

# Package ‘saeME’

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**Title** Small Area Estimation with Measurement Error

**Type** Package

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**Description** A set of functions and datasets implementation of small area estimation when auxiliary variable is measured with error. These functions provide a empirical best linear unbiased prediction (EBLUP) estimator and mean squared error (MSE) estimator of the EBLUP. These models were developed by Ybarra and Lohr (2008) <doi:10.1093/biomet/asn048>.

**License** GPL-2

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## R topics documented:

dataME . . . . .	2
datamix . . . . .	2
FHme . . . . .	3
FHme_nonsamples . . . . .	5
mse_FHme . . . . .	7
nonsample . . . . .	8
saeME . . . . .	9
<b>Index</b>	<b>10</b>

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 dataME

*dataME*


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### Description

This data generated by simulation based on Fay-Herriot with Measurement Error Model by following these steps:

1. Generate  $x_i$  from a UNIF(5, 10) distribution,  $\psi_i = 3$ ,  $c_i = 0.25$ , and  $\sigma_v^2 = 2$ .
2. Generate  $u_i$  from a N(0,  $c_i$ ) distribution,  $e_i$  from a N(0,  $\psi_i$ ) distribution, and  $v_i$  from a N(0,  $\sigma_v^2$ ) distribution.
3. Generate  $\hat{x}_i = x_i + u_i$ .
4. Then for each iteration, we generated  $Y_i = 2 + 0.5\hat{x}_i + v_i$  and  $y_i = Y_i + e_i$ .

Direct estimator  $y$ , auxiliary variable  $\hat{x}$ , sampling variance  $\psi$ , and  $c$  are arranged in a dataframe called dataME.

### Usage

```
data(dataME)
```

### Format

A data frame with 100 observations on the following 4 variables.

small\_area areas of interest.

y direct estimator for each domain.

x.hat auxiliary variable for each domain.

vardir sampling variances for each domain.

var.x mean squared error of auxiliary variable and sorted as x.hat

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 datamix

*datamix*


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### Description

This data generated by simulation based on Fay-Herriot with Measurement Error Model by following these steps:

1. Generate  $x_{1i}$  from a UNIF(5, 10) distribution,  $x_{2i}$  from a UNIF(9, 11) distribution,  $\psi_i = 3$ ,  $c_{1i} = c_{2i} = 0.25$ , and  $\sigma_v^2 = 2$ .
2. Generate  $u_{1i}$  from a N(0,  $c_{1i}$ ) distribution,  $u_{2i}$  from a N(0,  $c_{2i}$ ) distribution,  $e_i$  from a N(0,  $\psi_i$ ) distribution, and  $v_i$  from a N(0,  $\sigma_v^2$ ) distribution.
3. Generate  $x_{3i}$  from a UNIF(1, 5) distribution and  $x_{4i}$  from a UNIF(10, 14) distribution.

4. Generate  $\hat{x}_{1i} = x_{1i} + u_{1i}$  and  $\hat{x}_{2i} = x_{2i} + u_{2i}$ .
5. Then for each iteration, we generated  $Y_i = 2 + 0.5\hat{x}_{1i} + 0.5\hat{x}_{2i} + 2x_{3i} + 0.5x_{4i} + v_i$  and  $y_i = Y_i + e_i$ .

This data contain combination between auxiliary variable measured with error and without error. Direct estimator  $y$ , auxiliary variable  $\hat{x}_1 \hat{x}_2 x_3 x_4$ , sampling variance  $\psi$ , and  $c_1 c_2$  are arranged in a dataframe called `datamix`.

### Usage

```
data(datamix)
```

### Format

A data frame with 100 observations on the following 8 variables.

`small_area` areas of interest.

`y` direct estimator for each domain.

`x.hat1` auxiliary variable (measured with error) for each domain.

`x.hat2` auxiliary variable (measured with error) for each domain.

`x3` auxiliary variable (measured without error) for each domain.

`x4` auxiliary variable (measured without error) for each domain.

`vardir` sampling variances for each domain.

`var.x1` mean squared error of auxiliary variable and sorted as `x.hat1`

`var.x2` mean squared error of auxiliary variable and sorted as `x.hat2`

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FHme

*Fay-Herriot Model with Measurement Error*

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### Description

This function gives the EBLUP estimator based on Fay-Herriot model with measurement error.

