

# Package ‘ssmrob’

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**Type** Package

**Title** Robust Estimation and Inference in Sample Selection Models

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**Description** Package provides a set of tools for robust estimation and inference for models with sample selectivity and endogenous treatment model. For details, see Zhelonkin and Ronchetti (2021) <[doi:10.18637/jss.v099.i04](https://doi.org/10.18637/jss.v099.i04)>.

**License** GPL-2

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ssmrob-package

*Robust Estimation and Inference in Sample Selection Models*

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## Description

Package provides a set of tools for robust estimation and inference for models with sample selectivity and endogenous treatment model.

## Details

Package: ssmrob  
 Type: Package  
 Version: 1.0  
 Date: 2021-08-18

License: GPL-2

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti  
Maintainer: Mikhail Zhelonkin <Mikhail.Zhelonkin@gmail.com>

**References**

Heckman, J.J. (1979) Sample Selection Bias as a Specification Error. *Econometrica*, 47, p. 153-161.

Zhelonkin, M., Genton M.G., and Ronchetti, E. (2016) Robust Inference in Sample Selection Models. *Journal of the Royal Statistical Society, Series B*, 78, p. 805-827. doi: [10.1111/rssb.12136](https://doi.org/10.1111/rssb.12136)

Zhelonkin, M., Ronchetti, E. (2021) Robust Analysis of Sample Selection Models through the R Package ssmrob. *Journal of Statistical Software*, 99, 4, p. 1-35. doi: [10.18637/jss.v099.i04](https://doi.org/10.18637/jss.v099.i04)

**See Also**

[ssmrob](#), [etregrob](#), [heckitrob](#), [heckit5rob](#), [selection](#)

**Examples**

```
# Zhelonkin, Genton, Ronchetti (2016): page 823
data(MEPS2001)
selectEq <- dambexp ~ age + female + educ + blhisp + totchr + ins
outcomeEq <- lnambx ~ age + female + educ + blhisp + totchr + ins
meps.fit <- ssmrob(selectEq, outcomeEq, data = MEPS2001, control = heckitrob.control(tcc = 3.2))
summary(meps.fit)
```

---

coef.etregrob

*Extract Coefficients from Robust Endogenous Treatment Model Fit*

---

**Description**

Returns the coefficients of the robust two-stage estimator for endogenous treatment model.

**Usage**

```
## S3 method for class 'etregrob'
coef(object, ...)
```

**Arguments**

object	object of class " <a href="#">etregrob</a> "
...	currently not used

**Value**

Returns a list of two vectors of parameters of two stages.

S                    coefficients of the selection equation.  
 0                    coefficients of the outcome equation.

**Author(s)**

Mikhail Zhelonkin

---

coef.heckit5rob                    *Extract Coefficients from Robust Sample Selection Model Fit*

---

**Description**

Returns the coefficients of the robust two-stage estimator for simple Heckman's selection model or switching regression model.

**Usage**

```
## S3 method for class 'heckit5rob'
coef(object, ...)
```

**Arguments**

object                    object of class "heckitrob" or "heckit5rob"  
 ...                    currently not used

**Value**

Returns a list of two (censored) or three (switching) vectors of parameters of two stages.

S                    coefficients of the selection equation.  
 0                    coefficients of the outcome equation(s).

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

---

coef.heckitrob	<i>Extract Coefficients from Robust Sample Selection Model Fit</i>
----------------	--

---

**Description**

Returns the coefficients of the robust two-stage estimator for simple Heckman's selection model or switching regression model.

**Usage**

```
## S3 method for class 'heckitrob'
coef(object, ...)
```

**Arguments**

object	object of class "heckitrob" or "heckit5rob"
...	currently not used

**Value**

Returns a list of two (censored) or three (switching) vectors of parameters of two stages.

S	coefficients of the selection equation.
0	coefficients of the outcome equation(s).

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

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dLambdadSM	<i>Inverse Mills Ratio Derivative</i>
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---

**Description**

Computes a derivative of the inverse Mills ratio with respect to the parameter vector.

**Usage**

```
dLambdadSM(x, beta)
```

**Arguments**

x	vector of exogenous variables
beta	vector of parameters

**Details**

This function is necessary for computation of the asymptotic variance. In case of switching regressions the inverse Mills ratio term is different, and its derivative is computed in function dLambdadSM5. It can be also used to compute the influence function of the two-stage estimator.

**Value**

The gradient of the inverse Mills ratio is returned as a vector

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**References**

Zhelonkin, M., Genton M.G., and Ronchetti, E. (2016) Robust Inference in Sample Selection Models. *Journal of the Royal Statistical Society, Series B*, 78, p. 805-827.

---

dLambdadSM5

*Inverse Mills Ratio Derivative*


---

**Description**

Computes a derivative of the inverse Mills ratio with respect to the parameter vector.

**Usage**

```
dLambdadSM5(x, beta)
```

**Arguments**

x	vector of exogenous variables
beta	vector of parameters

**Details**

This function is necessary for computation of the asymptotic variance. In case of switching regressions the inverse Mills ratio term is different, and its derivative is computed in function dLambdadSM5. It can also be used to compute the influence function of the two-stage estimator.

