# Package 'truncSP'

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**Title** Semi-Parametric Estimators of Truncated Regression Models

**Version** 1.2.4

**Description** Estimators for semi-parametric linear regression models with truncated response variables (fixed truncation point). The estimators implemented are the Symmetrically Trimmed Least Squares (STLS) estimator introduced by Powell (1986) <doi:10.2307/1914308>, the Quadratic Mode (QME) estimator introduced by Lee (1993) <doi:10.1016/0304-4076(93)90056-B>, and the Left Truncated (LT) estimator introduced by Karlsson (2006) <doi:10.1007/s00184-005-0023-x>.

**Depends** R (>= 3.4.0)

**Imports** stats, methods, truncreg, boot

**License** GPL (>= 2)

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**Collate** 'PM10-data.R' 'PM10trunc-data.R' 'bootconfint.R' 'covar.boot.R' 'funcval.LT.R' 'mlcoef.R' 'funcLT.R' 'funcval.QME.R' 'funcQME.R' 'funcval.STLS.R' 'funcSTLS.R' 'lt-class.R' 'lt.fit.R' 'lt.R' 'summary.lt-class.R' 'ltmethods.r' 'qme-class.R' 'qme.fit.R' 'qme.R' 'summary.qme-class.R' 'qmemethods.r' 'stls-class.R' 'stls.fit.R' 'stls.R' 'summary.stls-class.R' 'stlsmethods.r' 'truncSP-package.R'

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# Contents

## truncSP-package *Estimators of semi-parametric truncated regression models*

### Description

Functions for estimation of semi-parametric linear regression models with truncated response variables (fixed truncation point). Estimation using the Symmetrically Trimmed Least Squares (STLS) estimator (Powell 1986), Quadratic Mode (QME) estimator (Lee 1993) and Left Truncated (LT) estimator (Karlsson 2006).

### Author(s)

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- Maria Karlsson <maria.karlsson@umu.se>

## bootconfint *Function to obtain bootstrap confidence intervals (percentile)*

### Description

Function to obtain bootstrap confidence intervals (percentile)

### Usage

```
bootconfint(bootrepl, level)
```

### Arguments

| | |
|---|---|
| bootrepl | bootsrap replicates |
| level | confidence level |

### Value

The function returns the bootstrap confidence intervals as a two-column matrix with one row per parameter

## coef.lt *Function to extract model coefficients for objects of class "lt"*

### Description

Function to extract model coefficients for objects of class "lt"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "lt" |
| ... | additional arguments |

## coef.qme *Function to extract model coefficients for objects of class "qme"*

### Description

Function to extract model coefficients for objects of class "qme"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "qme" |
| ... | additional arguments |

## coef.stls *Function to extract model coefficients for objects of class "stls"*

### Description

Function to extract model coefficients for objects of class "stls"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "stls" |
| ... | additional arguments |

## covar.boot *Function to obtain bootstrap covariance matrix*

### Description

Function to obtain bootstrap covariance matrix

### Usage

```
covar.boot(bootrepl)
```

### Arguments

| | |
|---|---|
| bootrepl | bootsrap replicates |

## fitted.lt *Function to obtain fitted values from objects of class "lt"*

### Description

Function to obtain fitted values from objects of class "lt"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "lt" |
| ... | additional arguments |

## fitted.qme *Function to obtain fitted values from objects of class "qme"*

### Description

Function to obtain fitted values from objects of class "qme"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "qme" |
| ... | additional arguments |

## fitted.stls *Function to obtain fitted values from objects of class "stls"*

### Description

Function to obtain fitted values from objects of class "stls"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "stls" |
| ... | additional arguments |

## funcLT *Function to be used by boot to obtain bootstrap replicates of the parameters estimated with QME*

### Description

Function to be used by boot to obtain bootstrap replicates of the parameters estimated with QME

### Usage

```
funcLT(
  mf,
  mf_orig,
  d,
  formula,
  beta,
  bet,
  clower,
  const,
  cupper,
  point,
  direction,
  control
)
```

### Arguments

| | |
|---|---|
| mf | the model.frame containing the variables to be used when fitting the model. |
| mf_orig | original model frame (before possible manipulations due to non-default truncation point or direction) used to ensure correct order of attributes in the call to truncreg |
| d | vector of indices to define the bootstrap samples |
| formula | a symbolic description of the model to be estimated |
| beta | the method of determining the starting values of the regression coefficients |
| bet | starting values to be used by optim. Only used if beta is numeric. |
| clower | the lower threshold value to be used when trimming the conditional density of the errors from below. |
| const | a number that can be used to alter the size of the lower threshold. |
| cupper | number indicating what upper threshold to use when trimming the conditional density of the errors from above. |
| point | the point of truncation |
| direction | the direction of truncation |
| control | list of control parameters to be used by optim |

### Author(s)

Anita Lindmark and Maria Karlsson

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## funcQME *Function to be used by boot to obtain bootstrap replicates of the parameters estimated with QME*

---

### Description

Function to be used by boot to obtain bootstrap replicates of the parameters estimated with QME

### Usage

```
funcQME(
  mf,
  mf_orig,
  d,
  formula,
  beta,
  bet,
  cval,
  const,
  point,
  direction,
  control
)
```

