

# Package ‘semisup’

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**Version** 1.33.0

**Title** Semi-Supervised Mixture Model

**Description** Implements a parametric semi-supervised mixture model. The permutation test detects markers with main or interactive effects, without distinguishing them. Possible applications include genome-wide association analysis and differential expression analysis.

**biocViews** SNP, GenomicVariation, SomaticMutation, Genetics,  
Classification, Clustering, DNASeq, Microarray,  
MultipleComparison

**Depends** R (>= 3.0.0)

**Imports** VGAM

**Suggests** knitr, testthat, SummarizedExperiment

**VignetteBuilder** knitr

**License** GPL-3

**LazyData** true

**RoxygenNote** 7.0.0

**URL** <https://github.com/rauschenberger/semisup>

**BugReports** <https://github.com/rauschenberger/semisup/issues>

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| semisup-package | <i>Semi-supervised mixture model</i> |
|-----------------|--------------------------------------|

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**Description**

This R package implements the semi-supervised mixture model. Use [mixture](#) for model fitting, and [scrutor](#) for hypothesis testing.

**Getting started**

Please type the following commands:  
utils::vignette("semisup")  
?semisup::mixture  
?semisup::scrutor

**More information**

A Rauschenberger, RX Menezes, MA van de Wiel, NM van Schoor, and MA Jonker (2020). "Semi-supervised mixture test for detecting markers associated with a quantitative trait", *Manuscript in preparation*.  
<a.rauschenberger@vumc.nl>

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|           |                      |
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| arguments | <i>Documentation</i> |
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**Description**

This page lists and describes all arguments of the R package [semisup](#).

**Arguments**

|                      |                                                                                                                                                                                   |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>y</code>       | <b>observations:</b> numeric vector of length <code>n</code>                                                                                                                      |
| <code>Y</code>       | <b>observations:</b> numeric vector of length <code>n</code> , or numeric matrix with <code>n</code> rows (samples) and <code>q</code> columns (variables)                        |
| <code>z</code>       | <b>class labels:</b> integer vector of length <code>n</code> , with entries 0, 1 and NA                                                                                           |
| <code>Z</code>       | <b>class labels:</b> numeric vector of length <code>n</code> , or numeric matrix with <code>n</code> rows (samples) and <code>p</code> columns (variables), with entries 0 and NA |
| <code>dist</code>    | <b>distributional assumption:</b> character "norm" (Gaussian), "nbinom" (negative binomial), or "zinb" (zero-inflated negative binomial)                                          |
| <code>phi</code>     | <b>dispersion parameters:</b> numeric vector of length <code>q</code> , or NULL                                                                                                   |
| <code>pi</code>      | <b>zero-inflation parameter(s):</b> numeric vector of length <code>q</code> , or NULL                                                                                             |
| <code>gamma</code>   | <b>offset:</b> numeric vector of length <code>n</code> , or NULL                                                                                                                  |
| <code>test</code>    | <b>resampling procedure:</b> character "perm" (permutation) or "boot" (parametric bootstrap), or NULL                                                                             |
| <code>iter</code>    | <b>(maximum) number of resampling iterations :</b> positive integer, or NULL                                                                                                      |
| <code>kind</code>    | <b>resampling accuracy:</b> numeric between 0 and 1, or NULL; all p-values above <code>kind</code> are approximate                                                                |
| <code>starts</code>  | <b>restarts of the EM algorithm:</b> positive integer (defaults to 1)                                                                                                             |
| <code>it.em</code>   | <b>(maximum) number of iterations in the EM algorithm:</b> positive integer (defaults to 100)                                                                                     |
| <code>epsilon</code> | <b>convergence criterion for the EM algorithm:</b> non-negative numeric (defaults to $1e-04$ )                                                                                    |
| <code>debug</code>   | <b>verification of arguments:</b> TRUE or FALSE                                                                                                                                   |
| <code>pass</code>    | <b>parameters for parametric bootstrap algorithm</b>                                                                                                                              |
| <code>...</code>     | <b>settings EM algorithm:</b> <code>starts</code> , <code>it.em</code> and <code>epsilon</code> (see <a href="#">arguments</a> )                                                  |

**See Also**

Use [mixture](#) for model fitting, and [scrutor](#) for hypothesis testing. All other functions of the R package [semisup](#) are [internal](#).

