Package ‘quantreg’

February 5, 2022

Title Quantile Regression

Description Estimation and inference methods for models of conditional quantiles:
Linear and nonlinear parametric and non-parametric (total variation penalized) models
for conditional quantiles of a univariate response and several methods for handling
censored survival data. Portfolio selection methods based on expected shortfall
risk are also now included. See Koenker (2006) <doi:10.1017/CBO9780511754098> and

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Density Estimation using Adaptive Kernel method

Description

Usage

\[ akj(x, z =, p =, h = -1, \alpha = 0.5, \kappa = 0.9, \text{iker1} = 0) \]

Arguments

- **x**: points used for centers of kernel assumed to be sorted.
- **z**: points at which density is calculated; defaults to an equispaced sequence covering the range of x.
- **p**: vector of probabilities associated with x's; defaults to 1/n for each x.
- **h**: initial window size (overall); defaults to Silverman’s normal reference.
- **alpha**: a sensitivity parameter that determines the sensitivity of the local bandwidth to variations in the pilot density; defaults to .5.
- **kappa**: constant multiplier for initial (default) window width
- **iker1**: integer kernel indicator: 0 for normal kernel (default) while 1 for Cauchy kernel (dcauchy).

Value

A list structure is with components

- **dens**: the vector of estimated density values \( f(z) \)
- **psi**: a vector of \( \psi = -f'/f \) function values.
- **score**: a vector of score \( \psi' = (f'/f)^2 - f''/f \) function values.
- **h**: same as the input argument h

Note

If the score function values are of interest, the Cauchy kernel may be preferable.

References


Examples

```r
set.seed(1)
x <- c(rnorm(600), 2 + 2*rnorm(400))
xx <- seq(-5, 8, length=200)
z <- akj(x, xx)
plot(xx, z$dens, ylim=range(0,z$dens), type ="l", col=2)
abline(h=0, col="gray", lty=3)
plot(xx, z$psi, type ="l", col=2, main = expression(hat(psi(x))))
plot(xx, z$score, type ="l", col=2,
     main = expression("score " * hat(psi) * "'" * (x)))
```
if(require("nor1mix")) {
  m3 <- norMix(mu = c(-4, 0, 3), sig2 = c(1/3^2, 1, 2^2),
               w = c(.1,.5,.4))
  plot(m3, p.norm = FALSE)
  set.seed(11)
  x <- rnorMix(1000, m3)
  z2 <- akj(x, xx)
  lines(xx, z2$dens, col=2)
  z3 <- akj(x, xx, kappa = 0.5, alpha = 0.88)
  lines(xx, z3$dens, col=3)
}

---

anova.rq

Anova function for quantile regression fits

Description

Compute test statistics for two or more quantile regression fits.

Usage

## S3 method for class 'rq'
anova(object, ..., test = "Wald", joint = TRUE, score =
        "tau", se = "nid", iid = TRUE, R = 200, trim = NULL)

## S3 method for class 'rqs'
anova(object, ..., se = "nid", iid = TRUE, joint = TRUE)

## S3 method for class 'rqlist'
anova(object, ..., test = "Wald", joint = TRUE,
       score = "tau", se = "nid", iid = TRUE, R = 200, trim = NULL)

rq.test.rank(x0, x1, y, v = NULL, score = "wilcoxon", weights = NULL, tau=.5,
             iid = TRUE, delta0 = rep(0,NCOL(x1)), omega = 1, trim = NULL, pvalue = "F")

rq.test.anowar(x0,x1,y,tau,R)

## S3 method for class 'anova.rq'
print(x, ...)

Arguments

object, ... objects of class ‘rq’, originating from a call to ‘rq’. or a single object of class
rqs, originating from a call to ‘rq’ with multiple taus specified.

test A character string specifying the test statistic to use. Can be either ‘Wald’ or
‘rank’.

joint A logical flag indicating whether tests of equality of slopes should be done as
joint tests on all slope parameters, or whether (when joint = FALSE) separate
tests on each of the slope parameters should be reported. This option applies
only to the tests of equality of slopes in the case that estimated models corre-
spend to distinct taus.
**score**  
A character string specifying the score function to use, only needed or applicable for the ‘rank’ form of the test.

**trim**  
optional trimming proportion parameter(s) – only applicable for the Wilcoxon score function – when one value is provided there is symmetric trimming of the score integral to the interval \((\text{trim},1-\text{trim})\), when there are two values provided, then the trimming restricts the integration to \((\text{trim}[1],\text{trim}[2])\).

**x**  
objects of class `summary.rq`, originating from a call to `summary`.

**x0**  
design matrix for the null component of the rank and anowar tests.

**x1**  
design matrix for the alternative component of the rank and anowar tests.

**y**  
response vector for the alternative component of the rank and anowar tests.

**v**  
optional rq process fit

**se**  
method for computing standard errors, either "nid" or "ker", note that "boot" cannot be used for testing homogeneity of slopes.

**tau**  
quantile of interest for quantile specific forms of testing.

**iid**  
logical flag for quantile specific forms of testing, if TRUE the test presumes that the conditional densities take identical values, if it is FALSE then local densities are estimated and used, see Koenker(2005) p. 90.

**delta0**  
vector of hypothetical parameter values under test, typically zeros but can be specified to be nonzero in cases where simulations are being used to evaluate the validity of the non-central chisquare theory of the test.

**omega**  
value to be used for the score and F dependent constant appearing in the non-centrality parameter, this is only needed/useful when delta0 is specified to be non-zero. In the usual Wilcoxon (untrimmed) case this value is the integral the squared density.

**pvalue**  
type of p-value to be used, by default a pseudo F-statistic is produced and the corresponding F p-value is computed, otherwise the more conventional chisquared p-values are reported.

**weights**  
optional weight vector to be used for fitting.

**R**  
The number of resampling replications for the anowar form of the test, used to estimate the reference distribution for the test statistic.

**Details**

There are two (as yet) distinct forms of the test. In the first the fitted objects all have the same specified quantile (tau) and the intent is to test the hypothesis that smaller models are adequate relative to the largest specified model. In the second form of the test the linear predictor of the fits are all the same, but the specified quantiles (taus) are different.

In the former case there are three options for the argument ‘test’, by default a Wald test is computed as in Bassett and Koenker (1982). If `test = 'anowar'` is specified then the test is based on the procedure suggested in Chen, Ying, Zhang and Zhao (2008); the test is based on the difference in the QR objective functions at the restricted and unrestricted models with a reference distribution computed by simulation. The p-value of this form of the test is produced by fitting a density to the simulation values forming the reference distribution using the `logspline` function from the `logspline` package. The acronym anowar stands for analysis of weighted absolute residuals. If
test='rank' is specified, then a rank test statistic is computed as described in Gutenbrunner, Jureckova, Koenker and Portnoy (1993). In the latter case one can also specify a form for the score function of the rank test, by default the Wilcoxon score is used, the other options are score='sign' for median (sign) scores, or score='normal' for normal (van der Waerden) scores. A fourth option is score='tau' which is a generalization of median scores to an arbitrary quantile, in this case the quantile is assumed to be the one associated with the fitting of the specified objects. The computing of the rank form of the test is carried out in the \texttt{rq.test.rank} function, see \texttt{ranks} for further details on the score function options. The Wald form of the test is local in sense that the null hypothesis asserts only that a subset of the covariates are "insignificant" at the specified quantile of interest. The rank form of the test can also be used to test the global hypothesis that a subset is "insignificant" over an entire range of quantiles. The use of the score function score = "tau" restricts the rank test to the local hypothesis of the Wald test.

In the latter case the hypothesis of interest is that the slope coefficients of the models are identical. The test statistic is a variant of the Wald test described in Koenker and Bassett (1982).