### Arguments

| | |
|---|---|
| mf | the model.frame containing the variables to be used when fitting the model. |
| mf_orig | original model frame (before possible manipulations due to non-default truncation point or direction) used to ensure correct order of attributes in the call to truncreg |
| d | vector of indices to define the bootstrap samples |
| formula | a symbolic description of the model to be estimated |
| beta | the method of determining the starting values of the regression coefficients |
| bet | starting values to be used by optim. Only used if beta is numeric. |
| cval | the threshold value to be used when trimming the conditional density of the errors. |
| const | a number that can be used to alter the size of the threshold value. |
| point | the point of truncation |
| direction | the direction of truncation |
| control | list of control parameters to be used by optim |

### Author(s)

Anita Lindmark and Maria Karlsson

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## funcSTLS *Function to be used by boot to obtain bootstrap replicates of the parameters estimated with STLS*

---

### Description

Function to be used by boot to obtain bootstrap replicates of the parameters estimated with STLS

### Usage

```
funcSTLS(mf, mf_orig, d, formula, beta, bet, point, direction, control)
```

### Arguments

| | |
|---|---|
| mf | the model.frame containing the variables to be used when fitting the model. |
| mf_orig | original model frame (before possible manipulations due to non-default truncation point or direction) used to ensure correct order of attributes in the call to truncreg |
| d | vector of indices to define the bootstrap samples |
| formula | a symbolic description of the model to be estimated |
| beta | the method of determining the starting values of the regression coefficients |
| bet | starting values to be used by optim. Only used if beta is numeric. |
| point | the point of truncation |
| direction | the direction of truncation |
| control | list of control parameters to be used by optim |

### Author(s)

Anita Lindmark and Maria Karlsson

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`funcval.LT` *LT objective function*

---

### Description

LT objective function

### Usage

```
funcval.LT(bet, x, y, cl, cu)
```

### Arguments

| | |
|---|---|
| `bet` | parameter values. Column matrix with p rows. |
| `x` | model matrix |
| `y` | response variable, column matrix |
| `cl` | lower threshold value to be used, number or numeric vector of length 1. (See `lt`, argument `clower`, for more information). |
| `cu` | upper threshold value to be used, number or numeric vector of length 1. (See `lt`, argument `cupper`, for more information). |

### Value

Returns the value of the objective function for given parameter values

### Author(s)

Anita Lindmark and Maria Karlsson

### See Also

`lt`

## funcval.QME *QME objective function*

### Description

QME objective function

### Usage

```
funcval.QME(bet, x, y, cv)
```

### Arguments

| | |
|---|---|
| bet | parameter values. Column matrix with p rows. |
| x | model matrix |
| y | response variable, column matrix |
| cv | threshold value (see qme, argument cval, for more information). |

### Value

Returns the value of the objective function for given parameter values

### Author(s)

Anita Lindmark and Maria Karlsson

### See Also

qme

## funcval.STLS *STLS objective function*

### Description

STLS objective function

### Usage

```
funcval.STLS(bet, x, y)
```

### Arguments

| | |
|---|---|
| bet | parameter values. Column matrix with p rows. |
| x | model matrix |
| y | response variable, column matrix |

## Value

Returns the value of the objective function for given parameter values

## Author(s)

Anita Lindmark and Maria Karlsson

## See Also

stls

---

`lt` *Estimation of truncated regression models using the Left Truncated (LT) estimator*

---

## Description

Estimates linear regression models with truncated response variables (fixed truncation point), using the LT estimator (Karlsson 2006).

## Usage

```
lt(
  formula,
  data,
  point = 0,
  direction = "left",
  clower = "ml",
  const = 1,
  cupper = 2,
  beta = "ml",
  covar = FALSE,
  na.action,
  ...
)
```

## Arguments

| | |
|---|---|
| `formula` | a symbolic description of the model to be estimated |
| `data` | an optional data frame |
| `point` | the value of truncation (the default is 0) |
| `direction` | the direction of truncation, either `"left"` (the default) or `"right"` |

clower — the lower threshold value to be used when trimming the conditional density of the errors from below. The default is "ml" meaning that the residual standard deviation from fitting a maximum likelihood model for truncated regression, using truncreg, is used. Method "ols" uses the estimated residual standard deviation from a linear model fitted by lm. It is also possible to manually supply the threshold value by setting clower to be equal to a number or numeric vector of length one.

const — a number that can be used to alter the size of the lower threshold. const=0.5 would give a lower threshold value that is half the original size. The default value is 1.

cupper — number indicating what upper threshold to use when trimming the conditional density of the errors from above. The number is used to multiply the lower threshold value, i.e. if cupper=2 (the default value) the upper threshold value is two times larger than the lower threshold value.

beta — the method of determining the starting values of the regression coefficients (See Details for more information):

- The default method is "ml", meaning that the estimated regression coefficients from fitting a maximum likelihood model for truncated regression, assuming Gaussian errors, are used. The maximum likelihood model is fitted using truncreg.
- Method "ols" means that the estimated regression coefficients from fitting a linear model with lm are used.
- The third option is to manually provide starting values as either a vector, column matrix or row matrix.

covar — logical. Indicates whether or not the covariance matrix should be estimated. If TRUE the covariance matrix is estimated using bootstrap. The default number of replicates is 2000 but this can be adjusted (see argument ...). However, since the bootstrap procedure is time-consuming the default is covar=FALSE.

na.action — a function which indicates what should happen when the data contain NAs.

... — additional arguments. For lt the number of bootstrap replicates can be adjusted by setting R=the desired number of replicates. Also the control argument of optim can be set by control=list() (see Details for more information).

## Details

Minimizes the objective function described in Karlsson (2006) wrt the vector of regression coefficients, in order to find the LT estimates. The minimization is performed by optim using the "Nelder–Mead" method, and a maximum number of iterations of 2000. The maximum number of iterations can be adjusted by setting control = list(maxit = ...) (for more information see the documentation for optim).