**Value**

The gradient of the inverse Mills ratio is returned as a vector

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

## References

Zhelonkin, M., Genton M.G., and Ronchetti, E. (2016) Robust Inference in Sample Selection Models. *Journal of the Royal Statistical Society, Series B*, 78, p. 805-827.

---

etreg2steprobVcov      *Variance Covariance Matrix*

---

## Description

Computation of the asymptotic variance matrix of the robust Heckman's two-stage estimator for endogenous treatment model.

## Usage

```
etreg2steprobVcov(y1vec, y2vec, x1Matr, x2Matr, eststage1, eststage2, eststage2sigma,
  weights = rep(1, nrow(y1vec)), t.c = 1.345)
```

## Arguments

y1vec	vector of endogenous variables of the selection stage
y2vec	vector of endogenous variables of the outcome stage
x1Matr	matrix of exogenous variables of the selection stage
x2Matr	matrix of exogenous variables of the outcome stage
eststage1	object of class "glmrob", corresponding to the robust probit fit
eststage2	vector of the coefficients of the outcome stage
eststage2sigma	the robust scale estimate of the second stage regression
weights	robustness weights
t.c	tuning constant of the second stage

## Details

The computation is made using the Huber (1967) - White (1980) sandwich estimator. In the computation of leverage weights the lambda's are assumed to be fixed.

## Value

Variance covariance matrix of the second stage estimator

## Author(s)

Mikhail Zhelonkin

## References

Huber, P.J. (1967) The Behavior of Maximum Likelihood Estimates under Nonstandard Conditions. *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*; L.M. LeCam, J. Neyman (Eds.), Berkeley: University of California Press, p. 221-233.

White, H.J. (1980) A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, 48, p. 817-838.

---

 etregrob

*Robust Fit of Endogenous Treatment Model*


---

## Description

Fits the endogenous treatment model using a robust two-stage estimator

## Usage

```
etregrob(selection, outcome, data, control = heckitrob.control())
```

## Arguments

selection	formula, the selection equation
outcome	formula, the outcome equation
data	an optional 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 etregrob is called.
control	a list of parameters for controlling the fitting process. The same list as for sample selection model

## Details

Compute robust two-step estimates of the Endogenous Treatment Model. The robust probit is fitted in the first stage. In the second stage the Mallows type M-estimator is used instead of traditional OLS. The correction for endogeneity is made by means of control function, which is the inverse Mills ratio for a complete sample (see Maddala, 1983, p. 120-122). The values of the tuning constants and the robustness weights can be modified in [heckitrob.control](#).

## Value

Object of class "etregrob".

coefficients	a named vector of coefficients
stage1	object of class glmrob that contains robust probit fit
stage2	object of class rlm that contains second stage robust fit. Note that the standard errors in this object are biased, since they are not corrected for the uncertainty in the first estimation step. Use vcov below



vcov	variance matrix of the second stage
sigma	the standard error of the error term of the outcome equation
CIMR	inverse Mills ratio for the complete sample
call	the matched call
method	method of estimation, currently only "robust two-stage" is implemented
converged	logical. Did all the estimators converge?
iterations	list containing the numbers of iterations

### Note

The treatment variable is automatically included in the formula for the second estimation step, i.e. one should not add the dependent variable from the selection equation in the formula of the outcome equation.

### Author(s)

Mikhail Zhelonkin

### References

Maddala G.S. (1983) Limited-Dependent and Qualitative Variables in Econometrics. Cambridge: Cambridge University Press.

Zhelonkin, M., Ronchetti, E. (2021) Robust Analysis of Sample Selection Models through the R Package *ssmrob*. *Journal of Statistical Software*, 99, 4, p. 1-35. doi: [10.18637/jss.v099.i04](https://doi.org/10.18637/jss.v099.i04)

### See Also

[glmrob](#), [rlm](#), [ssmrob](#), [heckitrob.control](#)

### Examples

```
library(mvtnorm)
set.seed(2)
N <- 3000
beta1 <- c(1.0, 1.0, 0.75)
beta2 <- c(1.5, 1.0, 0.5)
alpha <- 1.25
x1 <- rmvnorm(N, mean = c(0, -1, 1), sigma = diag(c(1, 0.5, 1)))
x2 <- x1
x2[, 3] <- rnorm(N, 1, 1)
eps <- rmvnorm(N, mean = rep(0, 2), sigma = matrix(c(1, -0.7, -0.7, 1), 2, 2))
x1beta1 <- x1[, 1]*beta1[1] + x1[, 2]*beta1[2] + x1[, 3]*beta1[3]
x2beta2 <- x2[, 1]*beta2[1] + x2[, 2]*beta2[2] + x2[, 3]*beta2[3]
y1 <- ifelse(x1beta1 + eps[, 1] > 0, 1, 0)
y2 <- x2beta2 + alpha*y1 + eps[,2]
etm.ctrl <- heckitrob.control(weights.x1 = "hat", weights.x2 = "covMcd")
etmsim.fit <- etregrob(y1 ~ x1, y2 ~ x2, control = etm.ctrl)
summary(etmsim.fit)
```

---

fitted.etregrob      *Fitted values of endogenous treatment model*

---

### Description

Calculate the fitted values of the endogenous treatment model using robust fit.

