABILITIES = NULL,
number.of.observations = nrow(predictor.matrix),
number.of.variables = ncol(predictor.matrix),
scale.by.residual.variance = FALSE,
sigma.upper.limit = Inf,
degrees.of.freedom.prior = UniformPrior(.1, 100)

```

### Arguments

predictor.matrix	The design matrix for the regression problem. Missing data is not allowed.
response.vector	The vector of responses for the regression. Missing data is not allowed.
expected.r2	The expected R-square for the regression. The spike and slab prior requires an inverse gamma prior on the residual variance of the regression. The prior can be parameterized in terms of a guess at the residual variance, and a "degrees of freedom" representing the number of observations that the guess should weigh. The guess at $\sigma^2$ is set to $(1 - \text{expected.r2}) * \text{var}(y)$ .
prior.df	A positive scalar representing the prior 'degrees of freedom' for estimating the residual variance. This can be thought of as the amount of weight (expressed as an observation count) given to the expected.r2 argument.
expected.model.size	A positive number less than $\text{ncol}(x)$ , representing a guess at the number of significant predictor p variables. Used to obtain the 'spike' portion of the spike and slab prior.
prior.beta.sd	A vector of positive numbers giving the prior standard deviation of each model coefficient, conditional on inclusion. If NULL it will be set to $10 * \text{ratio of sdy / sdx}$ .
optional.coefficient.estimate	If desired, an estimate of the regression coefficients can be supplied. In most cases this will be a difficult parameter to specify. If omitted then a prior mean of zero will be used for all coordinates except the intercept, which will be set to $\text{mean}(y)$ .
mean.y	The mean of the response vector, for use in cases when specifying the response vector is undesirable.
sdy	The standard deviation of the response vector, for use in cases when specifying the response vector is undesirable.
sdx	The standard deviations to use when scaling the prior sd of each coefficient.
prior.inclusion.proBABILITIES	A vector giving the prior probability of inclusion for each variable.

`number.of.observations`  
 The number of observations in the data to be modeled.

`number.of.variables`  
 The number of potential predictor variables in the data to be modeled.

`scale.by.residual.variance`  
 If TRUE the prior variance is  $\text{sigma\_sq} * V$ , where  $\text{sigma\_sq}$  is the residual variance of the linear regression modeled by this prior. Otherwise the prior variance is  $V$ , unscaled.

`sigma.upper.limit`  
 The largest acceptable value for the residual standard deviation. A non-positive number is interpreted as Inf.

`degrees.of.freedom.prior`  
 An object of class `DoubleModel` representing the prior distribution for the Student T tail thickness (or "degrees of freedom") parameter.

### Value

An `IndependentSpikeSlabPrior` with `degrees.of.freedom.prior` appended.

### Author(s)

Steven L. Scott

### References

Ghosh and Clyde (2011) "Rao-Blackwellization for Bayesian variable selection and model averaging in linear and binary regression: A novel data augmentation approach", *Journal of the American Statistical Association*, **106** 1041-1052. [http://homepage.stat.uiowa.edu/~jghsh/ghosh\\_clyde\\_2011\\_jasa.pdf](http://homepage.stat.uiowa.edu/~jghsh/ghosh_clyde_2011_jasa.pdf)

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lm.spike

*Spike and slab regression*

---

### Description

MCMC algorithm for linear regression models with a 'spike-and-slab' prior that places some amount of posterior probability at zero for a subset of the regression coefficients.

The model admits either Gaussian or student T errors; the latter are useful in the presence of outliers.

### Usage

```
lm.spike(formula,
          niter,
          data,
          subset,
          prior = NULL,
          error.distribution = c("gaussian", "student"),
```

```

contrasts = NULL,
drop.unused.levels = TRUE,
bma.method = c("SSVS", "ODA"),
oda.options = list(
  fallback.probability = 0.0,
  eigenvalue.fudge.factor = 0.01),
ping = niter / 10,
seed = NULL,
...)
```

### Arguments

formula	formula for the maximal model (with all variables included), this is parsed the same way as a call to <code>lm</code> .
niter	The number of MCMC iterations to run. Be sure to include enough so you can throw away a burn-in set.
data	an optional data frame, list or environment (or object coercible by <code>'as.data.frame'</code> to a data frame) containing the variables in the model. If not found in <code>'data'</code> , the variables are taken from <code>'environment(formula)'</code> , typically the environment from which <code>'lm.spike'</code> is called..
subset	an optional vector specifying a subset of observations to be used in the fitting process.
prior	An optional list returned by <a href="#">SpikeSlabPrior</a> . If prior is missing then a default prior will be used. See <a href="#">SpikeSlabPrior</a> .
error.distribution	Specify either Gaussian or Student T errors. If the error distribution is student then the prior must be a <a href="#">StudentSpikeSlabPrior</a> .
contrasts	An optional list. See the <code>contrasts.arg</code> argument of <a href="#">model.matrix.default</a> .
drop.unused.levels	Logical indicating whether unobserved factor levels should be dropped from the model.
bma.method	The MCMC method to use. <code>SSVS</code> is the stochastic search variable selection algorithm from George and McCulloch (1998). <code>ODA</code> is the orthogonal data augmentation method from Clyde and Ghosh (2011).
oda.options	If <code>bma.method == "ODA"</code> then these are some options for fine tuning the ODA algorithm. <ul style="list-style-type: none"> <li><code>fallback.probability</code>: Each MCMC iteration will use <code>SSVS</code> instead of <code>ODA</code> with this probability. In cases where the latent data have high leverage, <code>ODA</code> mixing can suffer. Mixing in a few <code>SSVS</code> steps can help keep an errant algorithm on track.</li> <li><code>eigenvalue.fudge.factor</code>: The latent <code>X</code>'s will be chosen so that the complete data <code>X'X</code> matrix (after scaling) is a constant diagonal matrix equal to the largest eigenvalue of the observed (scaled) <code>X'X</code> times <math>(1 + \text{eigenvalue.fudge.factor})</math>. This should be a small positive number.</li> </ul>
ping	The frequency with which to print status update messages to the screen. For example, if <code>ping == 10</code> then an update will be printed every 10 MCMC iterations.

seed	An integer to use as the random seed for the underlying C++ code. If NULL then the seed will be set using the clock.
...	Extra arguments to be passed to <code>SpikeSlabPrior</code> (if <code>method == "SSVS"</code> ) or <code>IndependentSpikeSlabPrior</code> (if <code>method == "DA"</code> ).

### Details

Both methods ("DA" and "SSVS") draw each variable inclusion indicator given all others, in a Gibbs sampler. The DA method includes an extra data augmentation step that renders each indicator conditionally independent of the others given the latent data. There is residual dependence between successive MCMC steps introduced by the latent data, but the paper by Ghosh and Clyde suggested that on balance mixing should be improved.

Regarding the overall compute time, the DA method decomposes the (potentially very large) model matrix one time, at the start of the algorithm. But it then works with independent scalar updates. The SSVS algorithm does not have the upfront cost, but it works with many small matrix decompositions each MCMC iteration. The DA algorithm is very likely to be faster in terms of time per iteration.

Finally, note that the two algorithms require slightly different priors. The DA algorithm requires a priori independence, while the SSVS algorithm can work with arbitrary conjugate priors.

### Value

Returns an object of class `lm.spike`, which is a list with the following elements

beta	A <code>niter</code> by <code>ncol(x)</code> matrix of regression coefficients, many of which may be zero. Each row corresponds to an MCMC iteration.
sigma	A vector of length <code>niter</code> containing the MCMC draws of the residual standard deviation parameter.
prior	The prior used to fit the model. If a prior was supplied as an argument it will be returned. Otherwise this will be the automatically generated prior based on the other function arguments.

### Author(s)

Steven L. Scott

### References

George and McCulloch (1997), "Approaches to Bayesian Variable Selection", *Statistica Sinica*, **7**, 339 – 373. <http://www3.stat.sinica.edu.tw/statistica/oldpdf/A7n26.pdf>

Ghosh and Clyde (2011) "Rao-Blackwellization for Bayesian variable selection and model averaging in linear and binary regression: A novel data augmentation approach", *Journal of the American Statistical Association*, **106** 1041-1052. [http://homepage.stat.uiowa.edu/~jghsh/ghosh\\_clyde\\_2011\\_jasa.pdf](http://homepage.stat.uiowa.edu/~jghsh/ghosh_clyde_2011_jasa.pdf)

### See Also

[SpikeSlabPrior](#), [plot.lm.spike](#), [summary.lm.spike](#), [predict.lm.spike](#).



**Examples**

```

n <- 100
p <- 10
ngood <- 3
niter <- 1000
sigma <- .8

x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
beta <- c(rnorm(ngood), rep(0, p - ngood))
y <- rnorm(n, x %*% beta, sigma)
x <- x[,-1]
model <- lm.spike(y ~ x, niter=niter)
plot.ts(model$beta)
hist(model$sigma) ## should be near 8
plot(model)
summary(model)
plot(model, "residuals")

## Now replace the first observation with a big outlier.
y[1] <- 50
model <- lm.spike(y ~ x, niter = niter)
model2 <- lm.spike(y ~ x, niter = niter, error.distribution = "student")
pred <- predict(model, newdata = x)
pred2 <- predict(model2, newdata = x)

## Maximize the plot window before making these box plots. They show
## the posterior predictive distribution of all 100 data points, so
## make sure your screen is 100 boxes wide!
par(mfrow = c(2,1))
BoxplotTrue(t(pred), truth = y, ylim = range(pred), pch = ".",
  main = "Posterior predictive distribution assuming Gaussian errors.")
BoxplotTrue(t(pred2), truth = y, ylim = range(pred), pch = ",",
  main = "Posterior predictive distribution assuming Student errors.")

## The posterior predictive distributions are much tighter in the
## student case than in the Gaussian case, even though the student
## model has heavier tails, because the "sigma" parameter is smaller.
par(mfrow = c(1,1))
CompareDensities(list(gaussian = model$sigma, student = model2$sigma),
  xlab = "sigma")

```

---

logit.spike

*Spike and slab logistic regression*


---

**Description**

MCMC algorithm for logistic regression models with a 'spike-and-slab' prior that places some amount of posterior probability at zero for a subset of the regression coefficients.

**Usage**

```
logit.spike(formula,
            niter,
            data,
            subset,
            prior = NULL,
            na.action = options("na.action"),
            contrasts = NULL,
            drop.unused.levels = TRUE,
            initial.value = NULL,
            ping = niter / 10,
            nthreads = 0,
            clt.threshold = 2,
            mh.chunk.size = 10,
            proposal.df = 3,
            sampler.weights = c("DA" = .333, "RWM" = .333, "TIM" = .333),
            seed = NULL,
            ...)
```

**Arguments**

formula	formula for the maximal model (with all variables included), this is parsed the same way as a call to <code>glm</code> , but no family argument is needed. Like <code>glm</code> , a two-column input format (success-count, failure-count). Otherwise, the response variable can be a logical or numeric vector. If numeric, then values >0 indicate a "success".
niter	The number of MCMC iterations to run. Be sure to include enough so you can throw away a burn-in set.
data	An optional data frame, list or environment (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 <code>logit.spike</code> is called.
subset	An optional vector specifying a subset of observations to be used in the fitting process.
prior	A n object inheriting from <code>LogitPrior</code> and <code>SpikeSlabPriorBase</code> . If prior is supplied it will be used. Otherwise a prior distribution will be constructed by calling <code>LogitZellnerPrior</code> with the remaining arguments.
na.action	A function which indicates what should happen when the data contain NAs. The default is set by the <code>na.action</code> setting of <code>options</code> , and is <code>na.fail</code> if that is unset. The factory-fresh default is <code>na.omit</code> . Another possible value is <code>NULL</code> , no action. Value <code>na.exclude</code> can be useful.
contrasts	An optional list. See the <code>contrasts.arg</code> of <code>model.matrix.default</code> .
drop.unused.levels	A logical value indicating whether factor levels that are unobserved should be dropped from the model.

<code>initial.value</code>	Initial value for the MCMC algorithm. Can either be a numeric vector, a <code>glm</code> object (from which the coefficients will be used), or a <code>logit.spike</code> object. If a <code>logit.spike</code> object is supplied, it is assumed to be from a previous MCMC run for which <code>niter</code> additional draws are desired. If a <code>glm</code> object is supplied then its coefficients will be used as the initial values for the simulation.
<code>ping</code>	If positive, then print a status update to the console every <code>ping</code> MCMC iterations.
<code>nthreads</code>	The number of CPU-threads to use for data augmentation. There is some small overhead to stopping and starting threads. For small data sets, thread overhead will make it faster to run single threaded. For larger data sets multi-threading can speed things up substantially. This is all machine dependent, so please experiment.
<code>clt.threshold</code>	When the model is presented with binomial data (i.e. when the response is a two-column matrix) the data augmentation algorithm can be made more efficient by updating a single, asymptotically normal scalar quantity for each unique value of the predictors. The asymptotic result will be used whenever the number of successes or failures exceeds <code>clt.threshold</code> .
<code>mh.chunk.size</code>	The maximum number of coefficients to draw in a single "chunk" of a Metropolis-Hastings update. See details.
<code>proposal.df</code>	The degrees of freedom parameter to use in Metropolis-Hastings proposals. See details.
<code>sampler.weights</code>	The proportion of MCMC iterations spent in each of the three algorithms described in the Details section. This must be a vector of length 3, with names "DA", "RWM" and "TIM", containing non-negative elements that sum to (within numerical error .999 or 1.001 are okay).
<code>seed</code>	Seed to use for the C++ random number generator. It should be NULL or an int. If NULL the seed value will be taken from the global <code>.Random.seed</code> object.
<code>...</code>	Extra arguments to be passed to <code>SpikeSlabPrior</code> .

## Details

Model parameters are updated using a composite of three Metropolis-Hastings updates. An auxiliary mixture sampling algorithm (Tuchler 2008) updates the entire parameter vector at once, but can mix slowly.

The second algorithm is a random walk Metropolis update based on a multivariate T proposal with `proposal.df` degrees of freedom. If `proposal.df` is nonpositive then a Gaussian proposal is used. The variance of the proposal distribution is based on the Fisher information matrix evaluated at the current draw of the coefficients.

The third algorithm is an independence Metropolis sampler centered on the posterior mode with variance determined by posterior information matrix (Fisher information plus prior information). If `proposal.df > 0` then the tails of the proposal are inflated so that a multivariate T proposal is used instead.

For either of the two MH updates, at most `mh.chunk.size` coefficients will be updated at a time. At each iteration, one of the three algorithms is chosen at random. The auxiliary mixture sampler is the only one that can change the dimension of the coefficient vector. The MH algorithms only update the coefficients that are currently nonzero.

**Value**

Returns an object of class `logit.spike`, which inherits from `lm.spike`. The returned object is a list with the following elements

<code>beta</code>	A <code>niter</code> by <code>ncol(x)</code> matrix of regression coefficients, many of which may be zero. Each row corresponds to an MCMC iteration.
<code>prior</code>	The prior used to fit the model. If a prior was supplied as an argument it will be returned. Otherwise this will be the automatically generated prior based on the other function arguments.

**Author(s)**

Steven L. Scott

**References**

Tuchler (2008), "Bayesian Variable Selection for Logistic Models Using Auxiliary Mixture Sampling", *Journal of Computational and Graphical Statistics*, **17** 76 – 94.

**See Also**

[lm.spike](#) [SpikeSlabPrior](#), [plot.logit.spike](#), [PlotLogitSpikeFitSummary](#) [PlotLogitSpikeResiduals](#) [summary.logit.spike](#), [predict.logit.spike](#).

**Examples**