---

 debug

*Internal function*


---

**Description**

This function verifies whether the arguments fulfill some formal requirements.

**Usage**

```
debug(y, z, dist, phi, pi, gamma, test, iter, kind, ...)
```

## Arguments

|       |                                                                                                                                          |
|-------|------------------------------------------------------------------------------------------------------------------------------------------|
| y     | <b>observations:</b> numeric vector of length n                                                                                          |
| z     | <b>class labels:</b> integer vector of length n, with entries 0, 1 and NA                                                                |
| dist  | <b>distributional assumption:</b> character "norm" (Gaussian), "nbinom" (negative binomial), or "zinb" (zero-inflated negative binomial) |
| phi   | <b>dispersion parameters:</b> numeric vector of length q, or NULL                                                                        |
| pi    | <b>zero-inflation parameter(s):</b> numeric vector of length q, or NULL                                                                  |
| gamma | <b>offset:</b> numeric vector of length n, or NULL                                                                                       |
| test  | <b>resampling procedure:</b> character "perm" (permutation) or "boot" (parametric bootstrap), or NULL                                    |
| iter  | <b>(maximum) number of resampling iterations :</b> positive integer, or NULL                                                             |
| kind  | <b>resampling accuracy:</b> numeric between 0 and 1, or NULL; all p-values above kind are approximate                                    |
| ...   | <b>settings EM algorithm:</b> starts, it.em and epsilon (see <a href="#">arguments</a> )                                                 |

## Details

If one or more entries of z are equal to 1, the mixture model can be fitted but not tested. Accordingly, kind is replaced by NULL.

Resampling-based testing cannot reach p-values below 1/iter. If kind is smaller than 1/iter, it is replaced by 0.

## Value

This function returns warnings and errors. It also returns kind (see details).

## See Also

This is an [internal](#) function. The user functions are [mixtura](#) and [scrutor](#).

## Examples

```
NULL
```

---

estim.nbinom

*Internal function*

---

## Description

These functions estimate the parameters of the (zero-inflated) negative binomial distribution by applying the maximum likelihood method to the labelled observations in class 0.

## Usage

```
estim.nbinom(y, z, gamma)
```

```
estim.zinb(y, z, gamma)
```

**Arguments**

|       |                                                                           |
|-------|---------------------------------------------------------------------------|
| y     | <b>observations:</b> numeric vector of length n                           |
| z     | <b>class labels:</b> integer vector of length n, with entries 0, 1 and NA |
| gamma | <b>offset:</b> numeric vector of length n, or NULL                        |

**Value**

These functions return a list of numerics.

**See Also**

These are [internal](#) functions. The user functions are [mixture](#) and [scrutor](#).

**Examples**

```
# data simulation
n <- 100
y <- stats::rnbino(n=n,mu=5,size=1/0.05)
y[sample(1:n,size=0.2*n)] <- 0
z <- rep(0,times=n)
gamma <- rep(1,times=n)

# parameter estimation
estim.nbinom(y,z,gamma)
estim.zinb(y,z,gamma)
```

---

fit.nbinom

*Internal function*


---

**Description**

This function fits the semi-supervised negative binomial mixture model. It is called by [fit.wrap](#).

**Usage**

```
fit.nbinom(y, z, phi, gamma, it.em, epsilon)
```

**Arguments**

|         |                                                                                               |
|---------|-----------------------------------------------------------------------------------------------|
| y       | <b>observations:</b> numeric vector of length n                                               |
| z       | <b>class labels:</b> integer vector of length n, with entries 0, 1 and NA                     |
| phi     | <b>dispersion parameters:</b> numeric vector of length q, or NULL                             |
| gamma   | <b>offset:</b> numeric vector of length n, or NULL                                            |
| it.em   | <b>(maximum) number of iterations in the EM algorithm:</b> positive integer (defaults to 100) |
| epsilon | <b>convergence criterion for the EM algorithm:</b> non-negative numeric (defaults to 1e-04)   |

**Value**

This function returns the parameter estimates, the posterior probabilities, and the likelihood.