### Usage

```
## S3 method for class 'etregrob'
fitted(object, ...)
```

### Arguments

object	object of class " <a href="#">"etregrob"</a>
...	currently not used

### Value

vector of fitted values

### Author(s)

Mikhail Zhelonkin

---

fitted.heckit5rob      *Fitted values of robust sample selection model*

---

### Description

Calculate the fitted values of the sample selection model using robust fit.

### Usage

```
## S3 method for class 'heckit5rob'
fitted(object, ...)
```

### Arguments

object	object of class " <a href="#">"heckitrob"</a> " or object of class " <a href="#">"heckit5rob"</a> "
...	currently not used

### Details

In case of truncated selection model one vector of fitted values is returned. In case of switching regression model a list, that contains two vectors corresponding to two regimes, is returned.

**Value**

vector of fitted values or a list that contains two vectors of fitted values

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

---

fitted.heckitrob      *Fitted values of robust sample selection model*

---

**Description**

Calculate the fitted values of the sample selection model using robust fit.

**Usage**

```
## S3 method for class 'heckitrob'  
fitted(object, ...)
```

**Arguments**

object            object of class "heckitrob" or object of class "heckit5rob"  
...                currently not used

**Details**

In case of truncated selection model one vector of fitted values is returned. In case of switching regression model a list, that contains two vectors corresponding to two regimes, is returned.

**Value**

vector of fitted values or a list that contains two vectors of fitted values

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

---

heck2steprobVcov      *Variance Covariance Matrix*

---

### Description

Computation of the asymptotic variance matrix of the robust Heckman's two-stage estimator for truncated selection model.

### Usage

```
heck2steprobVcov(y1vec, y2vec, x1Matr, x2Matr, eststage1, eststage2,
                 eststage2sigma, weights = rep(1,nrow(y1vec)), t.c = 1.345)
```

### Arguments

y1vec	vector of endogenous variables of the selection stage
y2vec	vector of endogenous variables of the outcome stage
x1Matr	matrix of exogenous variables of the selection stage
x2Matr	matrix of exogenous variables of the outcome stage
eststage1	object of class "glmrob", corresponding to the robust probit fit
eststage2	vector of the coefficients of the outcome stage
eststage2sigma	the robust scale estimate of the second stage regression
weights	vector of robustness weights
t.c	tuning constant of the second stage

### Details

The computation is made using the Huber (1967) - White (1980) sandwich estimator with Heckman (1979) correction. In the computation of leverage weights the lambda's are assumed to be fixed.

### Value

Variance covariance matrix of the second stage estimator

### Author(s)

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

### References

- Heckman, J.J. (1979) Sample Selection Bias as a Specification Error. *Econometrica*, 47, p. 153-161.
- Huber, P.J. (1967) The Behavior of Maximum Likelihood Estimates under Nonstandard Conditions. *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability; L.M. LeCam, J. Neyman (Eds.), Berkeley: University of California Press*, p. 221-233.
- White, H.J. (1980) A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, 48, p. 817-838.

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


---

 heck5twosteprobVcov     *Variance Covariance Matrix*


---

**Description**

Computation of the asymptotic variance matrix of the robust Heckman's two-stage estimator for the second regime of switching regression model, i.e. when  $y_1 = 0$ .

**Usage**

```
heck5twosteprobVcov(y1vec, y2vec, x1Matr, x2Matr, eststage1, eststage2,
                    eststage2sigma, weights = rep(1,nrow(y1vec)), t.c = 1.345)
```

**Arguments**

y1vec	vector of endogenous variables of the selection stage
y2vec	vector of endogenous variables of the outcome stage
x1Matr	matrix of exogenous variables of the selection stage
x2Matr	matrix of exogenous variables of the outcome stage
eststage1	object of class "glmrob", corresponding to the robust probit fit
eststage2	vector of the coefficients of the outcome stage
eststage2sigma	the robust scale estimate of the second stage regression
weights	vector of robustness weights
t.c	tuning constant of the second stage

**Details**

The computation is made using the Huber (1967) - White (1980) sandwich estimator with Heckman (1979) correction. In the computation of leverage weights the  $\lambda$ 's are assumed to be fixed.

**Value**

Variance covariance matrix of the second stage estimator

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

## References

- Amemiya, T. (1984) Tobit Models: a Survey. *Journal of Econometrics*, 24, p. 3-61.
- Heckman, J.J. (1979) Sample Selection Bias as a Specification Error. *Econometrica*, 47, p. 153-161.
- Huber, P.J. (1967) The Behavior of Maximum Likelihood Estimates under Nonstandard Conditions. *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability; L.M. LeCam, J. Neyman (Eds.), Berkeley: University of California Press*, p. 221-233.
- White, H.J. (1980) A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, 48, p. 817-838.

---

 heckit5rob

*Robust Heckit Fit: Switching Regressions*


---

## Description

Fits the switching regression model with probit selection using a robust two-stage estimator

## Usage

```
heckit5rob(selection, outcome1, outcome2, data, control = heckitrob.control())
```

## Arguments

selection	formula, the selection equation
outcome1	formula, first outcome equation
outcome2	formula, second outcome equation
data	an optional 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 heckit5rob is called.
control	a list of parameters for controlling the fitting process

## Details

Compute robust two-stage estimates of the switching regression model with probit selection. The robust probit is fitted in the first stage. In the second stage the Mallows type M-estimators are used. The values of the tuning constants and the robustness weights can be modified in [heckitrob.control](#).