By default, both forms of the tests return an F-like statistic in the sense that the an asymptotically Chi-squared statistic is divided by its degrees of freedom and the reported p-value is computed for an F statistic based on the numerator degrees of freedom equal to the rank of the null hypothesis and the denominator degrees of freedom is taken to be the sample size minus the number of parameters of the maintained model.

\textbf{Value}

An object of class ""anova"" inheriting from class ""data.frame"".

\textbf{WARNING}

An attempt to verify that the models are nested in the first form of the test is made, but this relies on checking set inclusion of the list of variable names and is subject to obvious ambiguities when variable names are generic. The comparison between two or more models will only be valid if they are fitted to the same dataset. This may be a problem if there are missing values and R’s default of 'na.action = na.omit’ is used. The rank version of the nested model tests involves computing the entire regression quantile process using parametric linear programming and thus can be rather slow and memory intensive on problems with more than several thousand observations.

\textbf{Author(s)}

Roger Koenker

\textbf{References}


See Also

The model fitting function \texttt{rq}, and the functions for testing hypothesis on the entire quantile regression process \texttt{KhmaladzeTest}. For further details on the rank tests see \texttt{ranks}.

Examples

```r
data(barro)
fit0 <- \texttt{rq(y.net ~ lgdp2 + fse2 + gedy2, data = barro)}
fit1 <- \texttt{rq(y.net ~ lgdp2 + fse2 + gedy2 + Iy2 + gcony2, data = barro)}
fit2 <- \texttt{rq(y.net ~ lgdp2 + fse2 + gedy2 + Iy2 + gcony2, data = barro,tau=.75)}
fit3 <- \texttt{rq(y.net ~ lgdp2 + fse2 + gedy2 + Iy2 + gcony2, data = barro,tau=.25)}
anova(fit1,fit0)
anova(fit1,fit2,fit3)
anova(fit1,fit2,fit3,joint=FALSE)
# Alternatively fitting can be done in one call:
fit <- \texttt{rq(y.net ~ lgdp2 + fse2 + gedy2 + Iy2 + gcony2,
               method = "fn", tau = 1:4/5, data = barro)}
```

---

**bandwidth.rq**

\textit{bandwidth selection for rq functions}

\textbf{Description}

function to compute bandwidth for sparsity estimation

\textbf{Usage}

\texttt{bandwidth.rq(p, n, hs=TRUE, alpha=0.05)}

\textbf{Arguments}

- \texttt{p} quantile(s) of interest
- \texttt{n} sample size
- \texttt{hs} flag for hall-sheather method
- \texttt{alpha} alpha level for intended confidence intervals

\textbf{Details}

If \texttt{hs=TRUE} (default) then the Hall-Sheather(1988) rule $O(n^{-1/3})$ is used, if \texttt{hs=FALSE} then the Bofinger $O(n^{-1/5})$ is used.

\textbf{Value}

returns a vector of bandwidths corresponding to the argument \texttt{p}.
Author(s)
Roger Koenker rkoenker@uiuc.edu

References
Hall and Sheather(1988, JRSS(B)), Bofinger (1975, Aus. J. Stat)

Description
Version of the Barro Growth Data used in Koenker and Machado(1999). This is a regression data set consisting of 161 observations on determinants of cross country GDP growth rates. There are 13 covariates with dimnames corresponding to the original Barro and Lee source. See https://www.nber.org/pub/barro.lee/. The first 71 observations are on the period 1965-75, remainder on 1987-85.

Usage
data(barro)

Format
A data frame containing 161 observations on 14 variables:

[.1] "Annual Change Per Capita GDP"
[.2] "Initial Per Capita GDP"
[.3] "Male Secondary Education"
[.4] "Female Secondary Education"
[.5] "Female Higher Education"
[.6] "Male Higher Education"
[.7] "Life Expectancy"
[.8] "Human Capital"
[.9] "Education/GDP"
[.10] "Investment/GDP"
[.11] "Public Consumption/GDP"
[.12] "Black Market Premium"
[.13] "Political Instability"
[.14] "Growth Rate Terms Trade"

References
boot.crq

Description

Functions used to estimated standard errors, confidence intervals and tests of hypotheses for censored quantile regression models using the Portnoy and Peng-Huang methods.

Usage

boot.crq(x, y, c, taus, method, ctype = "right", R = 100, mboot, bmethod = "jack", ...)

Arguments

x        The regression design matrix
y        The regression response vector
c        The censoring indicator
taus     The quantiles of interest
method   The fitting method: either "P" for Portnoy or "PH" for Peng and Huang.
cstyle   Either "right" or "left"
R        The number of bootstrap replications
bmethod  The bootstrap method to be employed. There are (as yet) three options: method = "jack" uses the delete-d jackknife method described by Portnoy (2013), method = "xy-pair" uses the xy-pair method, that is the usual multinomial resampling of xy-pairs, while method = "Bose" uses the Bose and Chatterjee (2003) weighted resampling method with exponential weights. The "jack" method is now the default.
mboot    Optional argument for the bootstrap method: for bmethod = "jack" it specifies the number, d, of the delete-d jackknife, for method = "xy-pair" it specifies the size of the bootstrap samples, that permits subsampling (m out of n) bootstrap. By default in the former case it is set to 2 [sqrt(n)], for the latter the default is n. Obviously mboot should be substantially larger than the column dimension of x, and should be less than the sample size in both cases.
...      Optional further arguments to control bootstrapping

Details

There are several refinements that are still unimplemented. Percentile methods should be incorporated, and extensions of the methods to be used in anova.rq should be made. Note that bootstrapping for the Powell method "Powell" is done via boot.rq. For problems with n > 3000 a message is printed indicated progress in the resampling.
Value
A matrix of dimension R by p is returned with the R resampled estimates of the vector of quantile regression parameters. When mofn < n for the "xy" method this matrix has been deflated by the factor sqrt(m/n).

Author(s)
Roger Koenker

References

See Also
summary.crq

Description
These functions can be used to construct standard errors, confidence intervals and tests of hypotheses regarding quantile regression models.

Usage
boot.rq(x, y, tau = 0.5, R = 200, bsmethod = "xy", mofn = length(y), coef = NULL, blbn = NULL, cluster = NULL, U = NULL, ...)

Arguments
- **x**: The regression design matrix
- **y**: The regression response vector
- **tau**: The quantile of interest
- **R**: The number of bootstrap replications
- **bsmethod**: The method to be employed. There are (as yet) five options: method = "xy" uses the xy-pair method, and method = "pwy" uses the method of Parzen, Wei and Ying (1994) method = "mcmb" uses the Markov chain marginal bootstrap of He and Hu (2002) and Kocherginsky, He and Mu (2003). The fourth method = "wxy" uses the generalized bootstrap of Bose and Chatterjee (2003) with unit exponential weights, see also Chamberlain and Imbens (2003). The fifth method "wild" uses the wild bootstrap method proposed by Feng, He and Hu (2011).
mofn  optional argument for the bootstrap method "xy" that permits subsampling (m out of n) bootstrap. Obviously mofn should be substantially larger than the column dimension of x, and should be less than the sample size.

coef  coefficients from initial fitted object

blbn  original sample size for the BLB model

cluster  If non-NULL this argument should specify cluster id numbers for each observation, in which case the clustered version of the bootstrap based on the proposal of Hagemann (2017). If present bsmethod is set to set to "cluster". If this option is used and the fitting method for the original call was "sfn" then the bootstrapping will be carried out with the "sfn" as well. This is usually substantially quicker than the older version which employed the "br" variant of the simplex method. Use of "sfn" also applies to the "pwy" method when the original fitting was done with "sfn". Finally, if na.action = "omit" and length(object$na.action) > 0 then these elements are also removed from the cluster variable. Consequently, the length of the cluster variable should always be the same as the length of the original response variable before any na.action takes place.

