

# Package ‘eshrink’

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**Title** Shrinkage for Effect Estimation

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**Author** Joshua Keller

**Maintainer** Joshua Keller <joshua.keller@colostate.edu>

**Description** Computes shrinkage estimators for regression problems. Selects penalty parameter by minimizing bias and variance in the effect estimate, where bias and variance are estimated from the posterior predictive distribution. See Keller and Rice (2017) <[doi:10.1093/aje/kwx225](https://doi.org/10.1093/aje/kwx225)> for more details.

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eshrink-package      *Shrinkage Estimators for Regression*

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### Description

Computes shrinkage estimators for regression problems. Selects penalty parameter by minimizing bias and variance in the effect estimate, where bias and variance are estimated from the posterior predictive distribution. See Keller and Rice (2017) <doi:10.1093/aje/kwx225> for more details.

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check\_CIbound      *Confidence intervals for 'fLoss' estimators*

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### Description

Compute confidence intervals by 'inverting the test' to determine if a given value should lie in the confidence region.

### Usage

```
check_CIbound(
  testBeta,
  obsEst,
  type = c("ridge", "lasso"),
  postParam,
  lambdaseq,
  X,
  nPost,
  ind = 1,
  Bstar = 100,
  B = 500,
  loss = "fMBV",
  lowerBound = TRUE,
  reproducible = TRUE,
  alpha = 0.025,
  returnDist = FALSE,
  ...
)

invertTest(
  interval,
  type = "ridge",
  lower.interval = interval,
  upper.interval = interval,
  ...,
  tol = 0.005,
  fulldetail = FALSE
)
```

**Arguments**

testBeta	Candidate value of beta to test.
obsEst	Estimate of beta from the observed data for which a confidence interval is desired
type	String indicating "ridge" or "LASSO".
postParam	List of parameters for the posterior distribution of beta. See <a href="#">samplePosterior</a> for expected names.
lambdaseq	Sequence of penalty values
X	design matrix
nPost	Number of posterior samples to use.
ind	Index of parameter to test. Defaults to 1.
Bstar	Number of estimators to compute for comparison distribution. Larger values improve the precision of the procedure but increase computational cost.
B	Passed to <a href="#">festLASSO</a>
loss	Either "fMBV" or "fMSE".
lowerBound	Logical indicating that the test is for a lower bound
reproducible	Should the simulated datasets be reproducible?
alpha	Percentile of the distribution to compare against. See details.
returnDist	If TRUE, then distribution of estimates generated is returned instead of comparison against alpha
...	In <code>invertTest</code> , these are passed to <code>check_CIbound</code> . In <code>check_CIbound</code> , these arguments are passed to <a href="#">samplePosterior</a> .
interval	Interval to check. Used for both upper and lower bound, if they are not provided
lower.interval, upper.interval	Bounding intervals over which to check for lower and upper endpoints of CI
tol	Passed to <a href="#">uniroot</a>
fulldetail	If TRUE, then output from <a href="#">uniroot</a> is included.

**Details**

This function is used as part of an 'inverting the test' approach to generate confidence intervals for estimators from [festRidge](#). Bstar datasets are generated from slices of the posterior distribution of the model parameters where beta (or other parameter indicated by `ind`) is fixed at the value `testBeta`. For each dataset, beta is estimated via [festRidge](#) or [festLASSO](#), and the resulting distribution of estimators is compared against the estimate from the observed data (`obsEst`).

The values of `lambdaseq`, `X`, `nPost`, and `loss` are passed to [festRidge](#) or [festLASSO](#) and typically match the values that were used to compute `obsEst`.

The computational cost of this function is most affected by the values of `nPost` and `Bstar`. Large values of the latter are important for adequately representing the distribution of parameter estimates. In some settings, `nPost` can be reduced without substantially impacting the results. However, each dataset is likely to be different.

**Author(s)**

Joshua Keller

**See Also**[festRidge](#)

---

estRidge*Estimate Coefficients for Ridge Regression*

---

**Description**

Computes a vector of regression coefficients for a provided ridge penalty.