It is recommended to use one of the methods for generating the starting values of the regression coefficients (see argument beta) rather than supplying these manually, unless one is confident that one has a good idea of what these should be. This because the starting values can have a great impact on the result of the minimization.

Note that setting cupper = 1 means that the LT estimates will coincide with the estimates from the Quadratic Mode Estimator (see function qme). For more detailed information see Karlsson and Lindmark (2014).

## Value

lt returns an object of class "lt".

The function summary prints a summary of the results, including two types of confidence intervals (normal approximation and percentile method). The generic accessor functions coef, fitted, residuals and vcov extract various useful features of the value returned by lt

An object of class "lt", a list with elements:

| | |
|---|---|
| coefficients | the named vector of coefficients |
| startcoef | the starting values of the regression coefficients used by optim |
| cvalues | information about the thresholds used. The method and constant used and the resulting lower and upper threshold values. |
| value | the value of the objective function corresponding to coefficients |
| counts | number of iterations used by optim. See the documentation for optim for further details |
| convergence | from optim. An integer code. 0 indicates successful completion. Possible error codes are<br>1 indicating that the iteration limit maxit had been reached.<br>10 indicating degeneracy of the Nelder–Mead simplex. |
| message | from optim. A character string giving any additional information returned by the optimizer, or NULL. |
| residuals | the residuals of the model |
| fitted.values | the fitted values |
| df.residual | the residual degrees of freedom |
| call | the matched call |
| covariance | if covar = TRUE, the estimated covariance matrix |
| R | if covar = TRUE, the number of bootstrap replicates |
| bootrepl | if covar = TRUE, the bootstrap replicates |

## Author(s)

Anita Lindmark and Maria Karlsson

## References

Karlsson, M. (2006) Estimators of regression parameters for truncated and censored data, *Metrika*, **63**, pp 329–341

Karlsson, M., Lindmark, A. (2014) truncSP: An R Package for Estimation of Semi-Parametric Truncated Linear Regression Models, *Journal of Statistical Software*, **57(14)**, pp 1–19, https://www.jstatsoft.org/article/view/v057i14

## See Also

lt.fit, the function that does the actual fitting

qme, for estimation of models with truncated response variables using the QME estimator

stls, for estimation of models with truncated response variables using the STLS estimator

truncreg for estimating models with truncated response variables by maximum likelihood, assuming Gaussian errors

## Examples

```
####################################
#          Simulated data          #
####################################
#Simulated data (asymmetrically distributed errors):
n <- 1000
set.seed(319993)
x1 <- runif(n, 0, 10)
x2 <- runif(n, 0, 10)
x3 <- runif(n, -5, 5)
eps <- rexp(n, 0.2) - 5
y <- 2 - 2*x1 + x2 + 2*x3 + eps
d <- data.frame(y = y, x1 = x1, x2 = x2, x3 = x3)


##Use a truncated subsample
dtrunc <- subset(d, y > 0)

##Use lt to consistently estimate the slope parameters
lt.sim <- lt(y ~ x1 + x2 + x3, dtrunc, point = 0, direction = "left", clower = "ml",
           const = 1, cupper = 2, beta = "ml", covar = FALSE)

summary(lt.sim)

####################################
#  Example using data "PM10trunc"  #
####################################

data(PM10trunc)

ltpm10 <- lt(PM10 ~ cars + temp + wind.speed + temp.diff + wind.dir + hour + day,
            data = PM10trunc, point = 2, control = list(maxit=2500))

summary(ltpm10)
```

## lt-class *An S4 class for objects from the lt function*

### Description

An S4 class for objects from the lt function

### Slots

`call` The matched call

`coefficients` A matrix

`startcoef` A matrix

`cvalues` A data frame

`value` Numeric

`counts` Integer

`convergence` Integer

`message` A character vector

`residuals` A matrix

`fitted.values` A matrix

`df.residual` Integer

`covariance` A matrix

`bootrepl` A matrix

## lt.fit *Function for fitting LT*

### Description

Function to find LT estimates of the regression coefficients for regression models with truncated response variables. Uses optim. Intended to be called through lt, not on its own, since lt also transforms data into the correct form etc.

### Usage

```
lt.fit(formula, mf, point, direction, bet, cl, cu, ...)
```

## Arguments

| | |
|---|---|
| formula | a symbolic description of the model to be estimated |
| mf | the model.frame containing the variables to be used when fitting the model. lt transforms the model frame to the correct form before calling lt.fit. If lt.fit is called on its own the model frame needs to be transformed manually. |
| point | the point of truncation |
| direction | the direction of truncation |
| bet | starting values to be used by optim. Column matrix with p rows. |
| cl | lower threshold value to be used, number or numeric vector of length 1. (See lt, argument clower, for more information). |
| cu | upper threshold value to be used, number or numeric vector of length 1. (See lt, argument cupper, for more information). |
| ... | additional arguments to be passed to optim (see the documentation for lt for further details). |

## Value

A list with components:

| | |
|---|---|
| startcoef | the starting values of the regression coefficients used by optim |
| coefficients | the named vector of coefficients |
| counts | number of iterations used by optim. See the documentation for optim for further details |
| convergence | from optim. An integer code. 0 indicates successful completion. Possible error codes are<br>1 indicating that the iteration limit maxit had been reached.<br>10 indicating degeneracy of the Nelder–Mead simplex. |
| message | from optim. A character string giving any additional information returned by the optimizer, or NULL. |
| residuals | the residuals of the model |
| df.residual | the residual degrees of freedom |
| fitted.values | the fitted values |