**See Also**

This is an [internal](#) function. The user functions are [mixture](#) and [scrutor](#).

**Examples**

```
# data simulation
n <- 100
z <- rep(0:1, each=n/2)
gamma <- runif(n=n, min=0, max=2)
y <- rnbino(n=n, mu=gamma*(5+2*z), size=1/0.05)
z[(n/4):n] <- NA

# model fitting
fit.nbinom(y, z, phi=0.05, gamma=gamma,
it.em=100, epsilon=1e-04)
```

---

fit.norm

*Internal function*


---

**Description**

This function fits the semi-supervised Gaussian mixture model. It is called by [fit.wrap](#).

**Usage**

```
fit.norm(y, z, it.em, epsilon)
```

**Arguments**

|         |                                                                                        |
|---------|----------------------------------------------------------------------------------------|
| y       | <b>observations:</b> numeric vector of length n                                        |
| z       | <b>class labels:</b> integer vector of length n, with entries 0, 1 and NA              |
| it.em   | (maximum) number of iterations in the EM algorithm: positive integer (defaults to 100) |
| epsilon | convergence criterion for the EM algorithm: non-negative numeric (defaults to 1e-04)   |

**Value**

This function returns the parameter estimates, the posterior probabilities, and the likelihood.

**See Also**

This is an [internal](#) function. The user functions are [mixture](#) and [scrutor](#).

## Examples

```
# data simulation
n <- 100
z <- rep(0:1,each=n/2)
y <- rnorm(n=n,mean=2*z,sd=1)
z[(n/4):n] <- NA

# model fitting
fit.norm(y,z,it.em=100,epsilon=1e-04)
```

fit.wrap

*Internal function*

## Description

This function fits the semi-supervised mixture model multiple times. It is called by [mixtura](#) and [scrutor](#).

## Usage

```
fit.wrap(y, z, dist, phi, pi, gamma, starts = 1, it.em = 100, epsilon = 1e-04)
```

## Arguments

|         |                                                                                                                                          |
|---------|------------------------------------------------------------------------------------------------------------------------------------------|
| y       | <b>observations:</b> numeric vector of length n                                                                                          |
| z       | <b>class labels:</b> integer vector of length n, with entries 0, 1 and NA                                                                |
| dist    | <b>distributional assumption:</b> character "norm" (Gaussian), "nbinom" (negative binomial), or "zinb" (zero-inflated negative binomial) |
| phi     | <b>dispersion parameters:</b> numeric vector of length q, or NULL                                                                        |
| pi      | <b>zero-inflation parameter(s):</b> numeric vector of length q, or NULL                                                                  |
| gamma   | <b>offset:</b> numeric vector of length n, or NULL                                                                                       |
| starts  | <b>restarts of the EM algorithm:</b> positive integer (defaults to 1)                                                                    |
| it.em   | <b>(maximum) number of iterations in the EM algorithm:</b> positive integer (defaults to 100)                                            |
| epsilon | <b>convergence criterion for the EM algorithm:</b> non-negative numeric (defaults to 1e-04)                                              |

## Details

The distributions are parametrised as follows:

- Gaussian  
 $y \sim N(\text{mean}, \text{sd}^2)$   
 $E[y] = \text{mean}$   
 $\text{Var}[y] = \text{sd}^2$
- Negative binomial  
 $y \sim \text{NB}(\mu, \phi)$   
 $E[y] = \mu$   
 $\text{Var}[y] = \mu + \phi * \mu^2$

- Zero-inflated negative binomial  
 $y \sim \text{ZINB}(\mu, \phi, \pi)$   
 $E[y] = (1 - \pi) * \mu$