```
if (requireNamespace("MASS")) {
  data(Pima.tr, package = "MASS")
  data(Pima.te, package = "MASS")
  pima <- rbind(Pima.tr, Pima.te)
  model <- logit.spike(type == "Yes" ~ ., data = pima, niter = 500)
  plot(model)
  plot(model, "fit")
  plot(model, "residuals")
  plot(model, "size")
  summary(model)
}
```

---

`logit.zellner.prior`     *Zellner Prior for Logistic Regression*

---

**Description**

A Zellner-style spike and slab prior for logistic regression models. See 'Details' for a definition.

**Usage**

```
LogitZellnerPrior(
  predictors,
  successes = NULL,
  trials = NULL,
  prior.success.probability = NULL,
  expected.model.size = 1,
  prior.information.weight = .01,
  diagonal.shrinkage = .5,
  optional.coefficient.estimate = NULL,
  max.flips = -1,
  prior.inclusion.proBABILITIES = NULL)
```

**Arguments**

- |                               |   |
|-------------------------------|---|
| predictors                    | The design matrix for the regression problem. No missing data is allowed.   |
| successes                     | The vector of responses, which can be 0/1, TRUE/FALSE, or 1/-1. This is only used to obtain the empirical overall success rate, so it can be left NULL if prior.success.probability is specified.   |
| trials                        | A vector of the same length as successes, giving the number of trials for each success count (trials cannot be less than successes). If successes is binary (or NULL) then this can be NULL as well, signifying that there was only one trial per experiment.   |
| prior.success.probability     | The overall prior guess at the proportion of successes. This is used in two places. It is an input into the intercept term of the default optional.coefficient.estimate, and it is used as a weight for the prior information matrix. See 'Details'.  |
| expected.model.size           | A positive number less than ncol(x), representing a guess at the number of significant predictor variables. Used to obtain the 'spike' portion of the spike and slab prior.   |
| prior.information.weight      | A positive scalar. Number of observations worth of weight that should be given to the prior estimate of beta.   |
| diagonal.shrinkage            | The conditionally Gaussian prior for beta (the "slab") starts with a precision matrix equal to the information in a single observation. However, this matrix might not be full rank. The matrix can be made full rank by averaging with its diagonal. diagonal.shrinkage is the weight given to the diagonal in this average. Setting this to zero gives Zellner's g-prior. |
| optional.coefficient.estimate | If desired, an estimate of the regression coefficients can be supplied. In most cases this will be a difficult parameter to specify. If omitted then a prior mean of zero will be used for all coordinates except the intercept, which will be set to mean(y).  |
| max.flips                     | The maximum number of variable inclusion indicators the sampler will attempt to sample each iteration. If negative then all indicators will be sampled.   |

prior.inclusion.proBABILITIES

A vector giving the prior probability of inclusion for each variable. If NULL then a default set of probabilities is obtained by setting each element equal to  $\min(1, \text{expected.model.size} / \text{ncol}(x))$ .

### Details

A Zellner-style spike and slab prior for logistic regression. Denote the vector of coefficients by  $\beta$ , and the vector of inclusion indicators by  $\gamma$ . These are linked by the relationship  $\beta_i \neq 0$  if  $\gamma_i = 1$  and  $\beta_i = 0$  if  $\gamma_i = 0$ . The prior is

$$\beta|\gamma \sim N(b, V)$$

$$\gamma \sim B(\pi)$$

where  $\pi$  is the vector of prior.inclusion.proBABILITIES, and  $b$  is the optional.coefficient.estimate. Conditional on  $\gamma$ , the prior information matrix is

$$V^{-1} = \kappa((1 - \alpha)x^Twx/n + \alpha\text{diag}(x^Twx/n))$$

The matrix  $x^Twx$  is, for suitable choice of the weight vector  $w$ , the total Fisher information available in the data. Dividing by  $n$  gives the average Fisher information in a single observation, multiplying by  $\kappa$  then results in  $\kappa$  units of "average" information. This matrix is averaged with its diagonal to ensure positive definiteness.

In the formula above,  $\kappa$  is prior.information.weight,  $\alpha$  is diagonal.shrinkage, and  $w$  is a diagonal matrix with all elements set to prior.success.proBABILITIES \* (1 - prior.success.proBABILITIES). The vector  $b$  and the matrix  $V^{-1}$  are both implicitly subscripted by  $\gamma$ , meaning that elements, rows, or columns corresponding to  $\gamma = 0$  should be omitted.

### Value

Returns an object of class `LogitZellnerPrior`, which is a list with data elements encoding the selected prior values. It inherits from `LogitPrior`, which implies that it contains an element `prior.success.proBABILITIES`.

This object is intended for use with `logit.spike`.

### Author(s)

Steven L. Scott

### References

Hugh Chipman, Edward I. George, Robert E. McCulloch, M. Clyde, Dean P. Foster, Robert A. Stine (2001), "The Practical Implementation of Bayesian Model Selection" *Lecture Notes-Monograph Series*, Vol. 38, pp. 65-134. Institute of Mathematical Statistics. <http://www.jstor.org/stable/4356164>

---

make.spike.slab.prior *Create a spike and slab prior for use with lm.spike.*

---

## Description

Creates a spike and slab prior for use with lm.spike.

## Usage

```
SpikeSlabPrior(x,
               y = NULL,
               expected.r2 = .5,
               prior.df = .01,
               expected.model.size = 1,
               prior.information.weight = .01,
               diagonal.shrinkage = .5,
               optional.coefficient.estimate = NULL,
               max.flips = -1,
               mean.y = mean(y, na.rm = TRUE),
               sdy = sd(as.numeric(y), na.rm = TRUE),
               prior.inclusion.probabilities = NULL,
               sigma.upper.limit = Inf)
```

## Arguments

x	The design matrix for the regression problem. Missing data is not allowed.
y	The vector of responses for the regression. Missing data is not allowed. If y is not available, you can pass y = NULL, and specify mean.y and sdy instead.
expected.r2	The expected R-square for the regression. The spike and slab prior requires an inverse gamma prior on the residual variance of the regression. The prior can be parameterized in terms of a guess at the residual variance, and a "degrees of freedom" representing the number of observations that the guess should weigh. The guess at $\sigma^2$ is set to $(1 - \text{expected.r2}) * \text{var}(y)$ .
prior.df	A positive scalar representing the prior 'degrees of freedom' for estimating the residual variance. This can be thought of as the amount of weight (expressed as an observation count) given to the expected.r2 argument.
expected.model.size	A positive number less than $\text{ncol}(x)$ , representing a guess at the number of significant predictor variables. Used to obtain the 'spike' portion of the spike and slab prior.
prior.information.weight	A positive scalar. Number of observations worth of weight that should be given to the prior estimate of beta.

<code>diagonal.shrinkage</code>	The conditionally Gaussian prior for beta (the "slab") starts with a precision matrix equal to the information in a single observation. However, this matrix might not be full rank. The matrix can be made full rank by averaging with its diagonal. <code>diagonal.shrinkage</code> is the weight given to the diagonal in this average. Setting this to zero gives Zellner's g-prior.
<code>optional.coefficient.estimate</code>	If desired, an estimate of the regression coefficients can be supplied. In most cases this will be a difficult parameter to specify. If omitted then a prior mean of zero will be used for all coordinates except the intercept, which will be set to <code>mean(y)</code> .
<code>max.flips</code>	The maximum number of variable inclusion indicators the sampler will attempt to sample each iteration. If <code>max.flips &lt;= 0</code> then all indicators will be sampled.
<code>mean.y</code>	The mean of the response vector, for use in cases when specifying the response vector is undesirable.
<code>sd.y</code>	The standard deviation of the response vector, for use in cases when specifying the response vector is undesirable.
<code>prior.inclusion.proBABILITIES</code>	A vector giving the prior probability of inclusion for each variable.
<code>sigma.upper.limit</code>	The largest acceptable value for the residual standard deviation. A non-positive number is interpreted as Inf.

**Value**

A list with with the components necessary to run `lm.spike`.

**Author(s)**

Steven L. Scott

**References**

George and McCulloch (1997), "Approaches to Bayesian Variable Selection", *Statistica Sinica*, **7**, 339 – 373.

<http://www3.stat.sinica.edu.tw/statistica/oldpdf/A7n26.pdf>

**Examples**

```
x <- cbind(1, matrix(rnorm(900), ncol = 9))
beta <- rep(0, 10)
beta[1] <- 3
beta[5] <- -4
beta[8] <- 2
y <- rnorm(100, x %*% beta)
## x has 10 columns, including the intercept
prior <- SpikeSlabPrior(x, y,
  expected.model.size = 3, # expect 3 nonzero predictors
  prior.df = .01,        # weaker prior than the default
```



```

    prior.information.weight = .01,
    diagonal.shrinkage = 0, # use Zellner's prior
    optional.coefficient.estimate = rep(0, 10) # shrink to zero
  )
## now 'prior' can be fed to 'lm.spike'
model <- lm.spike(y ~ x - 1, niter = 1000, prior = prior)

```

mlm.spike

*Spike and slab multinomial logistic regression***Description**

MCMC algorithm for multinomial logist models with a 'spike-and-slab' prior that places some amount of posterior probability at zero for a subset of the regression coefficients.

**Usage**