## Value

Object of class "heckit5rob".

coefficients	a named vector of coefficients
stage1	object of class glmrob that contains (first stage) robust probit fit

stage21	object of class <code>r1m</code> that contains second stage first regime robust fit. Note that the standard errors in this object are biased, since they are not corrected for the uncertainty in the first estimation step. Use <code>vcov1</code> below
stage22	object of class <code>r1m</code> that contains second stage second regime robust fit. Note that the standard errors in this object are biased, since they are not corrected for the uncertainty in the first estimation step. Use <code>vcov2</code> below
vcov1	variance matrix of the second stage first regime
vcov2	variance matrix of the second stage second regime
sigma1	the standard error of the error term of the outcome equation when $y_{-1}=1$
sigma2	the standard error of the error term of the outcome equation when $y_{-1}=0$
IMR1	inverse Mills ratio for the case when $y_{-1}=1$
IMR2	inverse Mills ratio for the case when $y_{-1}=0$
call	the matched call
method	method of estimation, currently only "robust two-stage" is implemented
converged	logical. Did all the estimators converge?
iterations	list containing the numbers of iterations

### Author(s)

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

### References

- Heckman, J.J. (1979) Sample Selection Bias as a Specification Error. *Econometrica*, 47, p. 153-161.
- Zhelonkin, M., Genton M.G., and Ronchetti, E. (2016) Robust Inference in Sample Selection Models. *Journal of the Royal Statistical Society, Series B*, 78, p. 805-827. doi: [10.1111/rssb.12136](https://doi.org/10.1111/rssb.12136)
- Zhelonkin, M., Ronchetti, E. (2021) Robust Analysis of Sample Selection Models through the R Package `ssmrob`. *Journal of Statistical Software*, 99, 4, p. 1-35. doi: [10.18637/jss.v099.i04](https://doi.org/10.18637/jss.v099.i04)

### See Also

[glmrob](#), [r1m](#), [ssmrob](#), [heckitrob](#), [heckitrob.control](#)

### Examples

```
## Not run:
library(mvtnorm)
set.seed(2)
N <- 5000
beta1 <- c(0, 1.0, 1.0, 0.75)
beta21 <- c(0, 1.5, 1.0, 0.5)
beta22 <- c(1, -1.5, 1.0, 0.5)
covm <- diag(3)
covm[lower.tri(covm)] <- c(0.75, 0.5, 0.25)
covm[upper.tri(covm)] <- covm[lower.tri(covm)]
```

```

eps <- rmvnorm(N, rep(0, 3), covm)
x1 <- rmvnorm(N, mean=c(0, -1, 1), sigma=diag(c(1, 0.5, 1)))
x21 <- x1
x22 <- x1
x21[, 3] <- rnorm(N, 1, 1)
x22[, 3] <- rnorm(N, 1, 1)
x1beta1 <- beta1[1] + x1[, 1]*beta1[2] + x1[, 2]*beta1[3] + x1[, 3]*beta1[4]
x21beta21 <- beta21[1] + x21[, 1]*beta21[2] + x21[, 2]*beta21[3] + x21[, 3]*beta21[4]
x22beta22 <- beta22[1] + x22[, 1]*beta22[2] + x22[, 2]*beta22[3] + x22[, 3]*beta22[4]
y1 <- ifelse(x1beta1 + eps[, 1] > 0, 1, 0)
y2 <- ifelse(y1 > 0.5, x21beta21 + eps[, 2],
x22beta22 + eps[, 3])
srsim.fit <- ssmrob(y1 ~ x1, list(y2 ~ x21, y2 ~ x22),
control = heckitrob.control(weights.x1 = "hat", weights.x2 = "covMcd"))
summary(srsim.fit)

## End(Not run)

```

---

heckitrob

*Robust Heckit Fit*


---

## Description

Fits the sample selection model using a robust two-stage estimator

## Usage

```
heckitrob(selection, outcome, data, control = heckitrob.control())
```

## Arguments

selection	formula, the selection equation
outcome	formula, the outcome equation
data	an optional 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>heckitrob</code> is called.
control	a list of parameters for controlling the fitting process

## Details

Compute robust two-stage estimates of the Heckman's selection model. The robust probit is fitted in the first stage. In the second stage the Mallows type M-estimator is used. The values of the tuning constants and the robustness weights can be modified in [heckitrob.control](#).



**Value**

Object of class "heckitrob".

coefficients	a named vector of coefficients
stage1	object of class <code>glmrob</code> that contains robust probit fit
stage2	object of class <code>rlm</code> that contains second stage robust fit. Note that the standard errors in this object are biased, since they are not corrected for the uncertainty in the first estimation step. Use <code>vcov</code> below
vcov	variance matrix of the second stage
sigma	the standard error of the error term of the outcome equation
IMR1	inverse Mills ratio for the case when <code>y_1=1</code>
call	the matched call
method	method of estimation, currently only "robust two-stage" is implemented
converged	logical. Did all the estimators converge?
iterations	list containing the numbers of iterations