**Usage**

```
estRidge(lambda, X, y, penalize, XtX = crossprod(X))
```

**Arguments**

lambda	ridge penalty factor
X	design matrix for the regression.
y	outcome vector. Unless X contains an intercept column, this should typically be centered.
penalize	vector giving penalty structure. Values must be in [0, 1]. See Details for more information.
XtX	(optional) cross product of the design matrix. If running simulations or other procedure for identical X, providing a pre-computed value can reduce computational cost.

**Details**

The input `penalize` is a vector of ridge penalty factors, such that the penalty for covariate `j` is `lambda*penalize[j]`. Although its primary purpose is for indicating which variables to penalize (1) and which to not penalize (0), fractional values between 0 and 1 are accepted. Defaults to `c(0, rep(1, p-1))`, where `p` is number of columns in `X` (this penalizes all coefficients but the first).

The design matrix `X` is assumed to contain only numeric values, so any factors should be coded according to desired contrast (e.g., via [model.matrix](#))

**Author(s)**

Joshua Keller

**See Also**[festRidge](#), [mseRidge](#)

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`festLASSO`*Compute 'Future Loss' Ridge or LASSO Estimates*

---

**Description**

Computes a ridge or LASSO estimate for a given regression problem, with penalty parameter chosen to minimize bias and variance.

**Usage**

```
festLASSO(  
  X,  
  y,  
  loss = c("fMSE", "fMBV", "both"),  
  ind = 1,  
  lseq,  
  B = 500,  
  penalize,  
  rescale.lambda = TRUE,  
  scale = FALSE,  
  returnMSE = FALSE,  
  postsamp,  
  returnPS = FALSE,  
  nPost = 1000,  
  se.version = c("varExp", "full", "none"),  
  ...  
)  
  
festRidge(  
  X,  
  y,  
  loss = c("fMSE", "fMBV", "both"),  
  ind = 1,  
  lseq,  
  penalize,  
  scale = FALSE,  
  returnMSE = FALSE,  
  postsamp,  
  returnPS = FALSE,  
  nPost = 1000,  
  se.version = c("varExp", "full", "none"),  
  XtXlamIinv = NULL,  
  ...  
)
```

**Arguments**

X	Design matrix for the regression. Assumed to contain only numeric values, so any factors should be coded according to desired contrast (e.g., via <a href="#">model.matrix</a> )
y	Outcome vector. Unless X contains an intercept column, this should typically be centered.
loss	Loss function for choosing the penalty parameter. See details.
ind	Vector of integers or logicals indicating which coefficients the loss is to be computed on.
lseq	Sequence of penalty values to consider.
B	Number of future datasets to simulate for each point in posterior sample.
penalize	See <a href="#">estRidge</a>
rescale.lambda	If TRUE, then lambda is rescaled to account for the default re-scaling done by glmnet. Can also be a scalar scaling factor.
scale	Logical indicating whether the design matrix X be scaled. See details.
returnMSE	Logical indicating whether mse object should be returned.
postsamp	List containing posterior sample (from <a href="#">samplePosterior</a> ). If missing, then a posterior sample is drawn. Currently checks on the provided postsamp are limited, so use with caution. Designed to facilitate simulations or other scenarios where it may be pre-computed.
returnPS	logical indicating whether or not the full posterior sample should be included in output.
nPost	Size of posterior sample to compute
se.version	String indicating which version of standard errors to use. See <a href="#">vcovfestRidge</a> .
...	Other arguments passed to <a href="#">samplePosterior</a>
XtXlamIinv	explicit value of $(X'X + \text{diag}(\text{penalty}))^{-1}$ . Useful for simulations to save computation.

**Details**

The value of the ridge or LASSO penalty is selected by minimizing the posterior expectation of the loss function, which is chosen by the argument `loss`. Possible options are `fMBV`, which uses the loss function  $fMBV = \max(Bias(\beta)^2, Var(\beta))$  and `fMSE`, which uses the loss function  $fMSE = Bias(\beta)^2 + Var(\beta)$ .