```

mlm.spike(subject.formula,
  choice.formula = NULL,
  niter,
  data,
  choice.name.separator = ".",
  contrasts = NULL,
  subset,
  prior = NULL,
  ping = niter / 10,
  proposal.df = 3,
  rwm.scale.factor = 1,
  nthreads = 1,
  mh.chunk.size = 10,
  proposal.weights = c("DA" = .5, "RWM" = .25, "TIM" = .25),
  seed = NULL,
  ...)

```

**Arguments**

subject.formula

A model [formula](#) describing the relationship between the response (which must be a factor) and the characteristics of the subjects associated with the decision process. If there are no subject-level predictors then  $y \sim 1$  will provide a model with a different intercept for each level of the response. If no intercepts are desired, use  $y \sim 0$ .

choice.formula

A model [formula](#) describing the relationship between the response and the characteristics of the object being chosen. This can be left NULL if no choice-level characteristics are to be used in the model. The variables appearing on the right hand side must be stored in data with the name of response levels appended, and a character (choice.name.separator) used as a separator. For example,

	if "MPG" is one of the variables in the formula, and the response can assume values of "Toyota", "Honda", and "Chevy", then data must contain MPG.Toyota, MPG.Honda, and MPG.Chevy.
niter	The number of MCMC iterations to run. Be sure to include enough so you can discard a burn-in set.
data	A data frame containing the data referenced in <code>subject.formula</code> and <code>choice.formula</code> arguments. If <code>choice.formula</code> is NULL then this argument is optional, and variables will be pulled from the parent environment if it is omitted. If <code>choice.formula</code> is non-NULL, then <code>data</code> must be supplied. Each row in <code>data</code> represents a single observation containing the relevant data about both the subject making the choice, as well as about the items being chosen among. A variable measuring a choice characteristic must be present for each choice level in the response variable. The stems for the choice-variable names that measure the same concepts must be identical, and choice level must be appended as a suffix, separated by a "." character. Thus, if 'HP' is a variable to be considered, and the response levels are 'Toyota', 'Honda', 'Chevy', then the data must contain variables named 'HP.Toyota', 'HP.Honda', and 'HP.Chevy'.
choice.name.separator	The character used to separate the predictor names from the choice values for the choice-level predictor variables in 'data'.
contrasts	An optional list. See the <code>contrasts.arg</code> of <code>model.matrix.default</code> .
subset	An optional vector specifying a subset of observations to be used in the fitting process.
prior	An object of class <code>IndependentSpikeSlabPrior</code> . The portions of the prior distribution relating to the residual variance are not used. A convenience function: <code>MultinomialLogitSpikeSlabPrior</code> is provided to help with the accounting headaches of vectorizing the <code>subject.beta</code> and <code>choice.beta</code> parameters.
ping	The frequency with which status updates are printed to the console. Measured in MCMC iterations. If <code>ping &lt; 0</code> then no status updates will be printed.
proposal.df	The "degrees of freedom" parameter that the Metropolis-Hastings algorithm should use for the multivariate T proposal distribution. If <code>proposal.df &lt;= 0</code> then a Gaussian proposal is used instead.
rwm.scale.factor	The scale factor to use for random walk Metropolis updates. See details.
nthreads	The number of CPU-threads to use for data augmentation.
mh.chunk.size	The maximum number of coefficients to draw in a single "chunk" of a Metropolis-Hastings update. See details.
proposal.weights	A vector of 3 probabilities (summing to 1) indicating the probability of each type of MH proposal during each iteration. The weights should be given names "DA", "RWM", and "TIM" for clarity.
seed	Seed to use for the C++ random number generator. It should be NULL or an int. If NULL the seed value will be taken from the global <code>.Random.seed</code> object.
...	Extra arguments to be passed to <code>MultinomialLogitSpikeSlabPrior</code> .

## Details

**Model Details::** A multinomial logit model has two sets of predictors: one measuring characteristics of the subject making the choice, and the other measuring characteristics of the items being chosen. The model can be written

$$Pr(y[i] = m) \propto \exp(\text{beta.subject}[i, m] * x.subject[i, ] + \text{beta.choice} * x.choice[i, , m])$$

The coefficients in this model are `beta.subject` and `beta.choice`. `beta.choice` is a `subject.xdim` by `('nchoices' - 1)` matrix. Each row multiplies the design matrix produced by `subject.formula` for a particular choice level, where the first choice level is omitted (logically set to zero) for identifiability. `beta.choice` is a vector multiplying the design matrix produced by `choice.formula`, and there are `'nchoices'` of such matrices.

The coefficient vector `'beta'` is the concatenation `c(beta.subject, beta.choice)`, where `beta.subject` is vectorized by stacking its columns (in the usual R fashion). This means that the first contiguous region of `beta` contains the subject-level coefficients for choice level 2.

**MCMC Details::** The MCMC algorithm randomly moves between three types of updates: data augmentation, random walk Metropolis (RWM), and tailored independence Metropolis (TIM).

- DA: Each observation in the model is associated with a set of latent variables that renders the complete data posterior distribution conditionally Gaussian. The augmentation scheme is described in Tuchler (2008). The data augmentation algorithm conditions on the latent data, and integrates out the coefficients, to sample the inclusion vector (i.e. the vector of indicators showing which coefficients are nonzero) using Gibbs sampling. Then the coefficients are sampled given complete data conditional on inclusion. This is the only move that attempts a dimension change.
- RWM: A chunk of the coefficient vector (up to `mh.chunk.size`) is selected. The proposal distribution is either multivariate normal or multivariate T (depending on `'proposal.df'`) centered on current values of this chunk. The precision parameter of the normal (or T) is the negative Hessian of the un-normalized log posterior, evaluated at the current value. The precision is divided by `rwm.scale.factor`. Only coefficients currently included in the model at the time of the proposal will be modified.
- TIM: A chunk of the coefficient vector (up to `mh.chunk.size`) is selected. The proposal distribution is constructed by locating the posterior mode (using the current value as a starting point). The proposal is a Gaussian (or multivariate T) centered on the posterior mode, with precision equal to the negative Hessian evaluated at the mode. This is an expensive, but effective step. If the posterior mode finding fails (for numerical reasons) then a RWM proposal will be attempted instead.

## Value

Returns an object of class `mlm.spike`, which inherits from `logit.spike` and `lm.spike`. The returned object is a list with the following elements

<code>beta</code>	A <code>niter</code> by <code>ncol(x)</code> matrix of regression coefficients, many of which may be zero. Each row corresponds to an MCMC iteration.
<code>prior</code>	The prior used to fit the model. If a prior was supplied as an argument it will be returned. Otherwise this will be the automatically generated prior based on the other function arguments.

MH.accounting A summary of the amount of time spent in each type of MCMC move, and the acceptance rate for each move type.

### Author(s)

Steven L. Scott

### References

Tuchler (2008), "Bayesian Variable Selection for Logistic Models Using Auxiliary Mixture Sampling", *Journal of Computational and Graphical Statistics*, **17** 76 – 94.

### See Also

[lm.spike](#) [SpikeSlabPrior](#), [plot.lm.spike](#), [summary.lm.spike](#), [predict.lm.spike](#).

### Examples

```
rmulti <- function (prob) {
  ## Sample from heterogeneous multinomial distributions.
  if (is.vector(prob)) {
    S <- length(prob)
    return(sample(1:S, size = 1, prob = prob))
  }
  nc <- apply(prob, 1, sum)
  n <- nrow(prob)
  S <- ncol(prob)
  u <- runif(n, 0, nc)
  alive <- rep(TRUE, n)
  z <- numeric(n)
  p <- rep(0, n)
  for (s in 1:S) {
    p <- p + prob[, s]
    indx <- alive & (u < p)
    alive[indx] <- FALSE
    z[indx] <- s
    if (!any(alive))
      break
  }
  return(z)
}

## Define sizes for the problem
subject.predictor.dimension <- 3
choice.predictor.dimension <- 4
nchoices <- 5
nobs <- 1000

## The response can be "a", "b", "c", ...
choice.levels <- letters[1:nchoices]
```

```

## Create "subject level characteristics".
subject.x <- matrix(rnorm(nobs * (subject.predictor.dimension - 1)),
                  nrow = nobs)
subject.beta <- cbind(
  0, matrix(rnorm(subject.predictor.dimension * (nchoices - 1)),
            ncol = nchoices - 1))
colnames(subject.x) <- state.name[1:ncol(subject.x)]

## Create "choice level characteristics".
choice.x <- matrix(rnorm(nchoices * choice.predictor.dimension * nobs),
                  nrow = nobs)
choice.characteristics <- c("foo", "bar", "baz", "qux")
choice.names <- as.character(outer(choice.characteristics, choice.levels, FUN = paste, sep = ":"))
colnames(choice.x) <- choice.names
choice.beta <- rnorm(choice.predictor.dimension)

## Combine an intercept term, subject data, and choice data.
X <- cbind(1, subject.x, choice.x)
p <- ncol(X)
true.beta <- c(subject.beta[, -1], choice.beta)
Beta <- matrix(nrow = nchoices, ncol = p)
for (m in 1:nchoices) {
  Beta[m, ] <- rep(0, p)
  Beta[m, 1:subject.predictor.dimension] <- subject.beta[, m]
  begin <- subject.predictor.dimension + 1 + (m-1) * choice.predictor.dimension
  end <- begin + choice.predictor.dimension - 1
  Beta[m, begin:end] <- choice.beta
}

eta <- X %*% t(Beta)
prob <- exp(eta)
prob <- prob / rowSums(prob)
response <- as.factor(choice.levels[rmulti(prob)])
simulated.data <- as.data.frame(X[, -1])
simulated.data$response <- response

model <- mlm.spike(response ~ Alabama + Alaska,
                  response ~ foo + bar + baz + qux,
                  niter = 500,
                  choice.name.separator = ":",
                  expected.subject.model.size = -1,
                  expected.choice.model.size = -1,
                  data = simulated.data,
                  proposal.weights = c("DA" = .8, "RWM" = .1, "TIM" = .1))

```

**Description**

Creates a spike and slab prior for use with `mlm.spike`.

**Usage**

```
MultinomialLogitSpikeSlabPrior(
  response,
  subject.x,
  expected.subject.model.size = 1,
  choice.x = NULL,
  expected.choice.model.size = 1,
  max.flips = -1,
  nchoices = length(levels(response)),
  subject.dim = ifelse(is.null(subject.x), 0, ncol(subject.x)),
  choice.dim = ifelse(is.null(choice.x), 0, ncol(choice.x)))
```

**Arguments**

<code>response</code>	The response variable in the multinomial logistic regression. The response variable is optional if <code>nchoices</code> is supplied. If 'response' is provided then the prior means for the subject level intercepts will be chosen to match the empirical values of the response.
<code>subject.x</code>	The design matrix for subject-level predictors. This can be NULL or of length 0 if no subject-level predictors are present.
<code>expected.subject.model.size</code>	The expected number of non-zero coefficients – per choice level – in the subject specific portion of the model. All coefficients can be forced into the model by setting this to a negative number, or by setting it to be larger than the dimension of the subject-level predictors.
<code>choice.x</code>	The design matrix for choice-level predictors. Each row of this matrix represents the characteristics of a choice in a choice occasion, so it takes 'nchoices' rows to encode one observation. This can be NULL or of length 0 if no choice-level predictors are present.
<code>expected.choice.model.size</code>	The expected number of non-zero coefficients in the choice-specific portion of the model. All choice coefficients can be forced into the model by setting this to a negative number, or by setting it to be larger than the dimension of the choice-level predictors (for a single response level).
<code>max.flips</code>	The maximum number of variable inclusion indicators the sampler will attempt to sample each iteration. If <code>max.flips &lt;= 0</code> then all indicators will be sampled.
<code>nchoices</code>	The number of potential response levels.
<code>subject.dim</code>	The number of potential predictors in the subject-specific portion of the model.
<code>choice.dim</code>	The number of potential predictors in the choice-specific portion of the model.

**Value**

An object of class `IndependentSpikeSlabPrior`, with elements arranged as expected by `mlm.spike`.

**Author(s)**

Steven L. Scott

**References**

Tuchler (2008), "Bayesian Variable Selection for Logistic Models Using Auxiliary Mixture Sampling", *Journal of Computational and Graphical Statistics*, **17** 76 – 94.

---

 model.matrix

*GetPredictorMatrix*


---

**Description**

Extract the matrix of predictors.

**Usage**

```
GetPredictorMatrix(object, newdata, na.action = na.omit, ...)
```

**Arguments**

object	An object of class <code>glm.spike</code> . The object must be a list with the following elements <ul style="list-style-type: none"> <li>• <code>beta</code>: a matrix of MCMC draws, with rows representing draws, and columns representing coefficients.</li> <li>• <code>xlevels</code>: the levels of any contrasts present in the original training data.</li> <li>• <code>contrasts</code>: the "contrasts" attribute of the original design matrix used to train the model.</li> <li>• <code>terms</code>: the terms of the formula used to fit the original model.</li> </ul>
newdata	A data frame, matrix, or vector containing the predictors needed to make a prediction. If <code>newdata</code> is a matrix it must have the same number of columns as <code>length(object\$beta)</code> , unless it is off by one and the model contains an intercept, in which case an intercept term will be added. If <code>length(object\$beta) == 1</code> (or 2, with one element containing an intercept) then <code>newdata</code> can be a numeric vector.
na.action	A function specifying what to do with NA's.
...	Extra arguments passed to <code>model.matrix</code> , in the event that <code>newdata</code> is a data frame.

**Value**

A matrix of predictor variables suitable for multiplication by `object$beta`.

**Author(s)**

Steven L. Scott

**See Also**

[lm.spike](#) [SpikeSlabPrior](#) [plot.lm.spike](#) [predict.lm.spike](#)

---

model.matrix.glm.spike

*Construct Design Matrices*

---

**Description**

Creates a matrix of predictors appropriate for glm.spike models.

**Usage**

```
## S3 method for class 'glm.spike'  
model.matrix(object, ...)
```

**Arguments**

object	An object of class glm.spike.
...	Extra arguments passed to <a href="#">model.matrix.default</a> .

**Details**

glm.spike objects do not store the predictors used to fit the model. If the training data is modified between when object is fit and when this function is called, the modifications will be reflected in the returned value.

**Value**

The matrix of predictors used at training time, so long as the original data used to fit the model is available in the frame where this function is called.

**Author(s)**

Steven L. Scott

**See Also**

[lm.spike](#)



---

nested.regression      *Nested Regression*

---

## Description

Fits a Bayesian hierarchical regression model to data nested within groups. The model is

$$y_{ig} \sim N(x_i \beta_g, \sigma^2) \quad 1/\sigma^2 \sim \text{Gamma}(df/2, ss/2) \quad \beta_g \sim N(b, V)$$

Optional hyperprior distributions can be supplied to the prior parameters.

$$b \sim N(\text{prior.mean}, \text{prior.variance}) \quad V \sim \text{InverseWishart}(df, \text{variance.guess}).$$

Either hyperprior can be omitted, in which case the corresponding prior parameter is assumed fixed at the user-supplied value.

## Usage