### Usage

```
FHme(
  formula,
  vardir,
  var.x,
  type.x = "witherror",
  MAXITER = 1000,
  PRECISION = 1e-04,
  data
)
```

## Arguments

<code>formula</code>	an object of class <code>formula</code> (or one that can be coerced to that class): a symbolic description of the model to be fitted. The variables included <code>formula</code> must have a length equal to the number of domains <code>m</code> . This formula can provide auxiliary variable either measured with error or without error or combination between them. If the auxiliary variable are combination between <code>noerror</code> and <code>witherror</code> variable, input all <code>witherror</code> variable first then <code>noerror</code> variable.
<code>var.dir</code>	vector containing the <code>m</code> sampling variances of direct estimators for each domain. The values must be sorted as the <code>Y</code> .
<code>var.x</code>	vector containing mean squared error of <code>X</code> . The values must be sorted as the <code>X</code> . if you use optional data, input this parameter use <code>c("")</code> , example: <code>var.x = c("c1")</code> or <code>var.x = c("c1", "c2")</code> .
<code>type.x</code>	type of auxiliary variable used in the model. Either source measured with <code>noerror</code> , <code>witherror</code> and <code>mix</code> . Default value is <code>witherror</code> .
<code>MAXITER</code>	maximum number of iterations allowed. Default value is 1000 iterations.
<code>PRECISION</code>	convergence tolerance limit. Default value is 0.0001.
<code>data</code>	optional data frame containing the variables named in <code>formula</code> , <code>var.dir</code> , and <code>var.x</code> .

## Details

A formula has an implied intercept term. To remove this use either  $y \sim x - 1$  or  $y \sim 0 + x$ . See [formula](#) for more details of allowed formulae.

## Value

The function returns a list with the following objects:

`eb1up` vector with the values of the estimators for the domains.

`fit` a list containing the following objects:

- `method` : type of fitting method.
- `convergence` : a logical value of convergence when calculating estimated beta and estimated random effects.
- `iterations` : number of iterations when calculating estimated beta and estimated random effects.
- `estcoef` : a data frame with the estimated model coefficient (`beta`) in the first column, their standard error (`std.error`) in the second column, the t-statistics (`t.statistics`) in the third column, and the p-values of the significance of each coefficient (`pvalue`) in the last column.
- `refvar` : a value of estimated random effects.
- `gamma` : vector with values of the estimated gamma for each domains.

## See Also

[mse\\_FHme](#)

**Examples**

```

data(dataME)
data(datamix)
sae.me <- FHme(formula = y ~ x.hat, vardir = vardir, var.x = c("var.x"), data = dataME)
sae.mix <- FHme(formula = y ~ x.hat1 + x.hat2 + x3 + x4,
                vardir = vardir, var.x = c("var.x1", "var.x2"), type.x = "mix", data = datamix)

```

FHme\_nonsamples

*Fay-Herriot Model with Measurement Error of Nonsampled Area***Description**

This function gives the EBLUP estimator of nonsampled area using cluster information.

**Usage**

```

FHme_nonsamples(
  formula,
  var.x,
  vardir,
  type.x = "witherror",
  MAXITER = 100,
  PRECISION = 1e-04,
  cluster.method = "kmeans",
  n.cluster,
  data
)

```

**Arguments**

formula	an object of class <code>formula</code> (or one that can be coerced to that class): a symbolic description of the model to be fitted. The variables included formula must have a length equal to the number of domains $m$ . This formula can provide auxiliary variable either measured with error or without error or combination between them. If the auxiliary variable are combination between <code>noerror</code> and <code>witherror</code> variable, input all <code>witherror</code> variable first then <code>noerror</code> variable.
var.x	vector containing mean squared error of $X$ . The values must be sorted as the $X$ . Input this parameter use <code>c("")</code> , example: <code>var.x = c("c1")</code> or <code>var.x = c("c1", "c2")</code> .
vardir	vector containing the $m$ sampling variances of direct estimators for each domain. The values must be sorted as the $Y$ .
type.x	type of auxiliary variable used in the model. Either source measured with <code>noerror</code> , <code>witherror</code> and <code>mix</code> . Default value is <code>witherror</code> .
MAXITER	maximum number of iterations allowed. Default value is 1000 iterations.
PRECISION	convergence tolerance limit. Default value is 0.0001.

`cluster.method` the cluster method used. Default value is `kmeans` and the other available method is `kmedoids`.

`n.cluster` either the number of clusters, say `k`, or a set of initial (distinct) cluster centers.

`data` a data frame containing the variables named in `formula`, `vardir`, and `var.x`.

### Details

A formula has an implied intercept term. To remove this use either `y ~ x - 1` or `y ~ 0 + x`. See [formula](#) for more details of allowed formulae.

### Value

The function returns a list with the following objects:

`nonsampled_data` a data frame of nonsampled areas containing data, the cluster information (`cluster`) and mean of random effect for each cluster (`refmean`).

`sampled_data` a data frame of sampled areas containing data, the cluster information (`cluster`) and mean of random effect for each cluster (`refmean`).

`result_sampled` a list containing following objects:

- `eblup`: vector with the values of the estimators for the sampled areas.
- `fit`: a list of method, convergence, iterations, `estcoef`, `refvar`, and `gamma`. For the description of these objects, see Value of [FHme](#) function.
- `ref`: values of the random effect for each area.

`result_nonsampled` a list containing following objects:

- `eblup`: vector with the values of the estimators for the nonsampled areas.
- `estcoef`: a data frame with the estimated model coefficient (`beta`) in the first column, their standard error (`std.error`) in the second column, the t-statistics (`t.statistics`) in the third column, and the p-values of the significance of each coefficient (`pvalue`) in the last column.