### Value

This function returns the parameter estimates, the posterior probabilities, and the likelihood.

|           |                                                                                   |
|-----------|-----------------------------------------------------------------------------------|
| posterior | probability of belonging to class 1: numeric vector of length n                   |
| converge  | path of the log-likelihood: numeric vector with maximum length <code>it.em</code> |
| estim0    | parameter estimates under H0: data frame                                          |
| estim1    | parameter estimates under H1: data frame                                          |
| loglik0   | log-likelihood under H0: numeric                                                  |
| loglik1   | log-likelihood under H1: numeric                                                  |
| lrts      | likelihood-ratio test statistic: positive numeric                                 |

### See Also

This is an [internal](#) function. The user functions are [mixture](#) and [scrutor](#).

### Examples

```
# data simulation
n <- 100
z <- rep(0:1, each=n/2)
y <- rnorm(n=n, mean=2*z, sd=1)
z[(n/4):n] <- NA

# model fitting
fit.wrap(y, z, dist="norm")
```

---

fit.zinb

*Internal function*


---

### Description

This function fits the semi-supervised zero-inflated negative binomial mixture model. It is called by [fit.wrap](#).

### Usage

```
fit.zinb(y, z, phi, pi, gamma, it.em, epsilon)
```

**Arguments**

|         |                                                                                               |
|---------|-----------------------------------------------------------------------------------------------|
| y       | <b>observations:</b> numeric vector of length n                                               |
| z       | <b>class labels:</b> integer vector of length n, with entries 0, 1 and NA                     |
| phi     | <b>dispersion parameters:</b> numeric vector of length q, or NULL                             |
| pi      | <b>zero-inflation parameter(s):</b> numeric vector of length q, or NULL                       |
| gamma   | <b>offset:</b> numeric vector of length n, or NULL                                            |
| it.em   | <b>(maximum) number of iterations in the EM algorithm:</b> positive integer (defaults to 100) |
| epsilon | <b>convergence criterion for the EM algorithm:</b> non-negative numeric (defaults to 1e-04)   |

**Value**

This function returns the parameter estimates, the posterior probabilities, and the likelihood.

**See Also**

This is an [internal](#) function. The user functions are [mixture](#) and [scrutor](#).

**Examples**

```
# data simulation
n <- 100
z <- rep(0:1,each=n/2)
gamma <- runif(n=n,min=0,max=2)
y <- rnbino(n=n,mu=gamma*(5+2*z),size=1/0.05)
y[sample(1:n,size=0.2*n)] <- 0
z[(n/4):n] <- NA

# model fitting
fit.zinb(y,z,phi=0.05,pi=0.2,gamma=gamma,
it.em=100,epsilon=1e-04)
```

---

internal

Documentation

---

**Description**

This page lists and describes some internal functions of the R package [semisup](#). These functions should not be used for analysing data.

[fit.wrap](#) multiple restarts  
[fit.norm](#) Gaussian mixture model  
[fit.nbinom](#) negative binomial mixture model  
[fit.zinb](#) zero-inflated negative binomial mixture model  
[estim.nbinom](#) dispersion estimation  
[estim.zinb](#) dispersion and zero-inflation estimation  
[resam.lrts](#) resampling (bootstrap, permutation)

**See Also**

Use [mixture](#) for model fitting, and [scrutor](#) for hypothesis testing.

## Description

This function fits a semi-supervised mixture model. It simultaneously estimates two mixture components, and assigns the unlabelled observations to these.