```
NestedRegression(response,
                  predictors,
                  group.id,
                  residual.prior = NULL,
                  coefficient.prior = NULL,
                  coefficient.mean.hyperprior = NULL,
                  coefficient.variance.hyperprior = NULL,
                  suf = NULL,
                  niter,
                  ping = niter / 10,
                  sampling.method = c("ASIS", "DA"),
                  seed = NULL)
```

## Arguments

response	A numeric vector. The response variable to be modeled.
predictors	A numeric matrix of predictor variables, including an intercept term if one is desired. The number of rows must match length(response).
group.id	A factor (or object that can be converted using <a href="#">as.factor</a> ) naming the group to which each entry in response belongs.
residual.prior	An object of type <a href="#">SdPrior</a> describing the prior distribution of the residual standard deviation.
coefficient.prior	An object of class <a href="#">MvnPrior</a> , or NULL. If non-NULL this gives the initial values of the prior distribution of the regression coefficients in the nested regression model. This argument must be non-NULL if either <code>coefficient.mean.hyperprior</code> or <code>coefficient.variance.hyperprior</code> is NULL.

<code>coefficient.mean.hyperprior</code>	An object of class <code>MvnPrior</code> , specifying the hyperprior distribution for the mean of <code>coefficient.prior</code> . This argument can also be <code>NULL</code> , or <code>FALSE</code> . If <code>NULL</code> then a default prior will be used when learning the mean of the prior distribution. If <code>FALSE</code> then the mean of the prior distribution will not be learned; the mean of the <code>coefficient.prior</code> distribution will be assumed instead.
<code>coefficient.variance.hyperprior</code>	An object of class <code>InverseWishartPrior</code> , specifying the hyperprior distribution for the variance of <code>coefficient.prior</code> . This argument can also be <code>NULL</code> , or <code>FALSE</code> . If <code>NULL</code> then a default prior will be used when learning the variance of the prior distribution. If <code>FALSE</code> then the variance of the prior distribution will not be learned; the variance of the <code>coefficient.prior</code> distribution will be assumed instead.
<code>suf</code>	A list, where each entry is of type <code>RegressionSuf</code> , giving the sufficient statistics for each group, or <code>NULL</code> . If <code>NULL</code> , then <code>suf</code> will be computed from response, predictors, and <code>group.id</code> . If non- <code>NULL</code> then these arguments will not be accessed, in which case they can be left unspecified. In 'big data' problems this can be a significant computational savings.
<code>niter</code>	The desired number of MCMC iterations.
<code>ping</code>	The frequency with which to print status updates.
<code>sampling.method</code>	The MCMC sampling scheme that should be used. If either hyperprior is set to <code>FALSE</code> then the "DA" method will be used.
<code>seed</code>	The integer-valued seed (or <code>NULL</code> ) to use for the C++ random number generator.

### Details

Note: ASIS (Yu and Meng, 2011) has slightly better MCMC convergence, but is slightly slower than the classic DA (data augmentation) method, which alternates between sampling group-level regression coefficients and prior parameters. Both methods are pretty fast.

### Value

A list containing MCMC draws from the posterior distribution of model parameters. Each of the following is a vector, matrix, or array, with first index corresponding to MCMC draws, and later indices to distinct parameters.

- `coefficients`: regression coefficients.
- `residual.sd`: the residual standard deviation from the regression model.
- `prior.mean`: The posterior distribution of the coefficient means across groups.
- `prior.variance`: The posterior distribution of the variance matrix describing the distribution of regression coefficients across groups.
- `priors`: A list of the prior distributions used to fit the model.

### Author(s)

Steven L. Scott

**Examples**

```

SimulateNestedRegressionData <- function() {
  beta.hyperprior.mean <- c(8, 6, 7, 5)
  xdim <- length(beta.hyperprior.mean)
  beta.hyperprior.variance <-
    rWishart(2 * xdim, diag(rep(1, xdim)), inverse = TRUE)

  number.of.groups <- 27
  nobs.per.group = 23
  beta <- rmvn(number.of.groups,
               beta.hyperprior.mean,
               beta.hyperprior.variance)

  residual.sd <- 2.4
  X <- cbind(1, matrix(rnorm(number.of.groups * (xdim - 1) * nobs.per.group),
                       ncol = xdim - 1))
  group.id <- rep(1:number.of.groups, len = nrow(X))
  y.hat <- numeric(nrow(X))
  for (i in 1:nrow(X)) {
    y.hat[i] = sum(X[i, ] * beta[group.id[i], ])
  }
  y <- rnorm(length(y.hat), y.hat, residual.sd)
  suf <- BoomSpikeSlab:::RegressionSufList(X, y, group.id)

  return(list(beta.hyperprior.mean = beta.hyperprior.mean,
             beta.hyperprior.variance = beta.hyperprior.variance,
             beta = beta,
             residual.sd = residual.sd,
             X = X,
             y = y,
             group.id = group.id,
             suf = suf))
}

d <- SimulateNestedRegressionData()
model <- NestedRegression(suf = d$suf, niter = 500)

```

---

plot.coefficients      *Plot Coefficients.*

---

**Description**

Produces boxplots showing the marginal distribution of the coefficients.

**Usage**

```

PlotLmSpikeCoefficients(
  beta,

```

```

burn = 0,
inclusion.threshold = 0,
scale.factors = NULL,
number.of.variables = NULL,
...)
```

### Arguments

beta	A matrix of model coefficients. Each row represents an MCMC draw. Each column represents a coefficient for a variable.
burn	The number of MCMC iterations in the object to be discarded as burn-in.
inclusion.threshold	Only plot coefficients with posterior inclusion probabilities exceeding this value.
scale.factors	If non-null then a vector of scale factors with which to scale the columns of beta. A NULL value is ignored.
number.of.variables	If non-NULL this specifies the maximum number of coefficients to plot. A NULL value is ignored.
...	Additional arguments to be passed to <a href="#">boxplot</a> .

### Value

Returns the value from the final call to [boxplot](#).

### Author(s)

Steven L. Scott

### See Also

[lm.spike](#) [SpikeSlabPrior](#) [summary.lm.spike](#) [predict.lm.spike](#)

### Examples

```

simulate.lm.spike <- function(n = 100, p = 10, ngood = 3, niter=1000, sigma = 1){
  x <- cbind(matrix(rnorm(n * (p-1)), nrow=n))
  beta <- c(rnorm(ngood), rep(0, p - ngood))
  y <- rnorm(n, beta[1] + x %*% beta[-1], sigma)
  draws <- lm.spike(y ~ x, niter=niter)
  return(invisible(draws))
}
model <- simulate.lm.spike(n = 1000, p = 50, sigma = .3)
plot(model, "coef", inclusion.threshold = .01)
```

---

plot.lm.spike	<i>Plot the results of a spike and slab regression.</i>
---------------	---

---

### Description

The default plot is a barplot of the marginal inclusion probabilities for each variable, as obtained by [PlotMarginalInclusionProbabilities](#). Other interesting plots can be obtained by supplying a string as the second argument.

### Usage

```
## S3 method for class 'lm.spike'
plot(x,
      y = c("inclusion", "coefficients", "scaled.coefficients",
            "residuals", "size", "help"),
      burn = SuggestBurnLogLikelihood(x$log.likelihood),
      ...)
```

### Arguments

x	An object of class <code>lm.spike</code> .
y	The type of plot desired.
burn	The number of MCMC iterations to discard as burn-in.
...	Additional arguments passed to the specific functions that do the plotting.

### Details

The actual plotting will be handled by [PlotMarginalInclusionProbabilities](#), [PlotLmSpikeCoefficients](#), [PlotLmSpikeResiduals](#), or [PlotModelSize](#). See the appropriate function for more options.

### Author(s)

Steven L. Scott

### See Also

[PlotMarginalInclusionProbabilities](#) [PlotLmSpikeCoefficients](#) [PlotLmSpikeResiduals](#) [PlotModelSize](#)  
[lm.spike](#) [SpikeSlabPrior](#) [summary.lm.spike](#) [predict.lm.spike](#)

### Examples

```
simulate.lm.spike <- function(n = 100, p = 10, ngood = 3, niter=1000, sigma = 8){
  x <- cbind(matrix(rnorm(n * (p-1)), nrow=n))
  beta <- c(rnorm(ngood), rep(0, p - ngood))
  y <- rnorm(n, beta[1] + x %>% beta[-1], sigma)
  draws <- lm.spike(y ~ x, niter=niter)
  return(invisible(draws))
}
```

```
}  
model <- simulate.lm.spike(n = 1000, p = 50, sigma = .3)  
plot(model, inclusion.threshold = .01)  
  
plot(model, "size")
```

---

plot.lm.spike.residuals

*Residual plot for lm.spike*

---

### Description

Plot residuals vs. fitted values in an `lm.spike` model.

### Usage

```
PlotLmSpikeResiduals(  
  object,  
  burn = SuggestBurnLogLikelihood(object$log.likelihood),  
  ...)
```

### Arguments

<code>object</code>	A model object inheriting from <code>lm.spike</code> .
<code>burn</code>	The number of MCMC iterations to be discarded as burn-in before computing posterior means.
<code>...</code>	Additional arguments passed to <code>plot</code> .

### Details

This plot is normally called via the `plot` function for `lm.spike` objects. See the help entry for `lm.spike` for example usage.

### Author(s)

Steven L. Scott

### See Also

[lm.spike](#) [plot.lm.spike](#)

---

plot.logit.spike      *Plot a logit.spike object*

---

### Description

Plot a `logit.spike` object. The default plot is a barplot of the marginal inclusion probabilities for each variable, as obtained by `PlotMarginalInclusionProbabilities`. See below for other types of plots.

### Usage

```
## S3 method for class 'logit.spike'
plot(x,
     y = c("inclusion", "coefficients", "scaled.coefficients", "fit",
           "residuals", "size", "help"),
     burn = SuggestBurnLogLikelihood(x$log.likelihood),
     ...)

## S3 method for class 'probit.spike'
plot(x,
     y = c("inclusion", "coefficients", "scaled.coefficients", "fit",
           "residuals", "size", "help"),
     burn = SuggestBurnLogLikelihood(x$log.likelihood),
     ...)
```

### Arguments

x	An object of class <code>logit.spike</code> .
y	The type of plot desired.
burn	The number of MCMC iterations to discard as burn-in.
...	Additional arguments passed to the specific functions that do the plotting.

### Details

The default plot is a barplot showing the marginal inclusion probabilities of the coefficients, constructed using `PlotMarginalInclusionProbabilities`.

The plot of the fit summary is handled by `PlotLogitSpikeFitSummary`.

The plot of the residuals is handled by `PlotLogitSpikeResiduals`.

The plot of model size is handled by `PlotModelSize`.

### Author(s)

Steven L. Scott

**See Also**

[PlotMarginalInclusionProbabilities](#) [PlotModelSize](#) [PlotLogitSpikeFitSummary](#) [PlotLogitSpikeResiduals](#)

**Examples**

```
## See the examples in ?logit.spike
```

---

```
plot.logit.spike.fit.summary
      Plot Logit or Probit Fit Summary
```

---

**Description**

Two plots can be accessed by this function. The first is a time series plot of the "deviance R-square" statistic, by MCMC iteration. The second is a Hosmer-Lemeshow plot in which the data is divided into 10 groups based on predicted probabilities, and the empirical success probabilities for that group are plotted against the expected probabilities from the model.

**Usage**

```
PlotLogitSpikeFitSummary(
  model,
  burn = 0,
  which.summary = c("both", "r2", "bucket"),
  scale = c("logit", "probability"),
  cutpoint.basis = c("sample.size", "equal.range"),
  number.of.buckets = 10,
  ...)
```

```
PlotProbitSpikeFitSummary(
  model,
  burn = 0,
  which.summary = c("both", "r2", "bucket"),
  scale = c("probit", "probability"),
  cutpoint.basis = c("sample.size", "equal.range"),
  number.of.buckets = 10,
  ...)
```

**Arguments**

model	A model object inheriting from <a href="#">logit.spike</a> or <a href="#">probit.spike</a> .
burn	The number of MCMC iterations in the object to be discarded as burn-in. Note that this only affects the deviance R-square plot. The fit summaries in the Hosmer-Lemeshow plot are constructed by <a href="#">logit.spike</a> or <a href="#">probit.spike</a> in order to keep permanent object sizes small.
which.summary	Which plot is desired?



**scale**                    The scale to use for the predicted probabilities in the Hosmer-Lemeshow plot.  
**cutpoint.basis**        How should cutpoints be determined for the Hosmer-Lemeshow plot? If "sample.size" then each bucket will have equal sample size. If "equal.range" then each bucket will occupy the same size on the chosen (logit/probit or probability) scale.  
**number.of.buckets**     The number of buckets to use in the Hosmer-Lemeshow plot.  
**...**                    Additional arguments to be passed to [barplot](#).

**Author(s)**

Steven L. Scott

**See Also**

[lm.spike](#) [SpikeSlabPrior](#) [summary.lm.spike](#) [predict.lm.spike](#)

**Examples**

```

simulate.logit.spike <- function(n = 100, p = 10, ngood = 3,
                                niter=1000){
  x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
  beta <- c(rnorm(ngood), rep(0, p - ngood))
  prob <- plogis(x %*% beta)
  y <- runif(n) < prob
  x <- x[,-1]
  draws <- logit.spike(y ~ x, niter=niter)
  plot.ts(draws$beta)
  return(invisible(draws))
}
model <- simulate.logit.spike()
plot(model, "fit")
plot(model, "fit", scale = "probability", number.of.buckets = 15)

```

---

plot.logit.spike.residuals

*Residual plot for [logit.spike](#) objects.*

---

**Description**

Plots the "deviance residuals" from a logit.spike model.

**Usage**