`mse_sample` a list containing the values of `mse` a vector with the estimated mean squared errors of the EBLUPs for the sampled areas.

`mse_nonsample` a list containing the values of `mse` a vector with the estimated mean squared errors of the EBLUPs for the nonsampled areas.

`cluster` a data frame with the cluster information (`cluster`) in the first column and mean of random effects for each cluster (`refmean`) in the second column.

### Examples

```
data(nonsample)
test <- FHme_nonsamples(formula = y ~ x.hat, var.x = c("var.x"),
                        vardir = vardir, n.cluster = 3, data = nonsample)
```

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mse_FHme	<i>Mean Squared Error Estimator of the EBLUP under a Fay-Herriot Model with Measurement Error</i>
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### Description

This function gives the mean squared error estimator of the EBLUP based on Fay-Herriot model with measurement error using jackknife method.

### Usage

```
mse_FHme(formula, vardir, var.x, type.x = "witherror", data)
```

### Arguments

formula	an object of class <a href="#">formula</a> (or one that can be coerced to that class): a symbolic description of the model to be fitted. The variables included formula must have a length equal to the number of domains $m$ . This formula can provide auxiliary variable either measured with error or without error or combination between them. If the auxiliary variable are combination between noerror and witherror variable, input all witherror variable first then noerror variable.
vardir	vector containing the $m$ sampling variances of direct estimators for each domain. The values must be sorted as the $Y$ .
var.x	vector containing mean squared error of $X$ . The values must be sorted as the $X$ . if you use optional data, input this parameter use <code>c("")</code> , example: <code>var.x = c("c1")</code> or <code>var.x = c("c1", "c2")</code> .
type.x	type of auxiliary variable used in the model. Either source measured with noerror, witherror and mix. Default value is witherror.
data	optional data frame containing the variables named in formula, vardir, and var.x.

### Details

A formula has an implied intercept term. To remove this use either  $y \sim x - 1$  or  $y \sim 0 + x$ . See [formula](#) for more details of allowed formulae.

### Value

The function returns a list with the following objects:

`mse` vector with the values of the mean squared errors of the EBLUPs for each domain.

### Examples

```
data(dataME)
data(datamix)
```

```
mse.sae.me <- mse_FHme(formula = y ~ x.hat, vardir = vardir, var.x = c("var.x"), data = dataME)
```

```
mse.sae.mix <- mse_FHme(formula = y ~ x.hat1 + x.hat2 + x3 + x4,
  vardir = vardir, var.x = c("var.x1", "var.x2"), type.x = "mix", data = datamix)
```

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nonsample

*data nonsample*

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### Description

This data similar to dataME but have 9 non-sampled area. Generated by following these steps:

1. Generate  $x_i$  from a UNIF(5, 10) distribution,  $\psi_i = 3$ ,  $c_i = 0.25$ , and  $\sigma_v^2 = 2$ .
2. Generate  $u_i$  from a  $N(0, c_i)$  distribution,  $e_i$  from a  $N(0, \psi_i)$  distribution, and  $v_i$  from a  $N(0, \sigma_v^2)$  distribution.
3. Generate  $\hat{x}_i = x_i + u_i$ .
4. Then for each iteration, we generated  $Y_i = 2 + 0.5\hat{x}_i + v_i$  and  $y_i = Y_i + e_i$ .

Direct estimator  $y$ , auxiliary variable  $\hat{x}$ , sampling variance  $\psi$ , and  $c$  are arranged in a dataframe called nonsample.

### Usage

```
data(nonsample)
```

### Format

A data frame with 100 observations on the following 4 variables.

`small_area` areas of interest.

`y` direct estimator for each domain.

`x.hat` auxiliary variable for each domain.

`vardir` sampling variances for each domain.

`var.x` mean squared error of auxiliary variable and sorted as `x.hat`



**Description**

The sae with measurement error provides function for small area estimation when auxiliary variable is measured with error, and function for mean squared error estimation using jackknife method. This package implement model of Fay Herriot with Measurement Error developed by Ybarra and Lohr (2008).

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**Functions**

[FHme](#) Gives the EBLUP for each domain based on Fay-Herriot with measurement error model.

[mse\\_FHme](#) Gives the MSE for each domain using the jackknife method.

[FHme\\_nonsamples](#) Gives the EBLUP for each non-sample area based on Fay-Herriot with measurement error model.

**References**

Ybarra, L.M. and Lohr, S. L. (2008). Small area estimation when auxiliary information is measured with error. *Biometrika* 95, 919-931.

# Index

dataME, [2](#)

datamix, [2](#)

FHme, [3](#), [6](#), [9](#)

FHme\_nonsamples, [5](#), [9](#)

formula, [4–7](#)

mse\_FHme, [4](#), [7](#), [9](#)

nonsample, [8](#)

saeME, [9](#)