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**References**

- Cameron, C.A., Trivedi, P.K. (2009) *Microeconometrics Using Stata*. College Station, TX: Stata Press.
- Heckman, J.J. (1979) Sample Selection Bias as a Specification Error. *Econometrica*, 47, p. 153-161.
- Zhelonkin, M., Genton M.G., and Ronchetti, E. (2016) Robust Inference in Sample Selection Models. *Journal of the Royal Statistical Society, Series B*, 78, p. 805-827. doi: [10.1111/rssb.12136](https://doi.org/10.1111/rssb.12136)
- Zhelonkin, M., Ronchetti, E. (2021) Robust Analysis of Sample Selection Models through the R Package `ssmrob`. *Journal of Statistical Software*, 99, 4, p. 1-35. doi: [10.18637/jss.v099.i04](https://doi.org/10.18637/jss.v099.i04)

**See Also**

[glmrob](#), [rlm](#), [ssmrob](#), [heckitrob.control](#), [heckit5rob](#), [etregrob](#)

**Examples**

```
# Zhelonkin, Genton, Ronchetti (2016): page 823
data(MEPS2001)
selectEq <- dambexp ~ age + female + educ + blhisp + totchr + ins
outcomeEq <- lnambx ~ age + female + educ + blhisp + totchr + ins
meps.fit <- ssmrob(selectEq, outcomeEq, data = MEPS2001, control = heckitrob.control(tcc = 3.2))
summary(meps.fit)
```

---

heckitrob.control      *Auxiliary for Controlling Robust Fitting*

---

### Description

Auxiliary function used for fitting the sample selection models. Contains control sequences, tuning constants and robustness weight functions.

### Usage

```
heckitrob.control(acc = 1e-04, test.acc = "coef", maxit = 50, maxit0 = 50,  
                 weights.x1 = c("none", "hat", "robCov", "covMcd"),  
                 weights.x2 = c("none", "hat", "robCov", "covMcd"),  
                 tcc = 1.345, t.c = 1.345)
```

### Arguments

acc	positive convergence level
test.acc	only "coef" is currently implemented
maxit	integer giving the maximum number of iterations: selection equation
maxit0	integer giving the maximum number of iterations: outcome equation
weights.x1	vector of robustness weights controlling for the leverage effect in the selection equation
weights.x2	vector of robustness weights controlling for the leverage effect in the outcome equation
tcc	tuning constant c for Huber's psi-function for the selection stage
t.c	tuning constant c for Huber's psi-function for the outcome stage

### Value

A list with the arguments as components.

### Author(s)

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

---

MEPS2001

*Ambulatory Expenditures Data*

---

### **Description**

The dataset is an extract from the Medical Expenditures Panel Survey. Sample of 3328 observations, with 526 zero expenditures. It was used for illustrative examples by Cameron and Trivedi (2009, Chapter 16).

### **Usage**

```
data(MEPS2001)
```

### **Format**

A data frame with 3328 observations on the following 12 variables.

educ Educational attainment, in years.

age Age.

income Income.

female Logical, TRUE if female.

totchr Number of chronic diseases.

age2 Age squared

ambexp Ambulatory expenditures.

lambexp Log ambulatory expenditures.

blhisp Ethnicity. Logical, TRUE if black or hispanic.

dambexp Logical, TRUE if the ambulatory expenditures are greater than zero.

lnambx Log ambulatory expenditures, with zeros replacing NA's.

ins Insurance status. Logical, TRUE if insured.

### **Source**

2001 Medical Expenditure Panel Survey by the Agency for Healthcare Research and Quality.

### **References**

Cameron, C.A. and Trivedi, P.K. (2009) *Microeconometrics Using Stata*, College Station, TX: Stata Press.

### **Examples**

```
data(MEPS2001)  
summary(MEPS2001)
```

MmatrM

*M Matrix***Description**

M matrix of a linear regression M-estimator of Mallows type.

**Usage**

```
MmatrM(x, y, beta, sigma, t.c = 1.345, weights = 1)
```

**Arguments**

x	matrix of explanatory variables
y	vector of dependent variables
beta	vector of parameters
sigma	robust scale estimate
t.c	tuning constant c for Huber's psi-function
weights	vector of robustness weights controlling for the leverage effects

**Details**

Computes the M matrix of the M-estimator of Mallows type. In current implementation only the Huber score function is available.

**Value**

M matrix for the sandwich formula.

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

---

model.matrix.etregrob *Design Matrix of Endogenous Treatment Model*

---

**Description**

Create design matrix of endogenous treatment model

**Usage**

```
## S3 method for class 'etregrob'
model.matrix(object, part = "outcome", ...)
```

**Arguments**

object	object of class etregrob
part	character string indicating which matrix to extract: "outcome" for the outcome equation, "selection" for the selection equation.
...	currently not used

**Value**

If argument part is "outcome", the design matrix of the outcome equation is returned.

If argument part is "selection", the design matrix of the selection equation is returned.

**Author(s)**

Mikhail Zhelonkin

---

model.matrix.heckit5rob

*Design Matrix of Switching Regression Model*

---

**Description**

Create design matrix of switching regression model

**Usage**

```
## S3 method for class 'heckit5rob'
model.matrix(object, part = "outcome", ...)
```

**Arguments**

object	object of class heckit5rob
part	character string indicating which matrix to extract: "outcome" for the outcome equations, "selection" for the selection equation.
...	currently not used

**Value**

If argument part is "outcome", the list containing design matrices of the outcome equations is returned.

stage21            design matrix for the first regime

stage22            design matrix for the second regime

If argument part is "selection", the design matrix of the selection equation is returned.