To balance the influence of covariates, it is recommended that the design matrix be standardized. This can be done by the user or via the argument `scale`. If `scale=TRUE`, then coefficient and standard error estimates are back-transformed.

Use the `XtXlamIinv` argument with caution. No checks are done on the provided value. Note that `lseq` is re-ordered to be decreasing, and provided values of `XtXlamIinv` must account for this.

**See Also**

[mseRidge](#), [vcovfestRidge](#), [simLASSO](#), [check\\_CIbound](#)

mseRidge

*Compute MSE, Bias, and Variance for Ridge Estimator***Description**

Computes the analytic mean-squared error (MSE), bias, and variance for ridge regression estimators given different values of the true beta and sigma2 parameters.

**Usage**

```
mseRidge(lambda, XtX, beta, sigma2, penalize, ind = 1, XtXlamIinv = NULL)
```

```
biasRidge(lambda, XtX, beta, penalize, ind = 1, XtXlamIinv = NULL)
```

```
varRidge(lambda, XtX, sigma2 = 1, penalize, ind = 1, XtXlamIinv = NULL)
```

**Arguments**

lambda	penalty parameter value. For biasRidge and varRidge, this should be a single value. For mseRidge, either a single value or a list of values.
XtX	Cross product of design matrix. Not needed if XtXlamIinv is provided.
beta	True parameter values. Either a vector of length p or a p x d matrix.
sigma2	Value of the variance parameter
penalize	Vector of penalty factors. See <a href="#">estRidge</a> for more information.
ind	Numerical or logical vector indicating which elements of the bias vector and variance matrix should be returned. Defaults to the first element.
XtXlamIinv	Optional explicit value of $(XtX + \text{diag}(\text{lambda} * \text{penalize}))^{-1}$ .

**Details**

The computations assume that all covariates are correctly included in the mean model and bias is due only to penalization. The bias is given by:

$$-(X'X + \Lambda)^{-1}\Lambda\beta$$

where  $\Lambda = \text{diag}(\lambda * \text{penalize})$ . The variance is given by:

$$\sigma^2(X'X + \Lambda)^{-1}X'X(X'X + \Lambda)^{-1}$$

If beta is provided as a matrix, this will treat each column of beta as a different true parameter vector and return a matrix of bias values (or a vector, if ind has length 1).

Providing a pre-computed value of XtXlamIinv can reduce the computational cost in simulations. However, the user is responsible for assuring that the value of lambda provided matches the value used to compute XtXlamIinv.

**Value**

For mseRidge, a list containing the variance, bias, and MSE. For biasRidge and varRidge, a matrix is returned.

**Author(s)**

Joshua Keller

samplePosterior

*Posterior Sample for Bayesian Linear Regression***Description**

Draws a sample from the posterior distribution of parameters from a Bayesian Linear regression model.

**Usage**

```
samplePosterior(
  X,
  y,
  n,
  a0 = 1,
  b0 = 5e-05,
  v0inv = 1/1000,
  mu0 = 0,
  returnParams = TRUE,
  intercept = FALSE
)
```

**Arguments**

X	Design matrix of size n by p.
y	Outcome variable
n	Size of posterior sample to be computed. A value of 0 is accepted.
a0, b0	Hyperparameters (shape, rate) for inverse gamma distribution of the error variance.
v0inv	Prior precision for the error term. Either a single value to be repeated in a diagonal precision matrix, or a p by p matrix.
mu0	Prior mean. Either a single value that will be repeated, or a vector of length p. Defaults to zero vector.
returnParams	Logical indicating whether the parameters of the posterior distribution are returned.
intercept	Logical indicating whether an intercept is included in the model. If FALSE, then y is centered.