U  If non-NULL this argument should specify an array of indices or gradient evaluations to be used by the corresponding bootstrap method as specified by bsmethod. This is NOT intended as a user specified input, instead it is specified in summary.rqs to ensure that bootstrap samples for multiple taus use the same realizations of the random sampling.

...  Optional arguments to control bootstrapping

Details

There are several refinements that are still unimplemented. Percentile methods should be incorporated, and extensions of the methods to be used in anova.rq should be made. And more flexibility about what algorithm is used would also be good.

Value

A list consisting of two elements: A matrix B of dimension R by p is returned with the R resampled estimates of the vector of quantile regression parameters. When mofn < n for the "xy" method this matrix has been deflated by the factor sqrt(m/n). A matrix U of sampled indices (for bsmethod in c("xy","wxy")) or gradient evaluations (for bsmethod in c("pwy","cluster")) used to generate the bootstrapped realization, and potentially reused for other taus when invoked from summary.rqs.

Author(s)

Roger Koenker (and Xuming He and M. Kocherginsky for the mcmmb code)

References


See Also

summary.rq

Examples

```r
y <- rnorm(50)
x <- matrix(rnorm(100),50)
fit <- rq(y~x,tau = .4)
summary(fit, se = "boot", bsmethod= "xy")
summary(fit, se = "boot", bsmethod= "pwy")
#summary(fit, se = "boot", bsmethod= "mcmb")
```

---

**boot.rq.pwxy**  
*Preprocessing weighted bootstrap method*

**Description**

Bootstrap method exploiting preprocessing strategy to reduce computation time for large problem. In contrast to `boot.rq.pxy` which uses the classical multinomial sampling scheme and is coded in R, this uses the exponentially weighted bootstrap scheme and is coded in fortran and consequently is considerably faster in larger problems.

**Usage**

`boot.rq.pwxy(x, y, tau, coef, R = 200, m0 = NULL, eps = 1e-06, ...)`

**Arguments**

- **x**: Design matrix
- **y**: response vector
- **tau**: quantile of interest
- **coef**: point estimate of fitted object
The number of bootstrap replications desired.

$m_0$ constant to determine initial sample size, defaults to $\sqrt{n*p}$ but could use some further tuning...

$\epsilon$ tolerance for convergence of fitting algorithm

... other parameters not yet envisaged.

Details

The fortran implementation is quite similar to the R code for `boot.rq.pxy` except that there is no multinomial sampling. Instead $\text{rexp}(n)$ weights are used.

Value

returns a list with elements:

1. coefficients a matrix of dimension $\text{ncol}(x)$ by $R$
2. nit a 5 by $m$ matrix of iteration counts
3. info an $m$-vector of convergence flags

Author(s)

Blaise Melly and Roger Koenker

References


See Also

`boot.rq.pxy`

Description

Bootstrap method exploiting preprocessing strategy to reduce computation time for large problem.

Usage

`boot.rq.pxy(x, y, s, tau = 0.5, coef, method = "fn", Mm.factor = 3)`
Arguments

- **x**: Design matrix
- **y**: response vector
- **s**: matrix of multinomial draws for xy bootstrap
- **tau**: quantile of interest
- **coef**: point estimate of fitted object
- **method**: fitting method for bootstrap
- **Mm.factor**: constant to determine initial sample size

Details

See references for further details.

Value

Returns matrix of bootstrap estimates.

Author(s)

Blaise Melly and Roger Koenker

References


See Also

rq.fit.ppro

---

**Bosco**

* Boscovich Data

Description

Boscovich data used to estimate the ellipticity of the earth. There are five measurements of the arc length of one degree of latitude taken at 5 different latitudes. See Koenker (2005) for further details and references.

Usage

data(Bosco)
Format

A data frame containing 5 observations on 2 variables

x  sine squared of latitude measured in degrees
y  arc length of one degree of latitude measured in toise - 56,700, one toise approximately equals 1.95 meters.

References


Examples

data(Bosco)
plot(0:10/10,0:10*100,xlab="sin^2(latitude)",
     ylab="arc-length of 1 degree of latitude",type="n")
points(Bosco)
text(Bosco, pos = 3, rownames(Bosco))
z <- rq(y ~ x, tau = -1, data = Bosco)
title("Boscovitch Ellipticity of the Earth Example")
xb <- c(.85,.9,.6,.6)
yb <- c(400,600,450,600)
for(i in 1:4){
    abline(c(z$sol[4:5,i]))
    interval <- paste("t=(",format(round(z$sol[1,i],2)),",",
                       format(round(z$sol[1,i+1],2)),")",delim="")
    text(xb[i],yb[i],interval)
}

CobarOre  Cobar Ore data

Description

Cobar Ore data from Green and Silverman (1994). The data consists of measurements on the "true width" of an ore-bearing rock layer from a mine in Cobar, Australia.

Usage

data(CobarOre)

Format

A data frame with 38 observations on the following 3 variables.

x  x-coordinate of location of mine site
y  y-coordinate of location of mine site
z  ore thickness
Source

Examples
```r
data(CobarOre)
plot(CobarOre)
```

### combos

**Ordered Combinations**

#### Description
All m combinations of the first n integers taken p at a time are computed and return as an p by m matrix. The columns of the matrix are ordered so that adjacent columns differ by only one element. This is just a reordered version of combn in base R, but the ordering is useful for some applications.

#### Usage
`combos(n,p)`

#### Arguments
- `n` The n in n choose p
- `p` The p in n choose p

#### Value
- a matrix of dimension p by choose(n,p)

#### Note
Implementation based on a Pascal algorithm of Limin Xiang and Kazuo Ushijima (2001) translated to ratfor for R. If you have `rgl` installed you might try `demo("combos")` for a visual impression of how this works.

#### References

#### Examples
```r
H <- combos(20,3)
```
Description

Critical values for uniform confidence bands for rqss fitting

Usage

critval(kappa, alpha = 0.05, rdf = 0)

Arguments

kappa  length of the tube
alpha  desired non-coverage of the band, intended coverage is 1 - alpha
rdf  "residual" degrees of freedom of the fitted object. If rdf=0 then the Gaussian version of the critical value is computed, otherwise the value is based on standard Student t theory.

Details

The Hotelling tube approach to inference has a long and illustrious history. See Johansen and Johnstone (1989) for an overview. The implementation here is based on Sun and Loader (1994) and Loader’s locfit package, although a simpler root finding approach is substituted for the iterative method used there. At this stage, only univariate bands may be constructed.

Value

A scalar critical value that acts as a multiplier for the uniform confidence band construction.

References


See Also

plot.rqss
**Description**

Fits a conditional quantile regression model for censored data. There are three distinct methods: the first is the fixed censoring method of Powell (1986) as implemented by Fitzenberger (1996), the second is the random censoring method of Portnoy (2003). The third method is based on Peng and Huang (2008).