```

PlotLogitSpikeResiduals(model, ...)
PlotProbitSpikeResiduals(model, ...)

```

**Arguments**

`model`            A model object inheriting from `logit.spike` or `probit.spike`.  
 ...                Additional arguments to be passed to `plot`.

**Details**

The "deviance residuals" are defined as the signed square root each observation's contribution to log likelihood. The sign of the residual is positive if half or more of the trials associated with an observation are successes. The sign is negative otherwise.

The "contribution to log likelihood" is taken to be the posterior mean of an observations log likelihood contribution, averaged over the life of the MCMC chain.

The deviance residual is plotted against the fitted value, again averaged over the life of the MCMC chain.

The plot also shows the .95 and .99 bounds from the square root of a chi-square(1) random variable. As a rough approximation, about 5% and 1% of the data should lie outside these bounds.

**Author(s)**

Steven L. Scott

**See Also**

[logit.spike](#) [plot.logit.spike](#)

**Examples**

```
simulate.logit.spike <- function(n = 100, p = 10, ngood = 3,
                                niter=1000){
  x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
  beta <- c(rnorm(ngood), rep(0, p - ngood))
  prob <- plogis(x %*% beta)
  y <- runif(n) < prob
  x <- x[,-1]
  draws <- logit.spike(y ~ x, niter=niter)
  plot.ts(draws$beta)
  return(invisible(draws))
}
model <- simulate.logit.spike()
plot(model, "fit")
plot(model, "fit", scale = "probability", number.of.buckets = 15)
```

---

```
plot.marginal.inclusion.proBABILITIES
```

*Plot marginal inclusion probabilities.*

---

### Description

Produces a barplot of the marginal inclusion probabilities for a set of model coefficients sampled under a spike and slab prior. The coefficients are sorted by the marginal inclusion probability, and shaded by the conditional probability that a coefficient is positive, given that it is nonzero.

### Usage

```
PlotMarginalInclusionProbabilities(
  beta,
  burn = 0,
  inclusion.threshold = 0,
  unit.scale = TRUE,
  number.of.variables = NULL,
  ...)
```

### Arguments

beta	A matrix of model coefficients. Each row represents an MCMC draw. Each column represents a coefficient for a variable.
burn	The number of MCMC iterations in the object to be discarded as burn-in.
inclusion.threshold	Only plot coefficients with posterior inclusion probabilities exceeding this value.
unit.scale	A logical value indicating whether the scale of the plot should be from 0 to 1. Otherwise the scale is determined by the maximum inclusion probability.
number.of.variables	If non-NULL this specifies the number of coefficients to plot, taking precedence over inclusion.threshold.
...	Additional arguments to be passed to <a href="#">barplot</a> .

### Value

Invisibly returns a list with the following elements.

barplot	The midpoints of each bar, which is useful for adding to the plot.
inclusion.prob	The marginal inclusion probabilities of each variable, ordered smallest to largest (the same order as the plot).
positive.prob	The probability that each variable has a positive coefficient, in the same order as inclusion.prob.
permutation	The permutation of beta that puts the coefficients in the same order as positive.prob and inclusion.prob. That is: beta[, permutation] will have the most significant coefficients in the right hand columns.

**Author(s)**

Steven L. Scott

**See Also**[lm.spike](#) [SpikeSlabPrior](#) [summary.lm.spike](#) [predict.lm.spike](#)**Examples**

```
simulate.lm.spike <- function(n = 100, p = 10, ngood = 3, niter=1000, sigma = 8){
  x <- cbind(matrix(rnorm(n * (p-1)), nrow=n))
  beta <- c(rnorm(ngood), rep(0, p - ngood))
  y <- rnorm(n, beta[1] + x %*% beta[-1], sigma)
  draws <- lm.spike(y ~ x, niter=niter)
  return(invisible(draws))
}
model <- simulate.lm.spike(n = 1000, p = 50, sigma = .3)
plot(model, inclusion.threshold = .01)
```

---

plot.poisson.spike      *Plot a poisson.spike object*

---

**Description**

Plot a [poisson.spike](#) object. The default plot is a barplot of the marginal inclusion probabilities for each variable, as obtained by [PlotMarginalInclusionProbabilities](#). See below for other types of plots.

**Usage**

```
## S3 method for class 'poisson.spike'
plot(x,
     y = c("inclusion", "coefficients", "scaled.coefficients", "size", "help"),
     burn = SuggestBurnLogLikelihood(x$log.likelihood),
     ...)
```

**Arguments**

x	An object of class <code>poisson.spike</code> .
y	The type of plot desired.
burn	The number of MCMC iterations to discard as burn-in.
...	Additional arguments passed to the specific functions that do the plotting.

**Details**

The default plot is a barplot showing the marginal inclusion probabilities of the coefficients, constructed using [PlotMarginalInclusionProbabilities](#).

The plot of model size is handled by [PlotModelSize](#).

**Author(s)**

Steven L. Scott

**See Also**[PlotMarginalInclusionProbabilities](#) [PlotModelSize](#)**Examples**

```
## See the examples in ?poisson.spike
```

---

plot.qreg.spike	<i>Plot the results of a spike and slab regression.</i>
-----------------	---

---

**Description**

The default plot is a barplot of the marginal inclusion probabilities for each variable, as obtained by [PlotMarginalInclusionProbabilities](#). Other interesting plots can be obtained by supplying a string as the second argument.

**Usage**

```
## S3 method for class 'qreg.spike'
plot(x,
     y = c("inclusion", "coefficients", "scaled.coefficients",
           "size", "help"),
     burn = SuggestBurnLogLikelihood(x$log.likelihood),
     ...)
```

**Arguments**

x	An object of class qreg.spike.
y	The type of plot desired.
burn	The number of MCMC iterations to discard as burn-in.
...	Additional arguments passed to the specific functions that do the plotting.

**Details**

The actual plotting will be handled by [PlotMarginalInclusionProbabilities](#), [PlotLmSpikeCoefficients](#), or [PlotModelSize](#). See the appropriate function for more options.

**Author(s)**

Steven L. Scott

**See Also**

[PlotMarginalInclusionProbabilities](#) [PlotLmSpikeCoefficients](#) [PlotModelSize](#) [qreg.spike](#)  
[SpikeSlabPrior](#) [predict.qreg.spike](#)

**Examples**

```
n <- 50
x <- rnorm(n)
y <- rnorm(n, 4 * x)
model <- qreg.spike(y ~ x,
                   quantile = .8,
                   niter = 1000,
                   expected.model.size = 100)

plot(model)
plot(model, "coef")
plot(model, "coefficients")
plot(model, "scaled.coefficients")
plot(model, "scal")
plot(model, "size")
plot(model, "help")
```

---

PlotModelSize

*Plot a distribution of model size*


---

**Description**

Produces a histogram of number of nonzero coefficients in a spike-and-slab regression.

**Usage**

```
PlotModelSize(beta, burn = 0, xlab= "Number of nonzero coefficients", ...)
```

**Arguments**

beta	A matrix of model coefficients. Each row represents an MCMC draw. Each column represents a coefficient for a variable.
burn	The number of MCMC iterations to be discarded as burn-in.
xlab	Label for the horizontal axis.
...	Additional arguments to be passed to <a href="#">hist</a>

**Value**

Invisibly returns the vector of MCMC draws of model sizes.

**Author(s)**

Steven L. Scott

**See Also**[lm.spike plot.lm.spike](#)**Examples**

```

simulate.lm.spike <- function(n = 100, p = 10, ngood = 3, niter=1000, sigma = 8){
  x <- cbind(matrix(rnorm(n * (p-1)), nrow=n))
  beta <- c(rnorm(ngood), rep(0, p - ngood))
  y <- rnorm(n, beta[1] + x %*% beta[-1], sigma)
  draws <- lm.spike(y ~ x, niter=niter)
  return(invisible(draws))
}
model <- simulate.lm.spike(n = 1000, p = 50, sigma = .3)

# To get the plot of model size directly.
PlotModelSize(model$beta, burn = 10)

# Another way to get the same plot.
plot(model, "size", burn = 10)

```

poisson.spike

*Spike and slab Poisson regression***Description**

MCMC algorithm for Poisson regression models with a 'spike-and-slab' prior that places some amount of posterior probability at zero for a subset of the coefficients.

**Usage**

```

poisson.spike(formula,
              exposure = 1,
              niter,
              data,
              subset,
              prior = NULL,
              na.action = options("na.action"),
              contrasts = NULL,
              drop.unused.levels = TRUE,
              initial.value = NULL,
              ping = niter / 10,
              nthreads = 4,
              seed = NULL,
              ...)

```

**Arguments**

formula	A model formula, as would be passed to <code>glm</code> , specifying the maximal model (i.e. the model with all predictors included).
exposure	A vector of exposure durations matching the length of the response vector. If exposure is of length 1 it will be recycled.
niter	The number of MCMC iterations to run.
data	An optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which <code>poisson.spike</code> is called.
subset	An optional vector specifying a subset of observations to be used in the fitting process.
prior	A list such as that returned by <code>SpikeSlabPrior</code> . If prior is supplied it will be used. Otherwise a prior distribution will be built using the remaining arguments. See <code>SpikeSlabPrior</code> .
na.action	A function which indicates what should happen when the data contain NAs. The default is set by the <code>na.action</code> setting of <code>options</code> , and is <code>na.fail</code> if that is unset. The factory-fresh default is <code>na.omit</code> . Another possible value is <code>NULL</code> , no action. Value <code>na.exclude</code> can be useful.
contrasts	An optional list. See the <code>contrasts.arg</code> of <code>model.matrix.default</code> .
drop.unused.levels	A logical value indicating whether factor levels that are unobserved should be dropped from the model.
initial.value	Initial value for the MCMC algorithm. Can either be a numeric vector, a <code>glm</code> object (from which the coefficients will be used), or a <code>poisson.spike</code> object. If a <code>poisson.spike</code> object is supplied, it is assumed to be from a previous MCMC run for which <code>niter</code> additional draws are desired. If a <code>glm</code> object is supplied then its coefficients will be used as the initial values for the simulation.
ping	If positive, then print a status update to the console every <code>ping</code> MCMC iterations.
nthreads	The number of CPU-threads to use for data augmentation.
seed	Seed to use for the C++ random number generator. It should be <code>NULL</code> or an int. If <code>NULL</code> the seed value will be taken from the global <code>.Random.seed</code> object.
...	Extra arguments to be passed to <code>SpikeSlabPrior</code> .

**Details**

The MCMC algorithm used here is based on the auxiliary mixture sampling algorithm published by Fruhwirth-Schnatter, Fruhwirth, Held, and Rue (2009).

**Value**

Returns an object of class `poisson.spike`. The returned object is a list with the following elements.



beta	A niter by ncol(x) matrix of regression coefficients, many of which may be zero. Each row corresponds to an MCMC iteration.
prior	The prior used to fit the model. If a prior was supplied as an argument it will be returned. Otherwise this will be the automatically generated prior based on the other function arguments.

**Author(s)**

Steven L. Scott

**References**

Sylvia Fruhwirth-Schnatter, Rudolf Fruhwirth, Leonhard Held, and Havard Rue. Statistics and Computing, Volume 19 Issue 4, Pages 479-492. December 2009

**See Also**

[lm.spike](#) [SpikeSlabPrior](#), [plot.lm.spike](#), [summary.lm.spike](#), [predict.lm.spike](#).

**Examples**

```
simulate.poisson.spike <- function(n = 100, p = 10, ngood = 3, niter=1000){
  x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
  beta <- c(rnorm(ngood), rep(0, p - ngood))
  lambda <- exp(x %*% beta)
  y <- rpois(n, lambda)
  x <- x[,-1]
  model <- poisson.spike(y ~ x, niter=niter)
  return(invisible(model))
}
model <- simulate.poisson.spike()
plot(model)
summary(model)
```

---

poisson.zellner.prior *Zellner Prior for Poisson Regression*

---

**Description**

A Zellner-style spike and slab prior for Poisson regression models. See 'Details' for a definition.

**Usage**

```
PoissonZellnerPrior(
  predictors,
  counts = NULL,
  exposure = NULL,
  prior.event.rate = NULL,
```