## Usage

```
mixtura(y, z, dist = "norm",
        phi = NULL, pi = NULL, gamma = NULL,
        test = NULL, iter = 100, kind = 0.05,
        debug = TRUE, ...)
```

## Arguments

|       |                                                                                                                                          |
|-------|------------------------------------------------------------------------------------------------------------------------------------------|
| y     | <b>observations:</b> numeric vector of length n                                                                                          |
| z     | <b>class labels:</b> integer vector of length n, with entries 0, 1 and NA                                                                |
| dist  | <b>distributional assumption:</b> character "norm" (Gaussian), "nbinom" (negative binomial), or "zinb" (zero-inflated negative binomial) |
| phi   | <b>dispersion parameters:</b> numeric vector of length q, or NULL                                                                        |
| pi    | <b>zero-inflation parameter(s):</b> numeric vector of length q, or NULL                                                                  |
| gamma | <b>offset:</b> numeric vector of length n, or NULL                                                                                       |
| test  | <b>resampling procedure:</b> character "perm" (permutation) or "boot" (parametric bootstrap), or NULL                                    |
| iter  | <b>(maximum) number of resampling iterations :</b> positive integer, or NULL                                                             |
| kind  | <b>resampling accuracy:</b> numeric between 0 and 1, or NULL; all p-values above kind are approximate                                    |
| debug | <b>verification of arguments:</b> TRUE or FALSE                                                                                          |
| ...   | <b>settings EM algorithm:</b> starts, it.em and epsilon (see <a href="#">arguments</a> )                                                 |

## Details

By default, phi and pi are estimated by the maximum likelihood method, and gamma is replaced by a vector of ones.

## Value

This function fits and compares a one-component (H0) and a two-component (H1) mixture model.

|           |                                                                             |
|-----------|-----------------------------------------------------------------------------|
| posterior | <b>probability of belonging to class 1:</b> numeric vector of length n      |
| converge  | <b>path of the log-likelihood:</b> numeric vector with maximum length it.em |
| estim0    | <b>parameter estimates under H0:</b> data frame                             |
| estim1    | <b>parameter estimates under H1:</b> data frame                             |
| loglik0   | <b>log-likelihood under H0:</b> numeric                                     |
| loglik1   | <b>log-likelihood under H1:</b> numeric                                     |
| lrts      | <b>likelihood-ratio test statistic:</b> positive numeric                    |
| p.value   | <b>H0 versus H1:</b> numeric between 0 and 1, or NULL                       |

## Reference

A Rauschenberger, RX Menezes, MA van de Wiel, NM van Schoor, and MA Jonker (2020). "Semi-supervised mixture test for detecting markers associated with a quantitative trait", *Manuscript in preparation*.

## See Also

Use [scrutor](#) for hypothesis testing. All other functions are [internal](#).

## Examples

```
# data simulation
n <- 100
z <- rep(0:1, each=n/2)
y <- rnorm(n=n, mean=2, sd=1)
z[(n/4):n] <- NA

# model fitting
mixture(y, z, dist="norm", test="perm")
```

---

|            |                          |
|------------|--------------------------|
| resam.lrts | <i>Internal function</i> |
|------------|--------------------------|

---

## Description

This function resamples the data, fits the semi-supervised mixture model, and returns the likelihood ratio test statistic. It is called by [mixture](#).

## Usage

```
resam.lrts(y, z, dist, phi, pi, gamma, test, pass, ...)
```

## Arguments

|       |                                                                                                                                          |
|-------|------------------------------------------------------------------------------------------------------------------------------------------|
| y     | <b>observations:</b> numeric vector of length n                                                                                          |
| z     | <b>class labels:</b> integer vector of length n, with entries 0, 1 and NA                                                                |
| dist  | <b>distributional assumption:</b> character "norm" (Gaussian), "nbinom" (negative binomial), or "zinb" (zero-inflated negative binomial) |
| phi   | <b>dispersion parameters:</b> numeric vector of length q, or NULL                                                                        |
| pi    | <b>zero-inflation parameter(s):</b> numeric vector of length q, or NULL                                                                  |
| gamma | <b>offset:</b> numeric vector of length n, or NULL                                                                                       |
| test  | <b>resampling procedure:</b> character "perm" (permutation) or "boot" (parametric bootstrap), or NULL                                    |
| pass  | <b>parameters for parametric bootstrap algorithm</b>                                                                                     |
| ...   | <b>settings EM algorithm:</b> starts, it.em and epsilon (see <a href="#">arguments</a> )                                                 |

## Value

This function returns a numeric.