**Usage**

```r
crq(formula, taus, data, subset, weights, na.action,
    method = c("Powell", "Portnoy", "Portnoy2", "PengHuang"), contrasts = NULL, ...)
crq.fit.pow(x, y, yc, tau=0.5, weights=NULL, start, left=TRUE, maxit = 500)
crq.fit.pen(x, y, cens, weights=NULL, grid, ctype = "right")
crq.fit.por(x, y, cens, weights=NULL, grid, ctype = "right")
crq.fit.por2(x, y, cens, weights=NULL, grid, ctype = "right")
Curv(y, yc, ctype=c("left","right"))
## S3 method for class 'crq'
print(x, ...)
## S3 method for class 'crq'
print(x, ...)
## S3 method for class 'crq'
predict(object, newdata, ...)
## S3 method for class 'crqs'
predict(object, newdata, type = NULL, ...)
## S3 method for class 'crq'
coef(object,taus = 1:4/5,...)
```

**Arguments**

- `formula`: A formula object, with the response on the left of the `~` operator, and the terms on the right. The response must be a `Surv` object as returned by either the `Curv` or `Surv` function. For the Powell method, the `Surv` object should be created by `Curv` and have arguments (event time, censoring time,type), where "type" can take values either "left" or "right". The default (for historical reasons) for type in this case is "left". For the Portnoy and Peng and Huang methods the `Surv` should be created with the usual `Surv` function and have (event time, censoring indicator).
- `y`: The event time.
- `newdata`: An optional data frame in which to look for variables with which to predict. If omitted, the fitted values are used.
- `grid`: A vector of taus on which the quantile process should be evaluated. This should be monotonic, and take values in (0,1). For the "Portnoy" method, grid = "pivot" computes the full solution for all distinct taus. The "Portnoy" method also enforces an equally spaced grid, see the code for details.
x

An object of class crq or crq.

object

An object of class crq or crq.

yc

The censoring times for the "Powell" method.

c_type

Censoring type: for the "Powell" method, used in Curv, by default "left". If you don't like "left", maybe you will like "right". Note that for fixed censoring assumed in the "Powell" method, censoring times yc must be provided for all observations and the event times y must satisfy the (respective) inequality constraints. For the Portnoy and Peng-Huang methods ctype is determined by the specification of the response as specified in Surv.

type

specifies either "left" or "right" as the form of censoring in the Surv function for the "Portnoy" and "PengHuang" methods.

cen

The censoring indicator for the "Portnoy" and "PengHuang" methods.

maxit

Maximum number of iterations allowed for the "Powell" methods.

start

The starting value for the coefs for the "Powell" method. Because the Fitzenberger algorithm stops when it achieves a local minimum of the Powell objective function, the starting value acts as an a priori "preferred point". This is advantageous in some instances since the global Powell solution can be quite extreme. By default the starting value is the "naive rq" solution that treats all the censored observations as uncensored. If start is equal to "global" then an attempt is made to compute to global optimum of the Powell objective. This entails an exhaustive evaluation of all n choose p distinct basic solution so is rather impractical for moderately large problems. Otherwise, the starting value can specify a set of p indices from 1:n defining an initial basic solution, or it may specify a p-vector of initial regression coefficients. In the latter case the initial basic solution is the one closest to the specified parameter vector.

left

A logical indicator for left censoring for the "Powell" method.

taus

The quantile(s) at which the model is to be estimated.

tau

The quantile at which the model is to be estimated.

data

A data.frame in which to interpret the variables named in the ‘formula’, in the ‘subset’, and the ‘weights’ argument.

subset

an optional vector specifying a subset of observations to be used in the fitting process.

weights

vector of observation weights; if supplied, the algorithm fits to minimize the sum of the weights multiplied into the absolute residuals. The length of weights vector must be the same as the number of observations. The weights must be nonnegative and it is strongly recommended that they be strictly positive, since zero weights are ambiguous.

na.action

a function to filter missing data. This is applied to the model.frame after any subset argument has been used. The default (with 'na.fail') is to create an error if any missing values are found. A possible alternative is 'na.omit', which deletes observations that contain one or more missing values.

method

The method used for fitting. There are currently two options: method "Powell" computes the Powell estimator using the algorithm of Fitzenberger (1996), method "Portnoy" computes the Portnoy (2003) estimator. The method is "PengHuang"
uses the method of Peng and Huang (2007), in this case the variable "grid" can be passed to specify the vector of quantiles at which the solution is desired.

contrasts

a list giving contrasts for some or all of the factors default = 'NULL' appearing in the model formula. The elements of the list should have the same name as the variable and should be either a contrast matrix (specifically, any full-rank matrix with as many rows as there are levels in the factor), or else a function to compute such a matrix given the number of levels.

... additional arguments for the fitting routine, for method "Powell" it may be useful to pass starting values of the regression parameter via the argument "start", while for methods "Portnoy" or "PengHuang" one may wish to specify an alternative to the default grid for evaluating the fit.

Details

The Fitzenberger algorithm uses a variant of the Barrodale and Roberts simplex method. Exploiting the fact that the solution must be characterized by an exact fit to p points when there are p parameters to be estimated, at any trial basic solution it computes the directional derivatives in the 2p distinct directions and choses the direction that (locally) gives steepest descent. It then performs a one-dimensional line search to choose the new basic observation and continues until it reaches a local minumum. By default it starts at the naive rq solution ignoring the censoring; this has the (slight) advantage that the estimator is consequently equivariant to canonical transformations of the data. Since the objective function is no longer convex there can be no guarantee that this produces a global minimum estimate. In small problems exhaustive search over solutions defined by p-element subsets of the n observations can be used, but this quickly becomes impractical for large p and n. This global version of the Powell estimator can be invoked by specifying start = "global". Users interested in this option would be well advised to compute choose(n,p) for their problems before trying it. The method operates by pivoting through this many distinct solutions and choosing the one that gives the minimal Powell objective. The algorithm used for the Portnoy method is described in considerable detail in Portnoy (2003). There is a somewhat simplified version of the Portnoy method that is written in R and iterates over a discrete grid. This version should be considered somewhat experimental at this stage, but it is known to avoid some difficulties with the more complicated fortran version of the algorithm that can occur in degenerate problems. Both the Portnoy and Peng-Huang estimators may be unable to compute estimates of the conditional quantile parameters in the upper tail of distribution. Like the Kaplan-Meier estimator, when censoring is heavy in the upper tail the estimated distribution is defective and quantiles are only estimable on a sub-interval of (0,1). The Peng and Huang estimator can be viewed as a generalization of the Nelson Aalen estimator of the cumulative hazard function, and can be formulated as a variant of the conventional quantile regression dual problem. See Koenker (2008) for further details. This paper is available from the package with vignette("crq").

Value

An object of class crq.

Author(s)

Steve Portnoy and Roger Koenker
References


See Also

summary.crq

Examples

# An artificial Powell example
set.seed(2345)
x <- sqrt(rnorm(100)^2)
y <- -0.5 + x + (.25 + .25*x)*rnorm(100)
plot(x,y, type="n")
s <- (y > 0)
points(x[s],y[s],cex=.9,pch=16)
points(x[!s],y[!s],cex=.9,pch=)
yLatent <- y
y <- pmax(0,y)
yc <- rep(0,100)
for(tau in (1:4)/5){
  f <- crq(Curv(y,yc) ~ x, tau = tau, method = "Pow")
  xs <- sort(x)
  lines(xs,pmax(0,cbind(1,xs)%*%f$coef),col="red")
  abline(rq(y ~ x, tau = tau), col="blue")
  abline(rq(yLatent ~ x, tau = tau), col="green")
}
legend(.15,2.5,c("Naive QR","Censored QR","Omniscient QR"),
       lty=rep(1,3),col=c("blue","red","green"))

# crq example with left censoring
set.seed(1968)
n <- 200
x <- rnorm(n)
y <- 5 + x + rnorm(n)
plot(x,y,cex = .5)
c <- 4 + x + rnorm(n)
d <- (y > c)
points(x[!d],y[!d],cex = .5, col = 2)
f <- crq(survival::Surv(pmax(y,c), d, type = "left") ~ x, method = "Portnoy")
g <- summary(f)
for(i in 1:4) abline(coef(g[[i]])[,1])

---

dither

**Function to randomly perturb a vector**

Description

With malice aforethought, dither adds a specified random perturbation to each element of the input vector, usually employed as a device to mitigate the effect of ties.