```

expected.model.size = 1,
prior.information.weight = .01,
diagonal.shrinkage = .5,
optional.coefficient.estimate = NULL,
max.flips = -1,
prior.inclusion.probabilities = NULL)

```

## Arguments

<code>predictors</code>	The design matrix for the regression problem. No missing data is allowed.
<code>counts</code>	The vector of responses, This is only used to obtain the empirical overall event rate, so it can be left NULL if <code>prior.event.rate</code> is specified.
<code>exposure</code>	A vector of the same length as <code>counts</code> , giving the "exposure time" for each observation. This can also be NULL, signifying that <code>exposure = 1.0</code> for each observation.
<code>prior.event.rate</code>	An a priori guess at the overall event rate. Used in two places: to set the prior mean of the intercept (if <code>optional.coefficient.estimate</code> is NULL) and to weight the information matrix in the "slab" portion of the prior.
<code>expected.model.size</code>	A positive number less than <code>ncol(x)</code> , representing a guess at the number of significant predictor variables. Used to obtain the 'spike' portion of the spike and slab prior.
<code>prior.information.weight</code>	A positive scalar. Number of observations worth of weight that should be given to the prior estimate of beta.
<code>diagonal.shrinkage</code>	The conditionally Gaussian prior for beta (the "slab") starts with a precision matrix equal to the information in a single observation. However, this matrix might not be full rank. The matrix can be made full rank by averaging with its diagonal. <code>diagonal.shrinkage</code> is the weight given to the diaonal in this average. Setting this to zero gives Zellner's g-prior.
<code>optional.coefficient.estimate</code>	If desired, an estimate of the regression coefficients can be supplied. In most cases this will be a difficult parameter to specify. If omitted then a prior mean of zero will be used for all coordinates except the intercept, which will be set to <code>mean(y)</code> .
<code>max.flips</code>	The maximum number of variable inclusion indicators the sampler will attempt to sample each iteration. If negative then all indicators will be sampled.
<code>prior.inclusion.probabilities</code>	A vector giving the prior probability of inclusion for each variable. If NULL then a default set of probabilities is obtained by setting each element equal to <code>min(1, expected.model.size / ncol(x))</code> .

## Details

A Zellner-style spike and slab prior for Poisson regression. Denote the vector of coefficients by  $\beta$ , and the vector of inclusion indicators by  $\gamma$ . These are linked by the relationship  $\beta_i \neq 0$  if  $\gamma_i = 1$

and  $\beta_i = 0$  if  $\gamma_i = 0$ . The prior is

$$\beta|\gamma \sim N(b, V)$$

$$\gamma \sim B(\pi)$$

where  $\pi$  is the vector of prior inclusion probabilities, and  $b$  is the optional coefficient estimate. Conditional on  $\gamma$ , the prior information matrix is

$$V^{-1} = \kappa((1 - \alpha)x^Twx/n + \alpha \text{diag}(x^Twx/n))$$

The matrix  $x^Twx$  is, for suitable choice of the weight vector  $w$ , the total Fisher information available in the data. Dividing by  $n$  gives the average Fisher information in a single observation, multiplying by  $\kappa$  then results in  $\kappa$  units of "average" information. This matrix is averaged with its diagonal to ensure positive definiteness.

In the formula above,  $\kappa$  is prior information weight,  $\alpha$  is diagonal shrinkage, and  $w$  is a diagonal matrix with all elements set to  $\text{prior.success.probability} * (1 - \text{prior.success.probability})$ . The vector  $b$  and the matrix  $V^{-1}$  are both implicitly subscripted by  $\gamma$ , meaning that elements, rows, or columns corresponding to  $\gamma = 0$  should be omitted.

## Value

Returns an object of class `PoissonZellnerPrior`, which is a list with data elements encoding the selected prior values. It inherits from `PoissonPrior` and from `SpikeSlabGlmPrior`, which implies that it contains an element `prior.success.probability`.

This object is intended for use with `poisson.spike`.

## Author(s)

Steven L. Scott

## References

Hugh Chipman, Edward I. George, Robert E. McCulloch, M. Clyde, Dean P. Foster, Robert A. Stine (2001), "The Practical Implementation of Bayesian Model Selection" *Lecture Notes-Monograph Series*, Vol. 38, pp. 65-134. Institute of Mathematical Statistics. <http://www.jstor.org/stable/4356164>

---

predict.lm.spike

*Predictions using spike-and-slab regression.*

---

## Description

Generate draws from the posterior predictive distribution of a spike and slab regression.

**Usage**

```
## S3 method for class 'lm.spike'
predict(object, newdata = NULL, burn = 0,
        na.action = na.pass, mean.only = FALSE, ...)

## S3 method for class 'logit.spike'
predict(object, newdata, burn = 0,
        type = c("prob", "logit", "link", "response"),
        na.action = na.pass, ...)

## S3 method for class 'poisson.spike'
predict(object, newdata = NULL,
        exposure = NULL, burn = 0,
        type = c("mean", "log", "link", "response"),
        na.action = na.pass, ...)

## S3 method for class 'probit.spike'
predict(object, newdata, burn = 0,
        type = c("prob", "probit", "link", "response"),
        na.action = na.pass, ...)

## S3 method for class 'qreg.spike'
predict(object, newdata, burn = 0,
        na.action = na.pass, ...)
```

**Arguments**

object	An object of class <code>lm.spike</code> .
newdata	Either <code>NULL</code> , or else a data frame, matrix, or vector containing the predictors needed to make the prediction.  If <code>newdata</code> is <code>NULL</code> then the predictors are taken from the training data used to create the model object. Note that <code>object</code> does not store its training data, so the data objects used to fit the model must be present for the training data to be recreated.  If <code>newdata</code> is a <code>data.frame</code> it must contain variables with the same names as the data frame used to fit <code>object</code> . If it is a <code>matrix</code> , it must have the same number of columns as <code>object\$beta</code> . An intercept term will be implicitly added if the number of columns is too small by one. If the dimension of <code>object\$beta</code> is 1 or 2, then <code>newdata</code> can be a vector.
exposure	A vector of positive real numbers the same size as <code>newdata</code> , or <code>NULL</code> . If both <code>newdata</code> and <code>exposure</code> are <code>NULL</code> then <code>exposure</code> is taken to be the exposure from the training data. If <code>newdata</code> is supplied and <code>exposure</code> is <code>NULL</code> then <code>exposure</code> is taken to be 1 for all observations.
burn	The number of MCMC iterations in the object to be discarded as burn-in.
na.action	a function which indicates what should happen when the data contain NA's. The default is set by the <code>na.action</code> setting of <code>options</code> , and is <code>na.fail</code> if that is

	unset. The "factory-fresh" default is <code>na.omit</code> . Another possible value is <code>NULL</code> , no action. Value <code>na.exclude</code> can be useful.
type	The type of prediction desired. For <code>logit.spike</code> , <code>prob</code> means the prediction is returned on the probability scale, while <code>logit</code> returns the scale of the linear predictor. Probits work similarly to logits. For <code>poisson.spike</code> , <code>mean</code> means the prediction is returned on the scale of the data, while <code>log</code> means it is on the scale of the linear predictor. Both cases also accept <code>link</code> and <code>response</code> for compatibility with <code>predict.glm</code> .
mean.only	Logical. If <code>TRUE</code> then return the posterior mean of the predictive distribution. If <code>FALSE</code> then return the entire distribution.
...	Unused, but present for compatibility with generic <code>predict</code> .

**Value**

Returns a matrix of predictions, with each row corresponding to a row in `newdata`, and each column to an MCMC iteration.

**Author(s)**

Steven L. Scott

**See Also**

[lm.spike](#) [SpikeSlabPrior](#) [summary.lm.spike](#) [plot.lm.spike](#)

**Examples**

```
niter <- 1000
n <- 100
p <- 10
ngood <- 3

x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
beta <- rep(0, p)
good <- sample(1:p, ngood)
beta[good] <- rnorm(ngood)
sigma <- 1

y <- rnorm(n, x %*% beta, sigma)
model <- lm.spike(y ~ x - 1, niter=niter)
plot(model)
plot.ts(model$beta)
hist(model$sigma) ## should be near true value

new.x <- cbind(1, matrix(rnorm(100 * (p-1)), ncol = (p-1)))
pred <- predict(model, newdata = new.x, burn = 100)
```

---

```
print.summary.lm.spike
```

*Print method for spikeslab objects.*

---

## Description

Print a spikeslab object.

## Usage

```
## S3 method for class 'summary.lm.spike'  
print(x, ...)  
## S3 method for class 'summary.logit.spike'  
print(x, ...)
```

## Arguments

`x` An object of class `summary.lm.spike`.  
`...` Additional arguments passed to `print.default`.

## Value

This function is called for its side effect, which is to print the spikeslab object to the screen.

## Author(s)

Steven L. Scott

## See Also

[lm.spike](#) [summary.lm.spike](#)

## Examples

```
n <- 100  
p <- 10  
ngood <- 3  
niter <- 1000  
sigma <- 2  
  
x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))  
beta <- c(rnorm(ngood), rep(0, p - ngood))  
y <- rnorm(n, x %*% beta, sigma)  
x <- x[,-1]  
model <- lm.spike(y ~ x, niter=niter)  
summary(model)
```

---

probit.spike	<i>Spike and slab probit regression</i>
--------------	---

---

## Description

MCMC algorithm for logistic regression models with a 'spike-and-slab' prior that places some amount of posterior probability at zero for a subset of the regression coefficients.

## Usage

```
probit.spike(formula,
             niter,
             data,
             subset,
             prior = NULL,
             na.action = options("na.action"),
             contrasts = NULL,
             drop.unused.levels = TRUE,
             initial.value = NULL,
             ping = niter / 10,
             clt.threshold = 5,
             proposal.df = 3,
             sampler.weights = c(.5, .5),
             seed = NULL,
             ...)
```

## Arguments

formula	Formula for the maximal model (with all variables included). This is parsed the same way as a call to <code>glm</code> , but no family argument is needed. Like <code>glm</code> , a two-column input format (success-count, failure-count) can be used for the response. Otherwise, the response variable can be a logical or numeric vector. If a single-column response is numeric, then a positive value indicates a "success".
niter	The number of MCMC iterations to run. Be sure to include enough so you can throw away a burn-in set.
data	An optional data frame, list or environment (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 <code>probit.spike</code> is called.
subset	An optional vector specifying a subset of observations to be used in the fitting process.
prior	An object inheriting from <code>LogitPrior</code> and <code>SpikeSlabPriorBase</code> . If prior is supplied it will be used. Otherwise a prior distribution will be constructed by calling <code>LogitZellnerPrior</code> with the remaining arguments. Despite the name, <code>LogitPrior</code> objects are appropriate for Probit models.

<code>na.action</code>	A function which indicates what should happen when the data contain NAs. The default is set by the <code>na.action</code> setting of options, and is <code>na.fail</code> if that is unset. The factory-fresh default is <code>na.omit</code> . Another possible value is <code>NULL</code> , no action. Value <code>na.exclude</code> can be useful.
<code>contrasts</code>	An optional list. See the <code>contrasts.arg</code> of <code>model.matrix.default</code> .
<code>drop.unused.levels</code>	A logical value indicating whether factor levels that are unobserved should be dropped from the model.
<code>initial.value</code>	Initial value for the MCMC algorithm. Can either be a numeric vector, a <code>glm</code> object (from which the coefficients will be used), or a <code>probit.spike</code> object. If a <code>probit.spike</code> object is supplied, it is assumed to be from a previous MCMC run for which <code>niter</code> additional draws are desired. If a <code>glm</code> object is supplied then its coefficients will be used as the initial values for the simulation.
<code>ping</code>	If positive, then print a status update to the console every <code>ping</code> MCMC iterations.
<code>clt.threshold</code>	When the model is presented with binomial data (i.e. when the response is a two-column matrix) the data augmentation algorithm can be made more efficient by updating a single, asymptotically normal scalar quantity for each unique value of the predictors. The asymptotic result will be used whenever the number of successes or failures exceeds <code>clt.threshold</code> .
<code>proposal.df</code>	The degrees of freedom parameter to use in Metropolis-Hastings proposals. See details.
<code>sampler.weights</code>	A two-element vector giving the probabilities of drawing from the two base sampling algorithm. The first element refers to the spike and slab algorithm. The second refers to the tailored independence Metropolis sampler. TIM is usually faster mixing, but cannot change model dimension.
<code>seed</code>	Seed to use for the C++ random number generator. It should be <code>NULL</code> or an int. If <code>NULL</code> the seed value will be taken from the global <code>.Random.seed</code> object.
<code>...</code>	Extra arguments to be passed to <code>LogitZellnerPrior</code> .

## Details

Model parameters are updated using a composite of two Metropolis-Hastings updates. A data augmentation algorithm (Albert and Chib 1993) updates the entire parameter vector at once, but can mix slowly.

The second algorithm is an independence Metropolis sampler centered on the posterior mode with variance determined by posterior information matrix (Fisher information plus prior information). If `proposal.df > 0` then the tails of the proposal are inflated so that a multivariate T proposal is used instead.

At each iteration, one of the three algorithms is chosen at random. The auxiliary mixture sampler is the only one that can change the dimension of the coefficient vector. The MH algorithm only updates the coefficients that are currently nonzero.



**Value**

Returns an object of class `probit.spike`, which inherits from `lm.spike`. The returned object is a list with the following elements

beta	A <code>niter</code> by <code>ncol(x)</code> matrix of regression coefficients, many of which may be zero. Each row corresponds to an MCMC iteration.
prior	The prior used to fit the model. If a prior was supplied as an argument it will be returned. Otherwise this will be the automatically generated prior based on the other function arguments.

**Author(s)**

Steven L. Scott

**See Also**

[lm.spike](#) [SpikeSlabPrior](#), [plot.probit.spike](#), [PlotProbitSpikeFitSummary](#) [PlotProbitSpikeResiduals](#) [summary.logit.spike](#), [predict.logit.spike](#).

**Examples**

```
if (requireNamespace("MASS")) {
  data(Pima.tr, package = "MASS")
  data(Pima.te, package = "MASS")
  pima <- rbind(Pima.tr, Pima.te)
  model <- probit.spike(type == "Yes" ~ ., data = pima, niter = 500)
  plot(model)
  plot(model, "fit")
  plot(model, "residuals")
  plot(model, "size")
  summary(model)
}
```

---

qreg.spike

*Quantile Regression*

---

**Description**

MCMC algorithm for quasi-Bayesian quantile models with a 'spike-and-slab' prior that places some amount of posterior probability at zero for a subset of the regression coefficients.

**Usage**

```
qreg.spike(formula,
            quantile,
            niter,
            ping = niter / 10,
            nthreads = 0,
```