**Author(s)**

Mikhail Zhelonkin

model.matrix.heckitrob

*Design Matrix of Sample Selection Model*

---

### **Description**

Create design matrix of sample selection model

### **Usage**

```
## S3 method for class 'heckitrob'  
model.matrix(object, part = "outcome", ...)
```

### **Arguments**

object	object of class heckitrob
part	character string indicating which matrix to extract: "outcome" for the outcome equation, "selection" for the selection equation.
...	currently not used

### **Value**

If argument part is "outcome", the design matrix of the outcome equation is returned.

If argument part is "selection", the design matrix of the selection equation is returned.

### **Author(s)**

Mikhail Zhelonkin

---

MROZ.RAW

*Wage Offer Data*

---

### **Description**

Sample of 753 observations, with 325 truncated observations.

### **Usage**

```
data(MROZ.RAW)
```

**Format**

A data frame with 753 observations on the following 22 variables.

inlf Logical, TRUE if in labor force.

hours Hours worked by wife in 1975.

kidslt6 Number of young children, 5 year or younger.

kidsge6 Number of children greater than 6 years of age.

age Wife's age.

educ Education level in years.

wage Average hourly earnings in 1975.

repwage Wife's wage reported at the time of the 1976 interview.

hushrs Husband's hours worked in 1975.

husage Husband's age.

huseduc Husband's education in years.

huswage Husband's wage in 1975.

faminc Family income in 1975.

mtr Marginal tax rate facing the wife.

motheduc Wife's mother's education in years.

fatheduc Wife's father's education in years.

unem Unemployment rate in county of residence.

city Logical, TRUE if live in large city.

exper Wife's labor market experience in years.

nwifeinc Non-wife income, households's total money minus wife's labor income.

lwage Wife's log-wage.

expersq Wife's squared experience.

**References**

Mroz , T.A. (1987) The Sensitivity of an Empirical Model of Married Women's Hours of Work to Economic and Statistical Assumptions. *Econometrica*, 55, p. 765-799.

Wooldridge, J.M. (2002) *Econometric Analysis of Cross Section and Panel Data*, Cambridge MA: MIT Press.

**Examples**

```
data(MROZ.RAW)
summary(MROZ.RAW)
```

---

nobs.heckitrob	<i>Number of Observations</i>
----------------	-------------------------------

---

**Description**

Number of observations

**Usage**

```
## S3 method for class 'heckitrob'
nobs(object, ...)
```

**Arguments**

object	object of class heckitrob, or heckit5rob or etregrob
...	currently not used

**Author(s)**

Mikhail Zhelonkin

---

print.etregrab	<i>Print a etregrob Object</i>
----------------	--------------------------------

---

**Description**

Print an object generated by [etregrob](#)

**Usage**

```
## S3 method for class 'etregrob'
print(x, digits = 4, ...)
```

**Arguments**

x	object of etregrob class
digits	number of significant digits to be printed
...	currently not used

**Author(s)**

Mikhail Zhelonkin

**See Also**

[etregrob](#)



---

print.heckit5rob      *Print a heckit5rob Object*

---

**Description**

Print an object generated by [ssmrob](#)

**Usage**

```
## S3 method for class 'heckit5rob'  
print(x, digits = 4, ...)
```

**Arguments**

x	object returned from the <a href="#">heckit5rob</a> representing the fit of the model
digits	number of significant digits to be printed
...	currently not used

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**

[ssmrob](#)

---

print.heckitrob      *Print a heckitrob Object*

---

**Description**

Print an object generated by [ssmrob](#)

**Usage**

```
## S3 method for class 'heckitrob'  
print(x, digits = 4, ...)
```

**Arguments**

x	object returned from the <a href="#">heckitrob</a> representing the fit of the model
digits	number of significant digits to be printed
...	currently not used

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**

[ssmrob](#)

---

`print.summary.etregrob`

*Print Function for summary.etregrob*

---

**Description**

Print a [summary.etregrob](#) object

**Usage**

```
## S3 method for class 'summary.etregrob'  
print(x, digits = 4, ...)
```

**Arguments**

<code>x</code>	Object of class <code>summary.etregrob</code> returned by a summary function
<code>digits</code>	number of nonzero digits after comma
<code>...</code>	currently not used

**Author(s)**

Mikhail Zhelonkin

---

`print.summary.heckit5rob`

*Print Function for summary.heckit5rob*

---

**Description**

Print a [summary.heckit5rob](#) object

**Usage**

```
## S3 method for class 'summary.heckit5rob'  
print(x, digits = 4, ...)
```

**Arguments**

x	Object of class <code>summary.heckitrob</code> returned by a summary function
digits	number of nonzero digits after comma
...	currently not used

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

---

print.summary.heckitrob

*Print Function for summary.heckitrob*

---

**Description**

Print a `summary.heckitrob` object

**Usage**

```
## S3 method for class 'summary.heckitrob'
print(x, digits = 4, ...)
```

**Arguments**

x	Object of class <code>summary.heckitrob</code> returned by a summary function
digits	number of nonzero digits after comma
...	currently not used

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

---

PsiMest

*Score Function of the Mallows M-Estimator*

---

**Description**

Score function of the Mallows-type M-estimator.