Usage

dither(x, type = "symmetric", value = NULL)

Arguments

- **x**
  - x a numeric vector
- **type**
  - type is either 'symmetric' or 'right'
- **value**
  - value scale of dequantization

Details

The function dither operates slightly differently than the function jitter in base R, permitting strictly positive perturbations with the option type = "right" and using somewhat different default schemes for the scale of the perturbation. Dithering the response variable is frequently a useful option in quantile regression fitting to avoid deleterious effects of degenerate solutions. See, e.g. Machado and Santos Silva (2005). For a general introduction and some etymology see the Wikipedia article on "dither". For integer data it is usually advisable to use value = 1. When 'x' is a matrix or array dither treats all elements as a vector but returns an object of the original class.

Value

A dithered version of the input vector 'x'.

Note

Some further generality might be nice, for example something other than uniform noise would be desirable in some circumstances. Note that when dithering you are entering into the "state of sin" that John von Neumann famously attributed to anyone considering "arithmetical methods of producing random digits." If you need to preserve reproducibility, then set.seed is your friend.

Author(s)

R. Koenker
References


See Also

jitter

Examples

```r
x <- rlnorm(40)
y <- rpois(40, exp(.5 + log(x)))
f <- rq(dither(y, type = "right", value = 1) ~ x)
```

dynrq

Dynamic Linear Quantile Regression

Description

Interface to `rq.fit` and `rq.wfit` for fitting dynamic linear quantile regression models. The interface is based very closely on Achim Zeileis's dynlm package. In effect, this is mainly "syntactic sugar" for formula processing, but one should never underestimate the value of good, natural sweeteners.

Usage

```
dynrq(formula, tau = 0.5, data, subset, weights, na.action, method = "br",
      contrasts = NULL, start = NULL, end = NULL, ...)
```

Arguments

- **formula**: a "formula" describing the linear model to be fit. For details see below and `rq`.
- **tau**: the quantile(s) to be estimated, may be vector valued, but all all values must be in (0,1).
- **data**: an optional "data.frame" or time series object (e.g., "ts" or "zoo"), containing the variables in the model. If not found in data, the variables are taken from `environment(formula)`, typically the environment from which `rq` is called.
- **subset**: an optional vector specifying a subset of observations to be used in the fitting process.
- **weights**: an optional vector of weights to be used in the fitting process. If specified, weighted least squares is used with weights `weights` (that is, minimizing `sum(w*e^2)`); otherwise ordinary least squares is used.
- **na.action**: a function which indicates what should happen when the data contain NAs. The default is set by the `na.action` setting of `options`, and is `na.fail` if that is unset. The "factory-fresh" default is `na.omit`. Another possible value is `NULL`, no action. Note, that for time series regression special methods like `na.contiguous`, `na.locf` and `na.approx` are available.
method

the method to be used; for fitting, by default method = "br" is used; method = "fn" employs the interior point (Frisch-Newton) algorithm. The latter is advantageous for problems with sample sizes larger than about 5,000.

contrasts

an optional list. See the contrasts.arg of model.matrix.default.

start

start of the time period which should be used for fitting the model.

end

end of the time period which should be used for fitting the model.

... additional arguments to be passed to the low level regression fitting functions.

Details

The interface and internals of dynrq are very similar to rq, but currently dynrq offers two advantages over the direct use of rq for time series applications of quantile regression: extended formula processing, and preservation of time series attributes. Both features have been shamelessly lifted from Achim Zeileis’s package dynlm.

For specifying the formula of the model to be fitted, there are several functions available which allow for convenient specification of dynamics (via d() and L()) or linear/cyclical patterns (via trend(), season(), and harmon()). These new formula functions require that their arguments are time series objects (i.e., "ts" or "zoo").

Dynamic models: An example would be d(y) ~ L(y,2), where d(x,k) is diff(x,lag = k) and L(x,k) is lag(x,lag = -k), note the difference in sign. The default for k is in both cases 1. For L(), it can also be vector-valued, e.g., y ~ L(y,1:4).

Trends: y ~ trend(y) specifies a linear time trend where (1:n)/freq is used by default as the covariate, n is the number of observations and freq is the frequency of the series (if any, otherwise freq = 1). Alternatively, trend(y, scale = FALSE) would employ 1:n and time(y) would employ the original time index.

Seasonal/cyclical patterns: Seasonal patterns can be specified via season(x, ref = NULL) and harmonic patterns via harmon(x, order = 1). season(x, ref = NULL) creates a factor with levels for each cycle of the season. Using the ref argument, the reference level can be changed from the default first level to any other. harmon(x, order = 1) creates a matrix of regressors corresponding to $cos(2 * o * pi * time(x))$ and $sin(2 * o * pi * time(x))$ where o is chosen from 1:order.

See below for examples.

Another aim of dynrq is to preserve time series properties of the data. Explicit support is currently available for "ts" and "zoo" series. Internally, the data is kept as a "zoo" series and coerced back to "ts" if the original dependent variable was of that class (and no internal NAs were created by the na.action).

See Also

zoo, merge.zoo

Examples

**************************************************
## Dynamic Linear Quantile Regression Models ##
**************************************************
require(zoo)
## multiplicative median SARIMA(1,0,0)(1,0,0)_12 model fitted to UK seatbelt data
uk <- log10(UKDriverDeaths)
dfm <- dynrq(uk ~ L(uk, 1) + L(uk, 12))
dfm

dfm3 <- dynrq(uk ~ L(uk, 1) + L(uk, 12), tau = 1:3/4)
summary(dfm3)
## explicitly set start and end
dfm1 <- dynrq(uk ~ L(uk, 1) + L(uk, 12), start = c(1975, 1), end = c(1982, 12))
## remove lag 12
dfm0 <- update(dfm1, . ~ . - L(uk, 12))
tuk1 <- anova(dfm0, dfm1)
## add seasonal term
dfm2 <- dynrq(uk ~ season(uk), start = c(1975, 1), end = c(1982, 12))
tuk2 <- anova(dfm1, dfm2)
## regression on multiple lags in a single L() call
dfm3 <- dynrq(uk ~ L(uk, c(1, 11, 12)), start = c(1975, 1), end = c(1982, 12))
anova(dfm1, dfm3)

####################################################
## Time Series Decomposition ##
####################################################
## airline data
## Not run:
ap <- log(AirPassengers)
fm <- dynrq(ap ~ trend(ap) + season(ap), tau = 1:4/5)
sfm <- summary(fm)
plot(sfm)
## End(Not run)

## Alternative time trend specifications:
## time(ap) 1949 + (0, 1, ..., 143)/12
## trend(ap) (1, 2, ..., 144)/12
## trend(ap, scale = FALSE) (1, 2, ..., 144)

####################################################
## An Edgeworth (1886) Problem##
####################################################
# DGP
fye <- function(n, m = 20){
a <- rep(0, n)
s <- sample(0:9, m, replace = TRUE)
a[1] <- sum(s)
for(i in 2:n){
    s[sample(1:20,1)] <- sample(0:9,1)
a[i] <- sum(s)
}
zoo::zoo(a)
x <- fye(1000)
f <- dynrq(x ~ L(x,1))
plot(x,cex = .5, col = "red")
lines(fitted(f), col = "blue")

---

**engel**

*Engel Data*

**Description**

Engel food expenditure data used in Koenker and Bassett(1982). This is a regression data set consisting of 235 observations on income and expenditure on food for Belgian working class households.