```

data,
subset,
prior = NULL,
na.action = options("na.action"),
contrasts = NULL,
drop.unused.levels = TRUE,
initial.value = NULL,
seed = NULL,
...)
```

### Arguments

formula	Formula for the maximal model (with all variables included).
quantile	A scalar value between 0 and 1 indicating the quantile of the conditional distribution being modeled.
niter	The number of MCMC iterations to run. Be sure to include enough so you can throw away a burn-in set.
ping	If positive, then print a status update to the console every ping MCMC iterations.
nthreads	The number of CPU-threads to use for data augmentation. There is some small overhead to stopping and starting threads. For small data sets, thread overhead will make it faster to run single threaded. For larger data sets multi-threading can speed things up substantially. This is all machine dependent, so please experiment.
data	An optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in <code>data</code> , the variables are taken from <code>environment(formula)</code> , typically the environment from which <code>qreg.spike</code> is called.
subset	An optional vector specifying a subset of observations to be used in the fitting process.
prior	An optional list such as that returned from <a href="#">SpikeSlabPrior</a> . If missing, <code>SpikeSlabPrior</code> will be called using the extra arguments passed via <code>...</code>
na.action	A function which indicates what should happen when the data contain NAs. The default is set by the <code>na.action</code> setting of <code>options</code> , and is <code>na.fail</code> if that is unset. The factory-fresh default is <code>na.omit</code> . Another possible value is <code>NULL</code> , no action. Value <code>na.exclude</code> can be useful.
contrasts	An optional list. See the <code>contrasts.arg</code> of <a href="#">model.matrix.default</a> .
drop.unused.levels	A logical value indicating whether factor levels that are unobserved should be dropped from the model.
initial.value	Initial value for the MCMC algorithm. Can either be a numeric vector, a <a href="#">glm</a> object (from which the coefficients will be used), or a <a href="#">qreg.spike</a> object. If a <a href="#">qreg.spike</a> object is supplied, it is assumed to be from a previous MCMC run for which <code>niter</code> additional draws are desired. If a <a href="#">glm</a> object is supplied then its coefficients will be used as the initial values for the simulation.

seed	Seed to use for the C++ random number generator. It should be NULL or an int. If NULL the seed value will be taken from the global <code>.Random.seed</code> object.
...	Extra arguments to be passed to <code>SpikeSlabPrior</code> .

### Details

Just like ordinary regression models the mean of a distribution as a linear function of X, quantile regression models a specific quantile (e.g. the 90th percentile) as a function of X.

Median regression is a special case of quantile regression. Median regression is sometimes cast in terms of minimizing  $\|y - X * \beta\|_1$ , because the median is the optimal action under L1 loss. Similarly, selecting quantile tau is optimal under the asymmetric loss function

$$\rho_\tau(u) = \tau u I(u > 0) + (1 - \tau) u I(u < 0)$$

Thus quantile regression (for a specific quantile tau) minimizes

$$Q(\beta) = \sum_i \rho_\tau(y_i - \beta^T x_i)$$

Bayesian quantile regression treats

$$\exp(-2Q(\beta))$$

as a likelihood function to which a prior distribution  $p(\beta)$  is applied. For posterior sampling, a data augmentation scheme is used where each observation is associated with a latent variable  $\lambda_i$ , which has a marginal distribution of

$$\text{Exp}(2\tau(1 - \tau)).$$

The conditional distribution given the residual  $r = y - x\beta$  is

$$\frac{1}{\lambda} |r| \sim \text{InvGaus}(1/|r|, 1.0)$$

The conditional distribution of beta given complete data (lambda and y) is a weighted least squares regression, where observation i has precision  $\lambda_i$  and where observation i is offset by  $2(\tau - 1)\lambda_i$ .

### Value

Returns an object of class `qreg.spike`, which inherits from `lm.spike`. The returned object is a list with the following elements

beta	A niter by ncol(x) matrix of regression coefficients, many of which may be zero. Each row corresponds to an MCMC iteration.
prior	The prior used to fit the model. If a prior was supplied as an argument it will be returned. Otherwise this will be the automatically generated prior based on the other function arguments.

### Author(s)

Steven L. Scott

**References**

Parzen and Polson (2011, unpublished)

**See Also**

[lm.spike](#) [SpikeSlabPrior](#), [plot.qreg.spike](#), [predict.qreg.spike](#).

**Examples**

```
n <- 50
x <- rnorm(n)
y <- rnorm(n, 4 * x)
model <- qreg.spike(y ~ x,
                   quantile = .8,
                   niter = 1000,
                   expected.model.size = 100)

## Should get a slope near 4 and an intercept near qnorm(.8).
PlotManyTs(model$beta[-(1:100)],
           same.scale = TRUE,
           truth = c(qnorm(.8), 4))
```

---

residuals.lm.spike      *Extract lm.spike Residuals*

---

**Description**

Get residuals from an [lm.spike](#) object.

**Usage**

```
## S3 method for class 'lm.spike'
residuals(
  object,
  burn = SuggestBurnLogLikelihood(object$log.likelihood),
  mean.only = FALSE,
  ...)
```

**Arguments**

object	An object of class <code>lm.spike</code> .
burn	The number of MCMC iterations in the object to be discarded as burn-in.
mean.only	Logical. If TRUE then the posterior mean of each residual is returned. If FALSE then the full posterior distribution of residuals is returned.
...	Unused, but present for compatibility with generic <code>residuals</code> function.

**Value**

The posterior distribution (or posterior mean) of residuals from the model object. If `mean.only` is TRUE then the return value is the vector of residuals, otherwise the return value is a matrix, with rows corresponding to MCMC iterations, and columns to individual observations.

**Author(s)**

Steven L. Scott

**See Also**

[lm.spike](#) [SpikeSlabPrior](#) [summary.lm.spike](#) [plot.lm.spike](#)

**Examples**

```
niter <- 1000
n <- 100
p <- 10
ngood <- 3

x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
beta <- rep(0, p)
good <- sample(1:p, ngood)
beta[good] <- rnorm(ngood)
sigma <- 1

y <- rnorm(n, x %*% beta, sigma)
model <- lm.spike(y ~ x - 1, niter=niter)
plot(model)
residuals(model)
residuals(model, mean.only = TRUE)
```

---

shrinkage.regression    *Shrinking Regression Coefficients*

---

**Description**

Fits a Bayesian regression model with a shrinkage prior on the coefficient. The model is

$$y_i \sim N(x_i\beta, \sigma^2) \quad 1/\sigma^2 \sim \text{Gamma}(df/2, ss/2) \quad g_1(\beta) \sim N(b_1, v_1) \quad g_2(\beta) \sim N(b_2, v_2) \dots$$

In this notation,  $g_k(\beta) \sim N(b_k, v_k)$  indicates that the subset of coefficients in group  $k$  are a priori independent draws from the specified normal distribution. In addition, each subset-level prior may include a hyperprior, in which case the subset-level prior parameters will be updated as part of the MCMC. The hyperprior has the form of independent priors on the mean and precision parameters:

$$b_i \sim N(\text{prior.mean}, \text{prior.variance}) \quad 1/v_i \sim \text{Chisq}(df, \text{guess.at.sd}).$$

**Usage**

```
ShrinkageRegression(response, predictors, coefficient.groups,
                    residual.precision.prior = NULL,
                    suf = NULL, niter, ping = niter / 10,
                    seed = NULL)
```

```
CoefficientGroup(indices, mean.hyperprior = NULL, sd.hyperprior = NULL,
                 prior = NULL)
```

**Arguments**

response	The numeric vector of responses.
predictors	The matrix of predictors, including an intercept term, if desired.
coefficient.groups	A list of objects of type <a href="#">CoefficientGroup</a> , defining the pattern in which the coefficients should be shrunk together. Each coefficient must belong to exactly one <a href="#">CoefficientGroup</a> .
residual.precision.prior	An object of type <a href="#">SdPrior</a> describing the prior distribution of the residual standard deviation.
suf	An object of class <a href="#">RegressionSuf</a> containing the sufficient statistics for the regression model. If this is NULL then it will be computed from response and predictors. If it is supplied then response and predictors are not used and can be left missing.
niter	The desired number of MCMC iterations.
ping	The frequency with which to print status updates.
seed	The integer-valued seed (or NULL) to use for the C++ random number generator.
indices	A vector of integers giving the positions of the regression coefficients that should be viewed as exchangeable.
mean.hyperprior	A <a href="#">NormalPrior</a> object describing the hyperprior distribution for the average coefficient.
sd.hyperprior	An <a href="#">SdPrior</a> object describing the hyperprior distribution for the standard deviation of the coefficients.
prior	An object of type <a href="#">NormalPrior</a> giving the initial value of the distribution describing the collection of coefficients in this group. If either hyperprior is NULL then the corresponding prior parameter will not be updated. If both hyperpriors are non-NULL then this parameter can be left unspecified.

**Value**

`ShrinkageRegression` returns a list containing MCMC draws from the posterior distribution of model parameters. Each of the following is a matrix, with rows corresponding to MCMC draws, and columns to distinct parameters.

- `coefficients`: regression coefficients.
- `residual.sd`: the residual standard deviation from the regression model.
- `group.means`: The posterior distribution of the mean of each coefficient group. If no mean hyperprior was assigned to a particular group, then the value here will be a constant (the values supplied by the prior argument to `CoefficientGroup` for that group).
- `group.sds`: The posterior distribution of the standard deviation of each coefficient group. If no sd.hyperprior was assigned to a particular group, then the value here will be a constant (the values supplied by the prior argument to `CoefficientGroup` for that group).

`CoefficientGroup` is a configuration utility used to define which coefficients should be shrunk together. It returns an object (list) formatted in the manner expected by `ShrinkageRegression`.

### Author(s)

Steven L. Scott

### Examples

```
b0 <- -1
b1 <- rnorm(20, 3, .2)
b2 <- rnorm(30, -4, 7)
nobs <- 10000
beta <- c(b0, b1, b2)

X <- cbind(1, matrix(rnorm(nobs * (length(beta) - 1)), nrow = nobs, ncol = length(beta) - 1))
y.hat <- X %*% beta
y <- rnorm(nobs, y.hat, .5)

groups <- list(intercept = CoefficientGroup(1, prior = NormalPrior(0, 100)),
              first = CoefficientGroup(2:21,
                                       mean.hyperprior = NormalPrior(0, 100),
                                       sd.hyperprior = SdPrior(.2, 1)),
              second = CoefficientGroup(22:51,
                                       mean.hyperprior = NormalPrior(0, 100),
                                       sd.hyperprior = SdPrior(7, 1)))

model <- ShrinkageRegression(y, X, groups,
                            residual.precision.prior = SdPrior(.5, 1),
                            niter = 1000)
```

---

spike.slab.glm.prior *Zellner Prior for Glm's*

---

### Description

A Zellner-style spike and slab prior for generalized linear models. It is intended as a base class for `LogitZellnerPrior`, `PoissonZellnerPrior`, and potential future extensions.

**Usage**

```
SpikeSlabGlmPrior(
  predictors,
  weight,
  mean.on.natural.scale,
  expected.model.size,
  prior.information.weight,
  diagonal.shrinkage,
  optional.coefficient.estimate,
  max.flips,
  prior.inclusion.probabilities)
```

**Arguments**

predictors	The design matrix for the regression problem. No missing data is allowed.
weight	A vector of length <code>nrow(predictors)</code> giving the prior weight assigned to each observation in <code>predictors</code> . This should ideally match the weights from the Fisher information (e.g. $p * (1-p)$ ) for logistic regression, or $\lambda$ for Poisson regression, but that depends on the model, so a typical thing to do is to set all the weights the same.
mean.on.natural.scale	Used to set the prior mean for the intercept. The mean of the response, expressed on the natural scale. This is $\text{logit}(\hat{p})$ for logits and $\text{log}(\bar{y})$ for Poissons.
expected.model.size	A positive number less than <code>ncol(x)</code> , representing a guess at the number of significant predictor variables. Used to obtain the 'spike' portion of the spike and slab prior.
prior.information.weight	A positive scalar. Number of observations worth of weight that should be given to the prior estimate of beta.
diagonal.shrinkage	The conditionally Gaussian prior for beta (the "slab") starts with a precision matrix equal to the information in a single observation. However, this matrix might not be full rank. The matrix can be made full rank by averaging with its diagonal. <code>diagonal.shrinkage</code> is the weight given to the diagonal in this average. Setting this to zero gives Zellner's g-prior.
optional.coefficient.estimate	If desired, an estimate of the regression coefficients can be supplied. In most cases this will be a difficult parameter to specify. If omitted then a prior mean of zero will be used for all coordinates except the intercept, which will be set to <code>mean(y)</code> .
max.flips	The maximum number of variable inclusion indicators the sampler will attempt to sample each iteration. If negative then all indicators will be sampled.
prior.inclusion.probabilities	A vector giving the prior probability of inclusion for each variable. If NULL then a default set of probabilities is obtained by setting each element equal to $\min(1, \text{expected.model.size} / \text{ncol}(x))$ .



## Details

A Zellner-style spike and slab prior for generalized linear models. Denote the vector of coefficients by  $\beta$ , and the vector of inclusion indicators by  $\gamma$ . These are linked by the relationship  $\beta_i \neq 0$  if  $\gamma_i = 1$  and  $\beta_i = 0$  if  $\gamma_i = 0$ . The prior is

$$\beta|\gamma \sim N(b, V)$$

$$\gamma \sim B(\pi)$$

where  $\pi$  is the vector of prior inclusion probabilities, and  $b$  is the optional coefficient estimate. Conditional on  $\gamma$ , the prior information matrix is

$$V^{-1} = \kappa((1 - \alpha)x^T w x/n + \alpha \text{diag}(x^T w x/n))$$

The matrix  $x^T w x$  is, for suitable choice of the weight vector  $w$ , the total Fisher information available in the data. Dividing by  $n$  gives the average Fisher information in a single observation, multiplying by  $\kappa$  then results in  $\kappa$  units of "average" information. This matrix is averaged with its diagonal to ensure positive definiteness.

In the formula above,  $\kappa$  is prior information weight,  $\alpha$  is diagonal shrinkage, and  $w$  is a diagonal matrix with all elements set to `prior.success.probability * (1 - prior.success.probability)`. The vector  $b$  and the matrix  $V^{-1}$  are both implicitly subscripted by  $\gamma$ , meaning that elements, rows, or columns corresponding to `gamma = 0` should be omitted.

## Value

Returns an object of class `SpikeSlabGlmPrior`, which is a list with data elements encoding the selected prior values.

This object is intended for use as a base class for `LogitZellnerPrior` and `PoissonZellnerPrior`.

## Author(s)

Steven L. Scott

## References

Hugh Chipman, Edward I. George, Robert E. McCulloch, M. Clyde, Dean P. Foster, Robert A. Stine (2001), "The Practical Implementation of Bayesian Model Selection" *Lecture Notes-Monograph Series*, Vol. 38, pp. 65-134. Institute of Mathematical Statistics. <http://www.jstor.org/stable/4356164>

---

spike.slabs.prior.base *Base class for spike and slab priors*

---

## Description

A base class for SpikeSlabPrior and SpikeSlabPriorBase to ensure that elements common to both classes are handled consistently. Users will not normally interact with this function.

## Usage