## Author(s)

Anita Lindmark and Maria Karlsson

## See Also

lt

## Examples

```
require(utils)
##Model frame
n <- 1000
x <- rnorm(n,0,2)
y <- 2+x+4*rnorm(n)

d <- data.frame(y=y, x=x)
dl0 <- subset(d, y>0)
mf <- model.frame(y~x, data=dl0)

##Starting values and threshold values
lmmod <- lm(data=mf)
bet <- lmmod$coef
bet <- matrix(bet)
cl <- sqrt(deviance(lmmod)/df.residual(lmmod))
cu <- 2*cl

str(lt. <- lt.fit(y~x,mf,point=0,direction="left",bet,cl,cu))
```

---

`mlcoef` *Gives the starting coefficients from fitting a maximum likelihood model for truncated regression, assuming Gaussian errors*

---

## Description

Gives the starting coefficients from fitting a maximum likelihood model for truncated regression, assuming Gaussian errors. Uses the `truncreg` function from the `truncreg` package.

## Usage

```
mlcoef(mf, mf_orig)
```

## Arguments

| | |
|---|---|
| `mf` | model frame |
| `mf_orig` | original model frame (before possible manipulations due to non-default truncation point or direction) used to ensure correct order of attributes in the call to `truncreg` |

## Author(s)

Anita Lindmark and Maria Karlsson

PM10 *Air pollution data*

## Description

The data are a subsample of 500 observations from a data set that originates in a study where air pollution at a road is related to traffic volume and meteorological variables, collected by the Norwegian Public Roads Administration. The response variable consists of hourly values of the logarithm of the concentration of PM10 (particles), measured at Alnabru in Oslo, Norway, between October 2001 and August 2003. (Source: Statlib)

## Usage

```
data(PM10)
```

## Format

A data frame with 500 observations on the following 8 variables.

`PM10` Hourly values of the logarithm of the concentration of PM10 (particles)

`cars` The logarithm of the number of cars per hour

`temp` Temperature 2 meters above ground (degree C)

`wind.speed` Wind speed (meters/second)

`temp.diff` The temperature difference between 25 and 2 meters above ground (degree C)

`wind.dir` Wind direction (degrees between 0 and 360)

`hour` Hour of day

`day` Day number from October 1, 2001

## Source

Aldrin, M. (2006) Improved predictions penalizing both slope and curvature in additive models, *Computational Statistics & Data Analysis*, **50**, pp 267–284

## References

Aldrin, M. (2006) Improved predictions penalizing both slope and curvature in additive models, *Computational Statistics & Data Analysis*, **50**, pp 267–284

## Examples

```
data(PM10)
```

## PM10trunc *Air pollution data (Truncated)*

### Description

Dataset PM10, truncated from the left at variable value PM10 = 2 (8 percent truncation).

### Usage

```
data(PM10)
```

### Format

A data frame with 460 observations on the following 8 variables.

`PM10` Hourly values of the logarithm of the concentration of PM10 (particles)

`cars` The logarithm of the number of cars per hour

`temp` Temperature 2 meters above ground (degree C)

`wind.speed` Wind speed (meters/second)

`temp.diff` The temperature difference between 25 and 2 meters above ground (degree C)

`wind.dir` Wind direction (degrees between 0 and 360)

`hour` Hour of day

`day` Day number from October 1, 2001

### Examples

```
data(PM10trunc)
```

## print.lt *Print function for objects of class "lt"*

### Description

Print function for objects of class "lt"

### Usage

```
## S3 method for class 'lt'
print(x, digits = max(3, getOption("digits") - 3), ...)
```

### Arguments

| | |
|---|---|
| x | object of class "lt" |
| digits | number of digits to be printed. |
| ... | additional arguments |

## print.qme *Print function for objects of class "qme"*

### Description

Print function for objects of class "qme"

### Usage

```
## S3 method for class 'qme'
print(x, digits = max(3, getOption("digits") - 3), ...)
```

### Arguments

| | |
|---|---|
| x | object of class "qme" |
| digits | number of digits to be printed. |
| ... | additional arguments |

## print.stls *Print function for objects of class "stls"*

### Description

Print function for objects of class "stls"

### Usage

```
## S3 method for class 'stls'
print(x, digits = max(3, getOption("digits") - 3), ...)
```

### Arguments

| | |
|---|---|
| x | object of class "stls" |
| digits | number of digits to be printed. |
| ... | additional arguments |

## print.summary.lt *Print function for objects of class* "summary.lt"

### Description

Print function for objects of class "summary.lt"

### Usage

```
## S3 method for class 'summary.lt'
print(x, digits = max(3, getOption("digits") - 3), ...)
```

### Arguments

| | |
|---|---|
| x | object of class "summary.lt" |
| digits | number of digits to be printed. |
| ... | additional arguments |

## print.summary.qme *Print function for objects of class* "summary.qme"

### Description

Print function for objects of class "summary.qme"

### Usage

```
## S3 method for class 'summary.qme'
print(x, digits = max(3, getOption("digits") - 3), ...)
```

### Arguments

| | |
|---|---|
| x | object of class "summary.qme" |
| digits | number of digits to be printed. |
| ... | additional arguments |

## print.summary.stls *Print function for objects of class "summary.stls"*

### Description

Print function for objects of class "summary.stls"