**Usage**

data(engel)

**Format**

A data frame containing 235 observations on 2 variables

- **income** annual household income in Belgian francs
- **foodexp** annual household food expenditure in Belgian francs

**References**


**Examples**

```r
## See also demo("engel1")
##
data(engel)
plot(engel, log = "xy",
    main = "'engel' data (log - log scale)"
) plot(log10(foodexp) ~ log10(income), data = engel,
    main = "'engel' data (log10 - transformed)"
) taus <- c(.15, .25, .50, .75, .95, .99)
rqs <- as.list(taus)
for(i in seq(along = taus)) {
    rqs[[i]] <- rq(log10(foodexp) ~ log10(income), tau = taus[i], data = engel)
    lines(log10(engel$income), fitted(rqs[[i]]), col = i+1)
}
legend("bottomright", paste("tau = ", taus, inset = .04,
    col = 2:(length(taus)+1), lty=1)
```
FAQ

FAQ and ChangeLog of a package

Description

Show the FAQ or ChangeLog of a specified package

Usage

FAQ(pkg = "quantreg")
ChangeLog(pkg = "quantreg")

Arguments

pkg Package Name

Details

Assumes that the FAQ and/or ChangeLog files exist in the proper "inst" directory.

Value

Has only the side effect of showing the files on the screen.

gasprice

Time Series of US Gasoline Prices

Description


Usage

data("gasprice")

Examples

data(gasprice)
KhmaladzeTest

Tests of Location and Location Scale Shift Hypotheses for Linear Models

Description

Tests of the hypothesis that a linear model specification is of the location shift or location-scale shift form. The tests are based on the Doob-Meyer Martingale transformation approach proposed by Khmaladze(1981) for general goodness of fit problems as adapted to quantile regression by Koenker and Xiao (2002).

Usage

KhmaladzeTest(formula, data = NULL, taus = 1:99/100, nullH = "location", trim = c(0.05, 0.95), h = 1, ...)

Arguments

- formula: a formula specifying the model to fit by rqProcess
- data: a data frame within which to interpret the formula
- taus: An equally spaced grid of points on which to evaluate the quantile regression process, if any taus fall outside (0,1) then the full process is computed.
- nullH: a character vector indicating whether the "location" shift hypothesis (default) or the "location-scale" shift hypothesis should be tested.
- trim: a vector indicating the lower and upper bound of the quantiles to included in the computation of the test statistics (only, not estimates).
- h: an initial bandwidth for the call to akj.
- ...: other arguments to be passed to summary.rq.

Value

an object of class KhmaladzeTest is returned containing:

- nullH: The form of the null hypothesis.
- Tn: Joint test statistic of the hypothesis that all the slope parameters of the model satisfy the hypothesis.
- THn: Vector of test statistics testing whether individual slope parameters satisfy the null hypothesis.

References


Examples

```r
data(barro)
T = KhmaladzeTest( y.net ~ lgdp2 + fse2 + gedy2 + Iy2 + gcony2,
data = barro, taus = seq(.05,.95,by = .01))
plot(T)
```

**kuantile**

**Quicker Sample Quantiles**

### Description

The function `kuantile` computes sample quantiles corresponding to the specified probabilities. The intent is to mimic the generic (base) function `quantile` but using a variant of the Floyd and Rivest (1975) algorithm which is somewhat quicker, especially for large sample sizes.

### Usage

```r
kuantile(x, probs = seq(0, 1, .25), na.rm = FALSE, names = TRUE, type = 7, ...)
```

### Arguments

- `x`: numeric vector whose sample quantiles are wanted.
- `probs`: numeric vector of probabilities with values in [0,1].
- `type`: an integer between 1 and 9 selecting one of the nine quantile algorithms detailed below to be used.
- `na.rm`: logical: if true, any 'NA' and 'NaN's are removed from 'x' before the quantiles are computed.
- `names`: logical: if true, the result has a 'names' attribute.
- `...`: further arguments passed to or from other methods.

### Details

A vector of length `length(p)` is returned. See the documentation for `quantile` for further details on the types. The algorithm was written by K.C. Kiwiel. It is a modified version of the (algol 68) SELECT procedure of Floyd and Rivest (1975), incorporating modifications of Brown(1976). The algorithm has linear growth in the number of comparisons required as sample size grows. For the median, average case behavior requires $1.5n + O((\text{log}n)^{1/2})$ comparisons. See Kiwiel (2005) and Knuth (1998) for further details. When the number of required elements of `p` is large, it may be preferable to revert to a full sort.

### Value

A vector of quantiles of the same length as the vector `p`.

### Author(s)

K.C. Kiwiel, R interface: Roger Koenker
References


See Also

quantile

Examples

kuantile(x <- rnorm(1001)) # Extremes & Quartiles by default

### Compare different types
p <- c(0.1, 0.5, 1, 2, 5, 10, 50)/100
res <- matrix(as.numeric(NA), 9, 7)
for(type in 1:9) res[, type] <- y <- kuantile(x, p, type=type)
dimnames(res) <- list(1:9, names(y))
ktiles <- res

### Compare different types
p <- c(0.1, 0.5, 1, 2, 5, 10, 50)/100
res <- matrix(as.numeric(NA), 9, 7)
for(type in 1:9) res[, type] <- y <- quantile(x, p, type=type)
dimnames(res) <- list(1:9, names(y))
qtiles <- res

max(abs(ktiles - qtiles))

---

**LassoLambdaHat**  
*Lambda selection for QR lasso problems*

**Description**

Default procedure for selection of lambda in lasso constrained quantile regression as proposed by Belloni and Chernozhukov (2011)

**Usage**

LassoLambdaHat(X, R = 1000, tau = 0.5, C = 1, alpha = 0.95)
Arguments

- \( X \) : Design matrix
- \( R \) : Number of replications
- \( \tau \) : Quantile of interest
- \( C \) : Cosmological constant
- \( \alpha \) : Interval threshold

Details

As proposed by Belloni and Chernozhukov, a reasonable default lambda would be the upper quantile of the simulated values. The procedure is based on idea that a simulated gradient can be used as a pivotal statistic. Elements of the default vector are standardized by the respective standard deviations of the covariates. Note that the \( \sqrt{\tau(1-\tau)} \) factor cancels in their (2.4)-(2.6). In this formulation even the intercept is penalized. If the lower limit of the simulated interval is desired one can specify \( \alpha = 0.05 \).

Value

vector of default lambda values of length \( p \), the column dimension of \( X \).

References


Examples

```R
n <- 200
p <- 10
x <- matrix(rnorm(n*p), n, p)
b <- c(1,1, rep(0, p-2))
y <- x %*% b + rnorm(n)
f <- rq(y ~ x, tau = 0.8, method = "lasso")
# See f$lambda to see the default lambda selection
```

latex

Make a latex version of an R object

Description

Generic function for converting an R object into a latex file.

Usage

latex(x, ...)

Arguments

x x is an \texttt{R} object

\ldots \ldots \texttt{optional arguments}

See Also

\texttt{latex.table}, \texttt{latex.summary.rqs}

---

\texttt{latex.summary.rqs} \hspace{1cm} \textit{Make a latex table from a table of rq results}

Description

Produces a file with latex commands for a table of rq results.

Usage

\begin{verbatim}
## S3 method for class 'summary.rqs'
latex(x, transpose = FALSE, caption = "caption goes here.",
      digits = 3, file = as.character(substitute(x)), \ldots)
\end{verbatim}

Arguments

x x is an object of class \texttt{summary.rqs}

transpose if \texttt{TRUE} transpose table so that rows are quantiles and columns are covariates.

caption caption for the table

digits decimal precision of table entries.

file name of file

\ldots \text{optional arguments for \texttt{latex.table}}

Details

Calls \texttt{latex.table}.

Value

Returns invisibly after writing the file.