**Details**

This function draws a sample from the posterior distributions of the coefficient parameter ( $\beta$ ) and error variance parameter ( $\sigma^2$ ) from a Bayesian linear regression model. The variance parameter is assumed to follow an inverse-gamma distribution. Conditional on the error variance parameter and a specified precision matrix, the coefficient parameters ( $\beta$ ) are multivariate normal.



**Value**

A list containing the following elements:

sigma2	A vector containing the posterior sample of $\sigma^2$ values.
beta	Matrix containing the posterior sample of $\beta$ values.
postMu	Vector containing the posterior mean (if returnParams =TRUE).
postV	Matrix giving the posterior mean (if returnParams =TRUE).
an,bn	Posterior hyperparameters for the inverse gamma distribution of the error variance (if returnParams =TRUE).

**Author(s)**

Joshua Keller

**Examples**

```
x <- rnorm(40, mean=2, sd=2)
y <- x + rnorm(40, sd=1)
samplePosterior(X=x, y=y, n=10)
samplePosterior(X=cbind(1, x), y=y, n=10, intercept=TRUE)
samplePosterior(X=cbind(1, x), y=y, n=0, mu=c(3, 3), intercept=TRUE)
```

---

simLASSO

*Compute Lasso Estimator for simulated Data*

---

**Description**

Simulates data from a regression model and computes the lasso estimate for this data.

**Usage**

```
simLASSO(lambda, X, beta, sigma, penalize, rescale.lambda = TRUE, ind = 1)
```

**Arguments**

lambda	Penalty factor to be applied
X	Design matrix of regression problem
beta	true value of parameter vector to simulate from
sigma	true value of square root of variance parameter for simulating.
penalize	Vector giving penalty structure. Supplied to glmnet as 'penalty.factor'. By default, all coefficients except first are penalized.
rescale.lambda	Should lambda be rescaled to account for the default re-scaling done by glmnet?
ind	Index of coefficient to be returned. Value of 0 implies all coefficients (i.e. the full parameter vector estimate)

**Details**

Simulates data from a regression model with true coefficient parameter  $\beta$  and normal errors with standard deviation  $\sigma$ . Computes the LASSO estimate for the coefficient vector using the `glmnet` function from the package of the same name.

**Author(s)**

Joshua Keller

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vcovfestRidge	<i>Standard Error Estimate</i>
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**Description**

Computes an estimate of the variance-covariance matrix for an 'fLoss' ridge estimator

**Usage**

```
vcovfestRidge(
  fLoss,
  lambda,
  XtX,
  postBeta,
  postSigma2,
  penalize,
  ind = 1,
  version = c("varExp", "full")
)
```

**Arguments**

fLoss	A matrix of loss function values to be minimized. Assumed structure is the columns correspond to different values of penalty parameter and rows correspond to points in a posterior sample of $(\beta, \sigma)$ .
lambda	The sequence of penalty parameter values corresponding to the columns of fLoss.
XtX	Cross product of the design matrix.
postBeta	Matrix containing the posterior sample of beta values. Assumed to be n-by-p, where n is number of samples (and equal to number of rows in fLoss) and p is number of regression parameters in model.
postSigma2	Vector containing the posterior sample of variance parameters. Should have same length as postBeta.
penalize	Vector indicating which variables are penalized in the regression model. See details for <a href="#">estRidge</a> for further details.

<code>ind</code>	Numerical or logical vector indicating which elements of the variance matrix should be returned. Defaults to the (1,1) element
<code>version</code>	Character string indicating which version of standard error to compute. 'varExp' or 'full', corresponding to the variance of the conditional mean of the estimator or that plus the expected value of the conditional variance. In practice, the latter is often too large.

**Details**

Computes a standard error estimate for an 'fLoss' estimator, where 'fLoss' is typically fMSE or fMBV. Approximates the variance of the estimator using the the variance conditional on the observed data (i.e. using the posterior distribution of parameters). Currently, two different versions are available.

**Author(s)**

Joshua Keller

**See Also**

[festRidge](#), [samplePosterior](#)

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