### Usage

```
## S3 method for class 'summary.stls'
print(x, digits = max(3, getOption("digits") - 3), ...)
```

### Arguments

| | |
|---|---|
| x | object of class "summary.stls" |
| digits | number of digits to be printed. |
| ... | additional arguments |

## qme *Estimation of truncated regression models using the Quadratic Mode Estimator (QME)*

### Description

Estimation of linear regression models with truncated response variables (fixed truncation point), using the Quadratic Mode Estimator (QME) (Lee 1993 and Laitila 2001)

### Usage

```
qme(
  formula,
  data,
  point = 0,
  direction = "left",
  cval = "ml",
  const = 1,
  beta = "ml",
  covar = FALSE,
  na.action,
  ...
)
```

## Arguments

| | |
|---|---|
| formula | a symbolic description of the model to be estimated |
| data | an optional data frame |
| point | the value of truncation (the default is 0) |
| direction | the direction of truncation, either "left" (the default) or "right" |
| cval | the threshold value to be used when trimming the conditional density of the errors. The default is "ml" meaning that the estimated residual standard deviation from a maximum likelihood model for truncated regression, fitted using truncreg, is used. Method "ols" uses the residual standard deviation from fitting a linear model using lm. It is also possible to manually supply the threshold by setting cval to be equal to a number or numeric vector of length one. |
| const | a number that can be used to alter the size of the threshold value. const=0.5 would give a threshold value that is half the original size. The default value is 1. |
| beta | the method of determining the starting values of the regression coefficients (See Details for more information):<br>• The default method is "ml", meaning that the estimated regression coefficients from fitting a maximum likelihood model for truncated regression, assuming Gaussian errors, are used. The maximum likelihood model is fitted using truncreg.<br>• Method "ols" means that the estimated regression coefficients from fitting a linear model with lm are used.<br>• The third option is to manually provide starting values as either a vector, column matrix or row matrix. |
| covar | logical. Indicates whether or not the covariance matrix should be estimated. If TRUE the covariance matrix is estimated using bootstrap, as described in Karlsson (2004). The default number of replicates is 2000 but this can be adjusted (see argument ...). However, since the bootstrap procedure is time-consuming the default is covar=FALSE. |
| na.action | a function which indicates what should happen when the data contain NAs. |
| ... | additional arguments. For qme the number of bootstrap replicates can be adjusted by setting R=the desired number of replicates. Also the control argument of optim can be set by control=list() (for more information on this see Details). |

## Details

Finds the QME estimates of the regression coefficients by maximizing the objective function described in Lee (1993) wrt the vector of regression coefficients. The maximization is performed by optim using the "Nelder–Mead" method. The maximum number of iterations is set at 2000, but this can be adjusted by setting control=list(maxit=...) (for more information see the documentation for optim).

The starting values of the regression coefficients can have a great impact on the result of the maximization. For this reason it is recommended to use one of the methods for generating these rather than supplying the values manually, unless one is confident that one has a good idea of what the starting values should be. For more detailed information see Karlsson and Lindmark (2014).

## Value

qme returns an object of class "qme".

The function summary prints a summary of the results, including two types of confidence intervals (normal approximation and percentile method). The generic accessor functions coef, fitted, residuals and vcov extract various useful features of the value returned by qme

An object of class "qme", a list with elements:

| | |
|---|---|
| coefficients | the named vector of coefficients |
| startcoef | the starting values of the regression coefficients used by optim |
| cval | information about the threshold value used. The method and constant value used and the resulting threshold value. |
| value | the value of the objective function corresponding to coefficients |
| counts | number of iterations used by optim. See the documentation for optim for further details |
| convergence | from optim. An integer code. 0 indicates successful completion. Possible error codes are<br>1 indicating that the iteration limit maxit had been reached.<br>10 indicating degeneracy of the Nelder–Mead simplex. |
| message | from optim. A character string giving any additional information returned by the optimizer, or NULL. |
| residuals | the residuals of the model |
| fitted.values | the fitted values |
| df.residual | the residual degrees of freedom |
| call | the matched call |
| covariance | if covar = TRUE, the estimated covariance matrix |
| R | if covar = TRUE, the number of bootstrap replicates |
| bootrepl | if covar = TRUE, the bootstrap replicates |

## Author(s)

Anita Lindmark and Maria Karlsson

## References

Karlsson, M. (2004) Finite sample properties of the QME, *Communications in Statistics - Simulation and Computation*, **5**, pp 567–583

Karlsson, M., Lindmark, A. (2014) truncSP: An R Package for Estimation of Semi-Parametric Truncated Linear Regression Models, *Journal of Statistical Software*, **57(14)**, pp 1–19, https://www.jstatsoft.org/article/view/v057i14

Laitila, T. (2001) Properties of the QME under asymmetrically distributed disturbances, *Statistics & Probability Letters*, **52**, pp 347–352

Lee, M. (1993) Quadratic mode regression, *Journal of Econometrics*, **57**, pp 1-19

Lee, M. & Kim, H. (1998) Semiparametric econometric estimators for a truncated regression model: a review with an extension, *Statistica Neerlandica*, **52(2)**, pp 200–225

## See Also

qme.fit, the function that does the actual fitting

stls, for estimation of models with truncated response variables using the STLS estimator

lt, for estimation of models with truncated response variables using the LT estimator

truncreg for estimating models with truncated response variables by maximum likelihood, assuming Gaussian errors