Author(s)

R. Koenker

See Also

\texttt{summary.rqs}, \texttt{latex.table}
latex.table  

Writes a latex formatted table to a file

Description

Automatically generates a latex formatted table from the matrix x. Controls rounding, alignment, etc.

Usage

```r
## S3 method for class 'table'
latex(x, file=as.character(substitute(x)),
      rowlabel=file, rowlabel.just="l", cgroup, n.cgroup, rgroup, n.rgroup=NULL,
      digits, dec, rdec, cdec, append=FALSE, dcolumn=FALSE, cdot=FALSE,
      longtable=FALSE, table.env=TRUE, lines.page=40, caption, caption.lot,
      label=file, double.slash=FALSE,...)
```

Arguments

- `x`: A matrix x with dimnames.
- `file`: Name of output file (.tex will be added).
- `rowlabel`: If 'x' has row dimnames, rowlabel is a character string containing the column heading for the row dimnames. The default is the name of the argument for x.
- `rowlabel.just`: If 'x' has row dimnames, specifies the justification for printing them. Possible values are '"l", "r", "c"'. The heading ('rowlabel') itself is left justified if 'rowlabel.just="l"', otherwise it is centered.
- `cgroup`: A vector of character strings defining major column headings. The default is to have none.
- `n.cgroup`: A vector containing the number of columns for which each element in `cgroup` is a heading. For example, specify `cgroup=c("Major 1","Major 2")`, `n.cgroup=c(3,3)` if "Major 1" is to span columns 1-3 and "Major 2" is to span columns 4-6. `rowlabel` does not count in the column numbers. You can omit `n.cgroup` if all groups have the same number of columns.
- `rgroup`: A vector of character strings containing headings for row groups. `n.rgroup` must be present when 'rgroup' is given. The first `n.rgroup[1]` rows are sectioned off and 'rgroup[1]' is used as a bold heading for them. The usual row dimnames (which must be present if 'rgroup' is) are indented. The next `n.rgroup[2]` rows are treated likewise, etc.
- `n.rgroup`: Integer vector giving the number of rows in each grouping. If 'rgroup' is not specified, 'n.rgroup' is just used to divide off blocks of rows by horizontal lines. If 'rgroup' is given but 'n.rgroup' is omitted, 'n.rgroup' will default so that each row group contains the same number of rows.
- `digits`: Causes all values in the table to be formatted to `digits` significant digits. 'dec' is usually preferred.
If 'dec' is a scalar, all elements of the matrix will be rounded to ‘dec’ decimal places to the right of the decimal. ‘dec’ can also be a matrix whose elements correspond to ‘x’, for customized rounding of each element.

rdec
a vector specifying the number of decimal places to the right for each row (‘cdec’ is more commonly used than ‘rdec’)

cdec
a vector specifying the number of decimal places for each column

append
defaults to ‘F’. Set to ‘T’ to append output to an existing file.

dcolumn
Set to ‘T’ to use David Carlisle’s ‘dcolumn’ style for decimal alignment. Default is ‘F’, which aligns columns of numbers by changing leading blanks to "~", the LaTeX space-holder. You will probably want to use ‘dcolumn’ if you use ‘rdec’, as a column may then contain varying number of places to the right of the decimal. ‘dcolumn’ can line up all such numbers on the decimal point, with integer values right-justified at the decimal point location of numbers that actually contain decimal places.

cdot
Set to ‘T’ to use centered dots rather than ordinary periods in numbers.

longtable
Set to ‘T’ to use David Carlisle’s LaTeX ‘longtable’ style, allowing long tables to be split over multiple pages with headers repeated on each page.

table.env
Set ‘table.env=FALSE’ to suppress enclosing the table in a LaTeX ‘table’ environment. ‘table.env’ only applies when ‘longtable=FALSE’. You may not specify a ‘caption’ if ‘table.env=FALSE’.

lines.page
Applies if ‘longtable=TRUE’. No more than ‘lines.page’ lines in the body of a table will be placed on a single page. Page breaks will only occur at ‘rgroup’ boundaries.

caption
a text string to use as a caption to print at the top of the first page of the table. Default is no caption.

caption.lot
a text string representing a short caption to be used in the "List of Tables". By default, LaTeX will use ‘caption’.

label
a text string representing a symbolic label for the table for referencing with the LaTeX ‘\ref{label}’ command. The default is ‘file’. ‘label’ is only used if ‘caption’ is given.

double.slash
set to ‘T’ to output ‘\’ as ‘\\’ in LaTeX commands. Useful when you are reading the output file back into an S vector for later output.

... other optional arguments

Value
returns invisibly

Author(s)
Roger Koenker

References
Minor modification of Frank Harrell’s Splus code
lm.fit.recursive  Recursive Least Squares

Description

This function fits a linear model by recursive least squares. It is a utility routine for the KhmaladzeTest function of the quantile regression package.

Usage

lm.fit.recursive(X, y, int=TRUE)

Arguments

- X  Design Matrix
- y  Response Variable
- int  if TRUE then append intercept to X

Value

return p by n matrix of fitted parameters, where p. The ith column gives the solution up to "time" i.

Author(s)

R. Koenker

References


lprq  locally polynomial quantile regression

Description

This is a toy function to illustrate how to do locally polynomial quantile regression univariate smoothing.

Usage

lprq(x, y, h, tau = .5, m = 50)
Arguments

x  The conditioning covariate
y  The response variable
h  The bandwidth parameter
tau The quantile to be estimated
m  The number of points at which the function is to be estimated

Details

The function obviously only does locally linear fitting but can be easily adapted to locally polynomial fitting of higher order. The author doesn’t really approve of this sort of smoothing, being more of a spline person, so the code is left is its (almost) most trivial form.

Value

The function compute a locally weighted linear quantile regression fit at each of the m design points, and returns:

xx  The design points at which the evaluation occurs
fv  The estimated function values at these design points
dev The estimated first derivative values at the design points

Note

One can also consider using B-spline expansions see bs.

Author(s)

R. Koenker

References


See Also

rqss for a general approach to nonparametric QR fitting.

Examples

```r
require(MASS)
data(mcycle)
attach(mcycle)
plot(times,accel,xlab = "milliseconds", ylab = "acceleration (in g)")
hs <- c(1,2,3,4)
for(i in hs){
  h = hs[i]
  fit <- lprq(times,accel,h=h,tau=.5)
  lines(fit$xx,fit$fv,lty=i)
```
Description

Observations on the maximal running speed of mammal species and their body mass.

Usage

data(Mammals)

Format

A data frame with 107 observations on the following 4 variables.

weight  Body mass in Kg for "typical adult sizes"
speed  Maximal running speed (fastest sprint velocity on record)
hoppers  logical variable indicating animals that ambulate by hopping, e.g. kangaroos
specials  logical variable indicating special animals with "lifestyles in which speed does not figure as an important factor": Hippopotamus, raccoon (Procyon), badger (Meles), coati (Nasua), skunk (Mephitis), man (Homo), porcupine (Erithizon), oppossum (didelphis), and sloth (Bradypus)

Details

Used by Chappell (1989) and Koenker, Ng and Portnoy (1994) to illustrate the fitting of piecewise linear curves.

Source


References


See Also

rqss
Examples

```r
data(Mammals)
attach(Mammals)
x <- log(weight)
y <- log(speed)
plot(x, y, xlab="Weight in log(Kg)", ylab="Speed in log(Km/hour)", type="n")
points(x[hoppers], y[hoppers], pch = "h", col="red")
points(x[specials], y[specials], pch = "s", col="blue")
others <- !(hoppers & specials)
points(x[others], y[others], col="black", cex = .75)
fit <- rqss(y ~ qss(x, lambda = 1), tau = .9)
plot(fit)
```

---

Description

function to recursively substitute arguments into rqss formula

Usage

```r
Munge(formula, ...)
```

Arguments

- `formula`: A rqss formula
- `...`: Arguments to be substituted into formula

Details

Intended (originally) for use with `demo(MCV)`. Based on an R-help suggestion of Gabor Grothendieck.