```
SpikeSlabPriorBase(number.of.variables,
                    expected.r2 = .5,
                    prior.df = .01,
                    expected.model.size = 1,
                    optional.coefficient.estimate = NULL,
                    mean.y,
                    sdy,
                    prior.inclusion.proBABILITIES = NULL,
                    sigma.upper.limit = Inf)
```

## Arguments

number.of.variables	The number of columns in $x$ .
expected.r2	The expected R-square for the regression. The spike and slab prior requires an inverse gamma prior on the residual variance of the regression. The prior can be parameterized in terms of a guess at the residual variance, and a "degrees of freedom" representing the number of observations that the guess should weigh. The guess at $\sigma^2$ is set to $(1 - \text{expected.r2}) * \text{var}(y)$ .
prior.df	A positive scalar representing the prior 'degrees of freedom' for estimating the residual variance. This can be thought of as the amount of weight (expressed as an observation count) given to the expected.r2 argument.
expected.model.size	A positive number less than $\text{ncol}(x)$ , representing a guess at the number of significant predictor $p$ variables. Used to compute a default value of prior.inclusion.proBABILITIES if the latter is NULL.
optional.coefficient.estimate	If desired, an estimate of the regression coefficients can be supplied. In most cases this will be a difficult parameter to specify. If omitted then a prior mean of zero will be used for all coordinates except the intercept, which will be set to mean.y.
mean.y	The mean of the response vector. Used to create a default value of optional.coefficient.estimate when the latter is NULL.
sdy	The standard deviation of the response vector. Used along with expected.r2 to create a prior estimate of the residual variance.

prior.inclusion.probabilities

A vector giving the prior probability of inclusion for each coefficient.

sigma.upper.limit

The largest acceptable value for the residual standard deviation. A non-positive number is interpreted as Inf.

### Value

Returns an object of class SpikeSlabPriorBase, which is a list with the following elements.

- prior.inclusion.probabilities A vector giving the prior probability of inclusion for each coefficient.
- mu A vector giving the prior mean of each coefficient conditional on inclusion.
- sigma.guess A prior estimate of the residual standard deviation.
- prior.df The number of observations worth of weight to be given to sigma.guess.

### Author(s)

Steven L. Scott

### References

George and McCulloch (1997), "Approaches to Bayesian Variable Selection", *Statistica Sinica*, **7**, 339 – 373.

<http://www3.stat.sinica.edu.tw/statistica/oldpdf/A7n26.pdf>

---

student.spike.slab.prior

*Spike and Slab Prior for Student-T Regression*

---

### Description

A Zellner-style spike and slab prior for regression models with Student-t errors.

### Usage

```
StudentSpikeSlabPrior(predictor.matrix,
  response.vector = NULL,
  expected.r2 = .5,
  prior.df = .01,
  expected.model.size = 1,
  prior.information.weight = .01,
  diagonal.shrinkage = .5,
  optional.coefficient.estimate = NULL,
  max.flips = -1,
  mean.y = mean(response.vector, na.rm = TRUE),
  sdy = sd(as.numeric(response.vector), na.rm = TRUE),
```

```
prior.inclusion.probabilities = NULL,
sigma.upper.limit = Inf,
degrees.of.freedom.prior = UniformPrior(.1, 100)
```

### Arguments

<code>predictor.matrix</code>	The design matrix for the regression problem. Missing data is not allowed.
<code>response.vector</code>	The vector of responses for the regression. Missing data is not allowed. If <code>response.vector</code> is not available, you can pass <code>response.vector = NULL</code> , and specify <code>mean.y</code> and <code>sd.y</code> instead.
<code>expected.r2</code>	The expected R-square for the regression. The spike and slab prior requires an inverse gamma prior on the residual variance of the regression. The prior can be parameterized in terms of a guess at the residual variance, and a "degrees of freedom" representing the number of observations that the guess should weigh. The guess at $\sigma^2$ is set to $(1 - \text{expected.r2}) * \text{var}(y)$ .
<code>prior.df</code>	A positive scalar representing the prior 'degrees of freedom' for estimating the residual variance. This can be thought of as the amount of weight (expressed as an observation count) given to the <code>expected.r2</code> argument.
<code>expected.model.size</code>	A positive number less than <code>ncol(x)</code> , representing a guess at the number of significant predictor variables. Used to obtain the 'spike' portion of the spike and slab prior.
<code>prior.information.weight</code>	A positive scalar. Number of observations worth of weight that should be given to the prior estimate of beta.
<code>diagonal.shrinkage</code>	The conditionally Gaussian prior for beta (the "slab") starts with a precision matrix equal to the information in a single observation. However, this matrix might not be full rank. The matrix can be made full rank by averaging with its diagonal. <code>diagonal.shrinkage</code> is the weight given to the diagonal in this average. Setting this to zero gives Zellner's g-prior.
<code>optional.coefficient.estimate</code>	If desired, an estimate of the regression coefficients can be supplied. In most cases this will be a difficult parameter to specify. If omitted then a prior mean of zero will be used for all coordinates except the intercept, which will be set to <code>mean(y)</code> .
<code>max.flips</code>	The maximum number of variable inclusion indicators the sampler will attempt to sample each iteration. If <code>max.flips &lt;= 0</code> then all indicators will be sampled.
<code>mean.y</code>	The mean of the response vector, for use in cases when specifying the response vector is undesirable.
<code>sd.y</code>	The standard deviation of the response vector, for use in cases when specifying the response vector is undesirable.
<code>prior.inclusion.probabilities</code>	A vector giving the prior probability of inclusion for each variable.

`sigma.upper.limit`

The largest acceptable value for the residual standard deviation. A non-positive number is interpreted as Inf.

`degrees.of.freedom.prior`

An object of class `DoubleModel` representing the prior distribution for the Student T tail thickness (or "degrees of freedom") parameter.

### Value

A `SpikeSlabPrior` with `degrees.of.freedom.prior` appended.

### Author(s)

Steven L. Scott

### References

George and McCulloch (1997), "Approaches to Bayesian Variable Selection", *Statistica Sinica*, **7**, 339 – 373.

<http://www3.stat.sinica.edu.tw/statistica/oldpdf/A7n26.pdf>

---

SummarizeSpikeSlabCoefficients

*Numerical summaries of coefficients from a spike and slab regression.*

---

### Description

Produces a summary of the marginal distribution of model coefficients from a spike and slab regression.

### Usage

```
SummarizeSpikeSlabCoefficients(beta, burn = 0, order = TRUE)
```

### Arguments

<code>beta</code>	A matrix containing MCMC draws of regression coefficients. Each row is an MCMC draw. Each column is a coefficient.
<code>burn</code>	The number of MCMC iterations in the object to be discarded as burn-in.
<code>order</code>	Logical. If TRUE then the coefficients are presented in order of their posterior inclusion probabilities. Otherwise the order of the coefficients is the same as in object.

**Value**

A five-column matrix with rows representing model coefficients. The first two columns are the posterior mean and standard deviation of each coefficient, including the point mass at zero. The next two columns are the posterior mean and standard deviations conditional on the coefficient being nonzero. The last column is the probability of a nonzero coefficient.

**Author(s)**

Steven L. Scott

**See Also**

[lm.spike](#) [summary.lm.spike](#)

**Examples**

```
n <- 100
p <- 10
ngood <- 3
niter <- 1000
sigma <- 2

x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
beta <- c(rnorm(ngood), rep(0, p - ngood))
y <- rnorm(n, x %*% beta, sigma)
x <- x[,-1]
model <- lm.spike(y ~ x, niter=niter)
plot(model)
plot.ts(model$beta)
hist(model$sigma) ## should be near 8
summary(model)
SummarizeSpikeSlabCoefficients(model$beta, burn = 100)
```

---

summary.lm.spike

*Numerical summaries of the results from a spike and slab regression.*

---

**Description**

Produces a summary of the marginal distribution of model coefficients from a spike and slab regression.

**Usage**

```
## S3 method for class 'lm.spike'
summary(object, burn = 0, order = TRUE, ...)
```

**Arguments**

object	An object of class <code>lm.spike</code> .
burn	The number of MCMC iterations in the object to be discarded as burn-in.
order	Logical. If TRUE then the coefficients are presented in order of their posterior inclusion probabilities. Otherwise the order of the coefficients is the same as in object.
...	Unused. Present for compatibility with <code>generic.summary()</code> .

**Value**

Returns a list with the following elements:

coefficients	A five-column matrix with rows representing model coefficients. The first two columns are the posterior mean and standard deviation of each coefficient, including the point mass at zero. The next two columns are the posterior mean and standard deviations conditional on the coefficient being nonzero. The last column is the probability of a nonzero coefficient.
residual.sd	A summary of the posterior distribution of the residual standard deviation parameter.
rsquare	A summary of the posterior distribution of the $R^2$ statistic: $1 - \text{residual.sd}^2 / \text{var}(y)$

**Author(s)**

Steven L. Scott

**See Also**

[lm.spike](#) [SpikeSlabPrior](#) [plot.lm.spike](#) [predict.lm.spike](#)

**Examples**

```
n <- 100
p <- 10
ngood <- 3
niter <- 1000
sigma <- 2

x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
beta <- c(rnorm(ngood), rep(0, p - ngood))
y <- rnorm(n, x %*% beta, sigma)
x <- x[,-1]
model <- lm.spike(y ~ x, niter=niter)
plot(model)
plot.ts(model$beta)
hist(model$sigma) ## should be near 8
summary(model)
```

---

summary.logit.spike    *Numerical summaries of the results from a spike and slab logistic regression.*

---

## Description

Produces a summary of the marginal distribution of model coefficients from a spike and slab logistic regression.

## Usage

```
## S3 method for class 'logit.spike'
summary(object,
        burn = 0,
        order = TRUE,
        cutpoint.scale = c("probability", "logit"),
        cutpoint.basis = c("sample.size", "equal.range"),
        number.of.buckets = 10,
        coefficients = TRUE,
        ...)

## S3 method for class 'probit.spike'
summary(object,
        burn = 0,
        order = TRUE,
        cutpoint.scale = c("probability", "probit"),
        cutpoint.basis = c("sample.size", "equal.range"),
        number.of.buckets = 10,
        coefficients = TRUE,
        ...)
```

## Arguments

object	An object of class <code>logit.spike</code> or <code>probit.spike</code> .
burn	The number of MCMC iterations in the object to be discarded as burn-in.
order	Logical. If TRUE then the coefficients are presented in order of their posterior inclusion probabilities. Otherwise the order of the coefficients is the same as in object.
cutpoint.scale	The scale that should be used to determine the buckets for the comparison of predicted and actual probabilities.
cutpoint.basis	How should the buckets be determined in the comparison of predicted to actual probabilities? If "sample.sample", then each bucket contains the same fraction of data. If "equal.range" then the buckets are formed by partitioning the range of the predicted probabilities, and each bucket occupies the same amount of space on the real line.



number.of.buckets	The number of buckets to use in the comparison of predicted to actual probabilities.
coefficients	Logical value indicating whether the coefficient summary should be included in the output. It can be useful to suppress the coefficients if there are many of them.
...	Unused. Present for compatibility with generic summary().

**Value**

Returns a list with the following elements

- `coefficients`: A five-column matrix summarizing the model coefficients, produced by [SummarizeSpikeSlabCoefficients](#)
- `null.log.likelihood`: The log likelihood of the null binomial model evaluated at the MLE.
- `mean.log.likelihood`: The average value of log likelihood visited by the sampler.
- `max.log.likelihood`: The largest log likelihood value visited by the sampler.
- `deviance.r2`: The deviance R-square obtained by taking  $(\text{null.likelihood} - \text{mean.log.likelihood}) / \text{null.log.likelihood}$
- `deviance.r2.distribution`: The value of the deviance R-square statistic at each point visited by the MCMC chain. This is not printed by the print method.
- `predicted.vs.actual`: A table obtained by partitioning the data into buckets, and comparing the average predicted probability with the empirical success rate in each bucket.

**Author(s)**

Steven L. Scott

**See Also**

[logit.spike](#) [probit.spike](#) [SpikeSlabPrior](#)

**Examples**

```
n <- 100
p <- 10
ngood <- 3
niter <- 1000

x <- cbind(1, matrix(rnorm(n * (p-1)), nrow=n))
beta <- c(rnorm(ngood), rep(0, p - ngood))
prob <- plogis(x %*% beta)
y <- runif(n) < prob
x <- x[,-1]
model <- logit.spike(y ~ x, niter=niter)
summary(model)
```

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