## Examples

```
####################################
#          Simulated data          #
####################################
#Simulated data (asymmetrically distributed errors):
n <- 1000
set.seed(319993)
x1 <- runif(n, 0, 10)
x2 <- runif(n, 0, 10)
x3 <- runif(n, -5, 5)
eps <- rexp(n, 0.2) - 5
y <- 2 - 2*x1 + x2 + 2*x3 + eps
d <- data.frame(y = y, x1 = x1, x2 = x2, x3 = x3)

##Use a truncated subsample
dtrunc <- subset(d, y > 0)

##Use qme to consistently estimate the slope parameters
qme.sim <- qme(y ~ x1 + x2 + x3, dtrunc, point = 0, direction = "left",
              cval = "ml", const = 1, beta = "ml", covar = FALSE)


summary(qme.sim)

####################################
#  Example using data "PM10trunc"  #
####################################

data(PM10trunc)

qmepm10 <- qme(PM10 ~ cars + temp + wind.speed + temp.diff + wind.dir + hour + day,
              data = PM10trunc, point = 2, control = list(maxit=4500))

summary(qmepm10)
```

## qme-class *An S4 class for objects from the qme function*

### Description

An S4 class for objects from the qme function

### Slots

`call` The matched call

`coefficients` A matrix

`startcoef` A matrix

`cval` A data frame

`value` Numeric

`counts` Integer

`convergence` Integer

`message` A character vector

`residuals` A matrix

`fitted.values` A matrix

`df.residual` Integer

`covariance` A matrix

`bootrepl` A matrix

## qme.fit *Function for fitting QME*

### Description

Function to find QME estimates of the regression coefficients for regression models with truncated response variables. Uses optim. Intended to be called through qme, not on its own, since qme also transforms data into the correct form etc.

### Usage

```
qme.fit(formula, mf, point, direction, bet, cv, ...)
```

## Arguments

| | |
|---|---|
| formula | a symbolic description of the model to be estimated |
| mf | the model.frame containing the variables to be used when fitting the model. qme transforms the model frame to the correct form before calling qme.fit. If qme.fit is called on its own the model frame needs to be transformed manually. |
| point | the point of truncation |
| direction | the direction of truncation |
| bet | starting values to be used by optim. Column matrix with p rows. |
| cv | threshold value to be used, number or numeric vector of length 1. (See qme, argument cval, for more information). |
| ... | additional arguments to be passed to optim (see the documentation for qme for further details). |

## Value

A list with components:

| | |
|---|---|
| startcoef | the starting values of the regression coefficients used by optim |
| coefficients | the named vector of coefficients |
| counts | number of iterations used by optim. See the documentation for optim for further details |
| convergence | from optim. An integer code. 0 indicates successful completion. Possible error codes are<br>1 indicating that the iteration limit maxit had been reached.<br>10 indicating degeneracy of the Nelder–Mead simplex. |
| message | from optim. A character string giving any additional information returned by the optimizer, or NULL. |
| residuals | the residuals of the model |
| df.residual | the residual degrees of freedom |
| fitted.values | the fitted values |

## Author(s)

Anita Lindmark and Maria Karlsson

## See Also

qme

## Examples

```
require(utils)

##Model frame
n <- 1000
x <- rnorm(n,0,2)
```

```
y <- 2+x+4*rnorm(n)

d <- data.frame(y=y, x=x)
dl0 <- subset(d, y>0)
mf <- model.frame(y~x, data=dl0)

##Starting values and threshold value
lmmod <- lm(data=mf)
bet <- lmmod$coef
bet <- matrix(bet)
cv <- sqrt(deviance(lmmod)/df.residual(lmmod))

str(qme. <- qme.fit(y~x,mf,point=0,direction="left",bet,cv))
```

---

`residuals.lt` *Function to extract model residuals from objects of class* `"lt"`

---

## Description

Function to extract model residuals from objects of class `"lt"`

## Usage

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

## Arguments

| | |
|---|---|
| `object` | object of class `"lt"` |
| `...` | additional arguments |

---

`residuals.qme` *Function to extract model residuals from objects of class* `"stls"`

---

## Description

Function to extract model residuals from objects of class `"stls"`

## Usage

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

## Arguments

| | |
|---|---|
| `object` | object of class `"stls"` |
| `...` | additional arguments |

## residuals.stls *Function to extract model residuals from objects of class "stls"*

### Description

Function to extract model residuals from objects of class "stls"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "stls" |
| ... | additional arguments |

## stls *Estimation of truncated regression models using the Symmetrically Trimmed Least Squares (STLS) estimator*

### Description

Function for estimation of linear regression models with truncated response variables (fixed truncation point), using the STLS estimator (Powell 1986)

### Usage

```
stls(
  formula,
  data,
  point = 0,
  direction = "left",
  beta = "ml",
  covar = FALSE,
  na.action,
  ...
)
```

## Arguments

| | |
|---|---|
| formula | a symbolic description of the model to be estimated |
| data | an optional data frame |
| point | the value of truncation (the default is 0) |
| direction | the direction of truncation, either "left" (the default) or "right" |
| beta | the method of determining the starting values of the regression coefficients (See Details for more information):<br>• The default method is "ml", meaning that the estimated regression coefficients from fitting a maximum likelihood model for truncated regression, assuming Gaussian errors, are used. The maximum likelihood model is fitted using truncreg.<br>• Method "ols" means that the estimated regression coefficients from fitting a linear model with lm are used.<br>• The third option is to manually provide starting values as either a vector, column matrix or row matrix. |
| covar | logical. Indicates whether or not the covariance matrix should be estimated. If TRUE the covariance matrix is estimated using bootstrap. The default number of replicates is 2000 but this can be adjusted (see argument ...). However, since the bootstrap procedure is time-consuming the default is covar=FALSE. |
| na.action | a function which indicates what should happen when the data contain NAs. |
| ... | additional arguments. For stls the number of bootstrap replicates can be adjusted by setting R=the desired number of replicates. Also the control argument of optim can be set by control=list() (for more information, see Details). |

## Details

Uses optim ("Nelder–Mead" method) to minimize the objective function described in Powell (1986) wrt the vector of regression coefficients in order to find the STLS estimates (see Karlsson and Lindmark 2014 for more detailed information and background). The maximum number of iterations is set at 2000, but this can be adjusted by setting control=list(maxit=...) (for more information see the documentation for optim).