**Usage**

```
PsiMest(x, y, beta, sigma, t.c, weight)
```

**Arguments**

x	vector of exogenous variables
y	scalar endogenous variable
beta	parameter vector
sigma	std.error
t.c	tuning constant of Huber Psi-function
weight	scalar weight on the exogenous variables

**Details**

Can be used to compute the influence function of the estimator. Also can be used to approximate the bias of the estimator.

**Value**

score of the Psi-function

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**References**

Hampel, Ronchetti, Rousseeuw, Stahel (1986). *Robust Statistics: The Approach Based on Influence Functions*. New York: Wiley.

---

residuals.etregrob     *Residuals of Robust Endogenous Treatment Model Fit*

---

**Description**

Calculate the residuals of the endogenous treatment model using robust fit.

**Usage**

```
## S3 method for class 'etregrob'
residuals(object, ...)
```

**Arguments**

object	object of class "etregrob"
...	currently not used

**Value**

numeric vector of residuals.

**Author(s)**

Mikhail Zhelonkin

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

---

residuals.heckit5rob *Residuals of Robust Sample Selection Model Fit*

---

**Description**

Calculate the residuals of the sample selection model using robust fit.

**Usage**

```
## S3 method for class 'heckit5rob'  
residuals(object, ...)
```

**Arguments**

object	object of class " <a href="#">heckitrob</a> " or object of class " <a href="#">heckit5rob</a> "
...	currently not used

**Details**

In case of truncated selection model one vector of residuals is returned. In case of switching regression model a list containing two vectors corresponding to two regimes is returned.

**Value**

The numeric vector(s) of the residuals.

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**[heckitrob](#); [heckit5rob](#)

---

residuals.heckitrob     *Residuals of Robust Sample Selection Model Fit*

---

### Description

Calculate the residuals of the sample selection model using robust fit.

### Usage

```
## S3 method for class 'heckitrob'  
residuals(object, ...)
```

### Arguments

object	object of class "heckitrob" or object of class "heckit5rob"
...	currently not used

### Details

In case of truncated selection model one vector of residuals is returned. In case of switching regression model a list containing two vectors corresponding to two regimes is returned.

### Value

vector(s) of residuals.

### Author(s)

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

### See Also

[heckitrob](#); [heckit5rob](#)

---

ssmrob     *Robust Sample Selection Model*

---

### Description

Compute robust two-stage estimates of truncated selection model (Tobit-2) and switching regression model (Tobit-5).

### Usage

```
ssmrob(selection, outcome, data, control = heckitrob.control())
```

**Arguments**

selection	formula, the selection equation
outcome	formula(s), the outcome equation(s)
data	an optional 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>ssmrob</code> is called.
control	a list of parameters for controlling the fitting process

**Details**

Outcome equation may be a simple formula for the case of Heckman selection model, or a list of two formulas for the case of switching regressions.

**Value**

Object of class "heckitrob" or object of class "heckit5rob".

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**References**

- Amemiya, T. (1984) Tobit Models: a Survey. *Journal of Econometrics*, 24, p. 3-61.
- Heckman, J.J. (1979) Sample Selection Bias as a Specification Error. *Econometrica*, 47, p. 153-161.
- Zhelonkin, M., Genton M.G., and Ronchetti, E. (2016) Robust Inference in Sample Selection Models. *Journal of the Royal Statistical Society, Series B*, 78, p. 805-827. doi: [10.1111/rssb.12136](https://doi.org/10.1111/rssb.12136)
- Zhelonkin, M., Ronchetti, E. (2021) Robust Analysis of Sample Selection Models through the R Package `ssmrob`. *Journal of Statistical Software*, 99, 4, p. 1-35. doi: [10.18637/jss.v099.i04](https://doi.org/10.18637/jss.v099.i04)

**See Also**

[heckitrob](#), [heckit5rob](#)

**Examples**

```
# sample selection model (Tobit-2)
# Zhelonkin, Genton, Ronchetti (2016): page 823
data(MEPS2001)
selectEq <- dambexp ~ age + female + educ + blhisp + totchr + ins
outcomeEq <- lnambx ~ age + female + educ + blhisp + totchr + ins
meps.fit <- ssmrob(selectEq, outcomeEq, data = MEPS2001, control = heckitrob.control(tcc = 3.2))
summary(meps.fit)

# switching regressions example (Tobit-5)
## Not run:
library(mvtnorm)
```

```

set.seed(2)
N <- 5000
beta1 <- c(0, 1.0, 1.0, 0.75)
beta21 <- c(0, 1.5, 1.0, 0.5)
beta22 <- c(1, -1.5, 1.0, 0.5)
covm <- diag(3)
covm[lower.tri(covm)] <- c(0.75, 0.5, 0.25)
covm[upper.tri(covm)] <- covm[lower.tri(covm)]
eps <- rmvnorm(N, rep(0, 3), covm)
x1 <- rmvnorm(N, mean=c(0, -1, 1), sigma=diag(c(1, 0.5, 1)))
x21 <- x1
x22 <- x1
x21[, 3] <- rnorm(N, 1, 1)
x22[, 3] <- rnorm(N, 1, 1)
x1beta1 <- beta1[1] + x1[, 1]*beta1[2] + x1[, 2]*beta1[3] + x1[, 3]*beta1[4]
x21beta21 <- beta21[1] + x21[, 1]*beta21[2] + x21[, 2]*beta21[3] + x21[, 3]*beta21[4]
x22beta22 <- beta22[1] + x22[, 1]*beta22[2] + x22[, 2]*beta22[3] + x22[, 3]*beta22[4]
y1 <- ifelse(x1beta1 + eps[, 1] > 0, 1, 0)
y2 <- ifelse(y1 > 0.5, x21beta21 + eps[, 2],
x22beta22 + eps[, 3])
srsim.fit <- ssmrob(y1 ~ x1, list(y2 ~ x21, y2 ~ x22),
control = hecitrrob.control(weights.x1 = "hat", weights.x2 = "covMcd"))
summary(srsim.fit)

## End(Not run)