## See Also

This is an [internal](#) function. The user functions are [mixture](#) and [scrutor](#).

## Examples

```
# data simulation
n <- 100
z <- rep(0:1, each=n/2)
y <- rnorm(n=n, mean=2*z, sd=1)
z[(n/4):n] <- NA

# observed test statistic
fit.wrap(y=y, z=z, dist="norm")$lrts

# simulated test statistic
resam.lrts(y=y, z=z, dist="norm",
           phi=NULL, pi=NULL, gamma=NULL,
           test="perm", pass=NULL)
```

---

scrutor

*Hypothesis testing*


---

## Description

This function tests whether the unlabelled observations come from a mixture of two distributions.

## Usage

```
scrutor(Y, Z, dist = "norm",
        phi = NULL, pi = NULL, gamma = NULL,
        test = "perm", iter = NULL, kind = NULL,
        debug = TRUE, ...)
```

## Arguments

|       |                                                                                                                                           |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Y     | <b>observations:</b> numeric vector of length n, or numeric matrix with n rows (samples) and q columns (variables)                        |
| Z     | <b>class labels:</b> numeric vector of length n, or numeric matrix with n rows (samples) and p columns (variables), with entries 0 and NA |
| dist  | <b>distributional assumption:</b> character "norm" (Gaussian), "nbinom" (negative binomial), or "zinb" (zero-inflated negative binomial)  |
| phi   | <b>dispersion parameter(s):</b> numeric vector of length q, or NULL (norm: none, nbinom: MLE)                                             |
| pi    | <b>zero-inflation parameter(s):</b> numeric vector of length q, or NULL (norm: none, nbinom: MLE)                                         |
| gamma | <b>offset:</b> numeric vector of length n, or NULL                                                                                        |
| test  | <b>resampling procedure:</b> character "perm" (permutation) or "boot" (parametric bootstrap), or NULL                                     |
| iter  | <b>(maximum) number of resampling iterations :</b> positive integer, or NULL                                                              |

|       |                                                                                                |
|-------|------------------------------------------------------------------------------------------------|
| kind  | resampling accuracy: numeric between 0 and 1, or NULL; all p-values above kind are approximate |
| debug | verification of arguments: TRUE or FALSE                                                       |
| ...   | settings EM algorithm: starts, it.em and epsilon (see <a href="#">arguments</a> )              |

### Details

By default, phi and pi are estimated by the maximum likelihood method, and gamma is replaced by a vector of ones.

### Value

This function tests a one-component ( $H_0$ ) against a two-component mixture model ( $H_1$ ).

|         |                    |
|---------|--------------------|
| y       | index observations |
| z       | index class labels |
| lrts    | test statistic     |
| p.value | p-value            |

### Reference

A Rauschenberger, RX Menezes, MA van de Wiel, NM van Schoor, and MA Jonker (2020). "Semi-supervised mixture test for detecting markers associated with a quantitative trait", *Manuscript in preparation*.

### See Also

Use [mixtura](#) for model fitting. All other functions are [internal](#).

### Examples

```
# data simulation
n <- 100
z <- rep(0:1, each=n/2)
y <- rnorm(n=n, mean=2*z, sd=1)
z[(n/4):n] <- NA

# hypothesis testing
scrutor(y, z, dist="norm")
```

---

|       |              |
|-------|--------------|
| table | <i>Table</i> |
|-------|--------------|

---

### Description

This dataset includes tables for the approximate mixture test (**not yet available**).

### Usage

```
data(table)
```

**Format**

A list of numeric vectors.

**Value**

All entries are numeric.

---

toydata

*Toydata*

---

**Description**

This dataset allows to reproduce the examples shown in the vignette.

**Usage**

```
data(toydata)
```

**Format**

A list of numeric vectors and matrices.

**Value**

All entries are numeric.

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