As the starting values of the regression coefficients can have a great impact on the result of the minimization it is recommended to use one of the methods for generating these rather than supplying the values manually (unless one is confident that one has a good idea of what the starting values should be).

## Value

stls returns an object of class "stls".

The function summary prints a summary of the results, including two types of confidence intervals (normal approximation and percentile method). The generic accessor functions coef, fitted, residuals and vcov extract various useful features of the value returned by stls

An object of class "stls", a list with elements:

| | |
|---|---|
| coefficients | the named vector of coefficients |

| | |
|---|---|
| startcoef | the starting values of the regression coefficients used by optim |
| value | the value of the objective function corresponding to coefficients |
| counts | number of iterations used by optim. See the documentation for optim for further details |
| convergence | from optim. An integer code. 0 indicates successful completion. Possible error codes are<br>1 indicating that the iteration limit maxit had been reached.<br>10 indicating degeneracy of the Nelder–Mead simplex. |
| message | from optim. A character string giving any additional information returned by the optimizer, or NULL. |
| residuals | the residuals of the model |
| fitted.values | the fitted values |
| df.residual | the residual degrees of freedom |
| call | the matched call |
| covariance | if covar = TRUE, the estimated covariance matrix |
| R | if covar = TRUE, the number of bootstrap replicates |
| bootrepl | if covar = TRUE, the bootstrap replicates |

## Author(s)

Anita Lindmark and Maria Karlsson

## References

Karlsson, M., Lindmark, A. (2014) truncSP: An R Package for Estimation of Semi-Parametric Truncated Linear Regression Models, *Journal of Statistical Software*, **57(14)**, pp 1–19, https://www.jstatsoft.org/article/view/v057i14

Powell, J. (1986) Symmetrically Trimmed Least Squares Estimation for Tobit Models, *Econometrika*, **54(6)**, pp 1435–1460

## See Also

stls.fit, the function that does the actual fitting

qme, for estimation of models with truncated response variables using the QME estimator

lt, for estimation of models with truncated response variables using the LT estimator

truncreg for estimating models with truncated response variables by maximum likelihood, assuming Gaussian errors

## Examples

```
####################################
#          Simulated data          #
####################################
##Simulated data
n <- 1000
set.seed(319993)
x1 <- runif(n, 0, 10)
x2 <- runif(n, 0, 10)
x3 <- runif(n, -5, 5)
y <- 1 - 2*x1 + x2 + 2*x3 + rnorm(n,0,2)
d <- data.frame(y = y, x1 = x1, x2 = x2, x3 = x3)

##Use a truncated subsample
dtrunc <- subset(d, y > 0)

##Use stls to estimate the model
stls.sim <- stls(y ~ x1 + x2 + x3, dtrunc, point = 0,
                 direction = "left", beta = "ml", covar = FALSE)

summary(stls.sim)

####################################
#  Example using data "PM10trunc"  #
####################################

data(PM10trunc)

stlspm10 <- stls(PM10 ~ cars + temp + wind.speed + temp.diff + wind.dir + hour + day,
                data = PM10trunc, point = 2)

summary(stlspm10)
```

---

`stls-class` *An S4 class for objects from the* `stls` *function*

---

## Description

An S4 class for objects from the `stls` function

## Slots

`call` The matched call

`coefficients` A matrix

`startcoef` A matrix

`value` Numeric

`counts` Integer

`convergence` Integer

`message` A character vector

`residuals` A matrix

`fitted.values` A matrix

`df.residual` Integer

`covariance` A matrix

`bootrepl` A matrix

---

`stls.fit` *Function for fitting STLS*

---

## Description

Function that utilizes `optim` to find STLS estimates of the regression coefficients for regression models with truncated response variables. Intended to be called through `stls`, not on its own, since `stls` also transforms data into the correct form etc.

## Usage

```
stls.fit(formula, mf, point, direction, bet, ...)
```

## Arguments

| | |
|---|---|
| `formula` | a symbolic description of the model to be estimated |
| `mf` | the `model.frame` containing the variables to be used when fitting the model. `stls` transforms the model frame to the correct form before calling `stls.fit`. If `stls.fit` is called on its own the model frame needs to be transformed manually. |
| `point` | the point of truncation |
| `direction` | the direction of truncation |
| `bet` | starting values to be used by `optim`. Column matrix with p rows. |
| `...` | additional arguments to be passed to `optim` (see the documentation for `stls` for further details). |

## Value

A list with components:

| | |
|---|---|
| `startcoef` | the starting values of the regression coefficients used by `optim` |
| `coefficients` | the named vector of coefficients |
| `counts` | number of iterations used by `optim`. See the documentation for `optim` for further details |

| | |
|---|---|
| convergence | from optim. An integer code. 0 indicates successful completion. Possible error codes are<br>1 indicating that the iteration limit maxit had been reached.<br>10 indicating degeneracy of the Nelder–Mead simplex. |
| message | from optim. A character string giving any additional information returned by the optimizer, or NULL. |
| residuals | the residuals of the model |
| df.residual | the residual degrees of freedom |
| fitted.values | the fitted values |