```

---

summary.etregrob

*Summarizing Robust Fits of Endogenous Treatment Models*


---

## Description

Summarizes robust fit of endogenous treatment models.

## Usage

```

## S3 method for class 'etregrob'
summary(object, ...)

```

## Arguments

object	object of class "etregrob"
...	currently not used

## Value

object of class "summary.etregrob"

## Author(s)

Mikhail Zhelonkin



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

---

summary.heckit5rob	<i>Summarizing Robust Fits of Sample Selection Models</i>
--------------------	---

---

**Description**

Summarize robust fit of Heckman selection model.

**Usage**

```
## S3 method for class 'heckit5rob'  
summary(object, ...)
```

**Arguments**

object	object of class " <a href="#">heckitrob</a> " or " <a href="#">heckit5rob</a> "
...	currently not used

**Value**

object of class "summary.heckitrob" or object of class "summary.heckit5rob"

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**

[heckitrob](#); [heckit5rob](#); [heck2steprobVcov](#); [heck5twosteprobVcov](#)

---

summary.heckitrob	<i>Summarizing Robust Fits of Sample Selection Models</i>
-------------------	---

---

**Description**

Summarize robust fit of Heckman selection model.

**Usage**

```
## S3 method for class 'heckitrob'  
summary(object, ...)
```

**Arguments**

object            object of class "[heckitrob](#)" or "[heckit5rob](#)"  
 ...                currently not used

**Value**

object of class "summary.heckitrob" or object of class "summary.heckit5rob"

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**

[heckitrob](#); [heckit5rob](#); [heck2steprobVcov](#); [heck5twosteprobVcov](#)

---

vcov. etregrob

*Extract Asymptotic Variance Covariance Matrix*

---

**Description**

Extracts the variance covariance matrix of the robust endogenous treatment model fit

**Usage**

```
## S3 method for class 'etregrob'
vcov(object, ...)
```

**Arguments**

object            object of class "[etregrob](#)"  
 ...                currently not used

**Value**

Variance covariance matrix of the second stage. Variance covariance matrix of the selection stage can be extracted using the vcov function for the probit estimator, e.g. `vcov(etregrob.object$stage1)`.

**Author(s)**

Mikhail Zhelonkin

**See Also**

[etreg2steprobVcov](#)

---

vcov.heckit5rob	<i>Extract Asymptotic Variance Covariance Matrix</i>
-----------------	--

---

**Description**

Extract the variance covariance matrix of the robust sample selection model fit

**Usage**

```
## S3 method for class 'heckit5rob'
vcov(object, ...)
```

**Arguments**

object	object of class " <a href="#">heckitrob</a> " or object of class " <a href="#">heckit5rob</a> "
...	currently not used

**Value**

Variance covariance matrix of the second stage. Variance covariance matrix of the selection stage can be extracted using the vcov function for the probit estimator, e.g. `vcov(heckitrob.object$stage1)`.

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**

[heck2steprobVcov](#)

---

vcov.heckitrob	<i>Extract Asymptotic Variance Covariance Matrix</i>
----------------	--

---

**Description**

Extract the variance covariance matrix of the robust sample selection model fit

**Usage**

```
## S3 method for class 'heckitrob'
vcov(object, ...)
```

**Arguments**

object	object of class " <a href="#">heckitrob</a> " or object of class " <a href="#">heckit5rob</a> "
...	currently not used

**Value**

Variance covariance matrix of the second stage. Variance covariance matrix of the selection stage can be extracted using the `vcov` function for the probit estimator, e.g. `vcov(heckitrob.object$stage1)`.

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**

[heck2steprobVcov](#)

---

x2weight.covMcd

*Robustness Weights*

---

**Description**

Auxiliary function. Computation of the leverage weights based on robust Mahalanobis distance. For computation of location and scatter the MCD method is used.

**Usage**

```
x2weight.covMcd(xMat)
```

**Arguments**

xMat            matrix of explanatory variables

**Value**

vector of weights

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**

[cov.rob](#)

---

x2weight.robCov	<i>Robustness Weights</i>
-----------------	---------------------------

---

**Description**

Auxiliary function. Computation of the leverage weights based on robust Mahalanobis distance. For computation of location and scatter the MVE method is used.

**Usage**

```
x2weight.robCov(xMat)
```

**Arguments**

xMat            matrix of explanatory variables

**Value**

vector of weights

**Author(s)**

Mikhail Zhelonkin, Marc G. Genton, Elvezio Ronchetti

**See Also**

[cov.rob](#)

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