## Author(s)

Anita Lindmark and Maria Karlsson

## See Also

stls

## Examples

```
require(utils)

##Model frame
n <- 1000
x <- rnorm(n,0,2)
y <- 2+x+4*rnorm(n)

d <- data.frame(y=y, x=x)
dl0 <- subset(d, y>0)
mf <- model.frame(y~x, data=dl0)

##Starting values
lmmod <- lm(data=mf)
bet <- lmmod$coef
bet <- matrix(bet)

str(stls. <- stls.fit(y~x,mf,point=0,direction="left",bet))
```

---

summary.lt *Summary function for objects of class "lt"*

---

## Description

Summary function for objects of class "lt"

## Usage

```
## S3 method for class 'lt'
summary(object, level = 0.95, ...)
```

## Arguments

| | |
|---|---|
| object | object of class "lt" |
| level | confidence level. A number between 0 and 1. The default value is 0.95. |
| ... | additional arguments |

## Value

A list with values:

| | |
|---|---|
| coefficients | the named vector of coefficients |
| cvalues | information about the thresholds used. The method and constant used and the resulting lower and upper threshold values. |
| counts | number of iterations used by optim. See the documentation for optim for further details |
| call | the matched call |
| covariance | if covar = TRUE, the estimated covariance matrix |
| level | confidence level |
| confint | confidence intervals, based on normal distribution |
| bootconfint | bootstrap confidence intervals, percentile method |

---

# summary.lt-class *An S4 class for objects from the* summary.lt *function*

---

## Description

An S4 class for objects from the summary.lt function

## Slots

call The matched call

coefficients A matrix

startcoef A matrix

cvalues A data frame

value Numeric

counts Integer

convergence Integer

message A character vector

`residuals` A matrix

`fitted.values` A matrix

`df.residual` Integer

`covariance` A matrix

`bootrepl` A matrix

`level` Numeric

`confint` A matrix

`bootconfint` A matrix

---

`summary.qme` *Summary function for objects of class* `"qme"`

---

## Description

Summary function for objects of class `"qme"`

## Usage

```
## S3 method for class 'qme'
summary(object, level = 0.95, ...)
```

## Arguments

| | |
|---|---|
| `object` | object of class `"qme"` |
| `level` | confidence level. A number between 0 and 1. The default value is `0.95`. |
| `...` | additional arguments |

## Value

A list with values:

| | |
|---|---|
| `coefficients` | the named vector of coefficients |
| `cval` | information about the threshold used. The method and constant used and the resulting lower and upper threshold value. |
| `counts` | number of iterations used by `optim`. See the documentation for `optim` for further details |
| `call` | the matched call |
| `covariance` | if `covar = TRUE`, the estimated covariance matrix |
| `level` | confidence level |
| `confint` | confidence intervals, based on normal distribution |
| `bootconfint` | bootstrap confidence intervals, percentile method |

## summary.qme-class *An S4 class for objects from the* summary.qme *function*

### Description

An S4 class for objects from the summary.qme function

### Slots

call The matched call

coefficients A matrix

startcoef A matrix

cval A data frame

value Numeric

counts Integer

convergence Integer

message A character vector

residuals A matrix

fitted.values A matrix

df.residual Integer

covariance A matrix

bootrepl A matrix

level Numeric

confint A matrix

bootconfint A matrix

## summary.stls *Summary function for objects of class* "stls"

### Description

Summary function for objects of class "stls"

### Usage

```
## S3 method for class 'stls'
summary(object, level = 0.95, ...)
```

### Arguments

| | |
|---|---|
| object | object of class "stls" |
| level | confidence level. A number between 0 and 1. The default value is 0.95. |
| ... | additional arguments |

### Value

A list with values:

| | |
|---|---|
| coefficients | the named vector of coefficients |
| counts | number of iterations used by optim. See the documentation for optim for further details |
| call | the matched call |
| covariance | if covar = TRUE, the estimated covariance matrix |
| level | confidence level |
| confint | confidence intervals, based on normal distribution |
| bootconfint | bootstrap confidence intervals, percentile method |

---

## summary.stls-class *An S4 class for objects from the summary.stls function*

---

### Description

An S4 class for objects from the summary.stls function

### Slots

call The matched call

coefficients A matrix

startcoef A matrix

value Numeric

counts Integer

convergence Integer

message A character vector

residuals A matrix

fitted.values A matrix

df.residual Integer

covariance A matrix

bootrepl A matrix

level Numeric

confint A matrix

bootconfint A matrix

## vcov.lt — *Function to obtain the variance-covariance matrix for objects of class "lt"*

### Description

Function to obtain the variance-covariance matrix for objects of class "lt"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "lt" |
| ... | additional arguments |

## vcov.qme — *Function to obtain the variance-covariance matrix for objects of class "qme"*

### Description

Function to obtain the variance-covariance matrix for objects of class "qme"

### Usage

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

### Arguments

| | |
|---|---|
| object | object of class "qme" |
| ... | additional arguments |

`vcov.stls` *Function to obtain the variance-covariance matrix for objects of class* `"stls"`

## Description

Function to obtain the variance-covariance matrix for objects of class `"stls"`

## Usage

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

## Arguments

| | |
|---|---|
| `object` | object of class `"stls"` |
| `...` | additional arguments |

# Index