Value

A new formula after substitution

See Also

demo(MCV)

Examples

```r
lams <- c(1.3, 3.3)
f <- y ~ qss(x, lambda = lams[1]) + qss(z, lambda = lams[2]) + s
ff <- Munge(f, lams = lams)
```
nlrq

Function to compute nonlinear quantile regression estimates

Description

This function implements an R version of an interior point method for computing the solution to quantile regression problems which are nonlinear in the parameters. The algorithm is based on interior point ideas described in Koenker and Park (1994).

Usage

nlrq(formula, data=parent.frame(), start, tau=0.5, control, trace=FALSE, method="L-BFGS-B")

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

## S3 method for class 'summary.nlrq'
print(x, digits = max(5, .Options$digits - 2), ...)

Arguments

formula formula for model in nls format; accept self-starting models
data an optional data frame in which to evaluate the variables in ‘formula’
start a named list or named numeric vector of starting estimates
tau a vector of quantiles to be estimated
control an optional list of control settings. See ‘nlrq.control’ for the names of the settable control values and their effect.
trace logical value indicating if a trace of the iteration progress should be printed. Default is ‘FALSE’. If ‘TRUE’ intermediary results are printed at the end of each iteration.
method method passed to optim for line search, default is "L-BFGS-B" but for some problems "BFGS" may be preferable. See optim for further details. Note that the algorithm wants to pass upper and lower bounds for the line search to optim, which is fine for the L-BFGS-B method. Use of other methods will produce warnings about these arguments – so users should proceed at their own risk.
object an object of class nlrq needing summary.
x an object of class summary.nlrq needing printing.
digits Significant digits reported in the printed table.
... Optional arguments passed to printing function.
**Details**

An ‘nlrq’ object is a type of fitted model object. It has methods for the generic functions ‘coef’ (parameters estimation at best solution), ‘formula’ (model used), ‘deviance’ (value of the objective function at best solution), ‘print’, ‘summary’, ‘fitted’ (vector of fitted variable according to the model), ‘predict’ (vector of data points predicted by the model, using a different matrix for the independent variables) and also for the function ‘tau’ (quantile used for fitting the model, as the tau argument of the function). Further help is also available for the method ‘residuals’. The summary method for nlrq uses a bootstrap approach based on the final linearization of the model evaluated at the estimated parameters.

**Value**

A list consisting of:

- m: an ‘nlrqModel’ object similar to an ‘nlsModel’ in package nls
- data: the expression that was passed to ‘nlrq’ as the data argument. The actual data values are present in the environment of the ‘m’ component.

**Author(s)**

Based on S code by Roger Koenker modified for R and to accept models as specified by nls by Philippe Grosjean.

**References**


**See Also**

- nlrq.control
- residuals.nlrq

**Examples**

```r
# build artificial data with multiplicative error
Dat <- NULL; Dat$x <- rep(1:25, 20)
set.seed(1)
Dat$y <- SSlogis(Dat$x, 10, 12, 2)*rnorm(500, 1, 0.1)
plot(Dat)

# fit first a nonlinear least-square regression
Dat.nls <- nls(y ~ SSlogis(x, Asym, mid, scal), data=Dat); Dat.nls
lines(1:25, predict(Dat.nls, newdata=list(x=1:25)), col=1)

# then fit the median using nlrq
Dat.nlrq <- nlrq(y ~ SSlogis(x, Asym, mid, scal), data=Dat, tau=0.5, trace=TRUE)
lines(1:25, predict(Dat.nlrq, newdata=list(x=1:25)), col=2)

# the 1st and 3rd quartiles regressions
Dat.nlrq <- nlrq(y ~ SSlogis(x, Asym, mid, scal), data=Dat, tau=0.25, trace=TRUE)
lines(1:25, predict(Dat.nlrq, newdata=list(x=1:25)), col=3)
Dat.nlrq <- nlrq(y ~ SSlogis(x, Asym, mid, scal), data=Dat, tau=0.75, trace=TRUE)
lines(1:25, predict(Dat.nlrq, newdata=list(x=1:25)), col=3)
```
# and finally "external envelopes" holding 95 percent of the data
Dat.nlrq <- nlrq(y ~ SSlogis(x, Asym, mid, scal), data=Dat, tau=0.025, trace=TRUE)
lines(1:25, predict(Dat.nlrq, newdata=list(x=1:25)), col=4)
Dat.nlrq <- nlrq(y ~ SSlogis(x, Asym, mid, scal), data=Dat, tau=0.975, trace=TRUE)
lines(1:25, predict(Dat.nlrq, newdata=list(x=1:25)), col=4)
leg <- c("least squares", "median (0.5)", "quartiles (0.25/0.75)", ".95 band (0.025/0.975)"")
legend(1, 12.5, legend=leg, lty=1, col=1:4)

nlrq.control

---

**Description**

Set algorithmic parameters for nlrq (nonlinear quantile regression function)

**Usage**

```r
nlrq.control(maxiter=100, k=2, InitialStepSize = 1, big=1e+20, eps=1e-07, beta=0.97)
```

**Arguments**

- `maxiter`: maximum number of allowed iterations
- `k`: the number of iterations of the Meketon algorithm to be calculated in each step, usually 2 is reasonable, occasionally it may be helpful to set `k`=1
- `InitialStepSize`: Starting value in optim to determine the step length of iterations. The default value of 1 is sometimes too optimistic. In such cases, the value 0 forces optim to just barely stick its toe in the water.
- `big`: a large scalar
- `eps`: tolerance for convergence of the algorithm
- `beta`: a shrinkage parameter which controls the recentering process in the interior point algorithm.

**See Also**

`nlrq`
Estimation and Inference on the Pareto Tail Exponent for Linear Models

Description

Estimation and inference about the tail behavior of the response in linear models are based on the adaptation of the univariate Hill (1975) and Pickands (1975) estimators for quantile regression by Chernozhukov, Fernandez-Val and Kaji (2018).

Usage

ParetoTest(formula, tau = 0.1, data = NULL, flavor = "Hill", m = 2, cicov = .9, ...)

Arguments

- formula: a formula specifying the model to fit by rq
- tau: A threshold on which to base the estimation
- data: a data frame within which to interpret the formula
- flavor: Currently limited to either "Hill" or "Pickands"
- m: a tuning parameter for the Pickands method.
- cicov: Desired coverage probability of confidence interval.
- ... other arguments to be passed to summary.rq. by default the summary method is the usual xy bootstrap, with B = 200 replications.

Value

an object of class ParetoTest is returned containing:

- z: A named vector with components: the estimate, a bias corrected estimate, a lower bound of the confidence interval, an upper bound of the confidence interval, and a Bootstrap Standard Error estimate.
- tau: The tau threshold used to compute the estimate.

References


Examples

\[
\begin{align*}
n & = 500 \\
x & = \text{rnorm}(n) \\
y & = x + \text{rt}(n, 2) \\
Z & = \text{ParetoTest}(y \sim x, .9, \text{flavor} = \text{"Pickands"})
\end{align*}
\]

Description

Data from sequence experiments conducted by C.S. Pierce in 1872 to determine the distribution of response times to an auditory stimulus.

Usage

\[\text{data(Peirce)}\]

Format

A link(list) of 24 objects each representing one day of the experiment. Each element of the list consists of three components: the date the measurements were made, an \(x\) component recording the response time in milliseconds, and an associated \(y\) component recording a count of the number of times that the response was recorded to be equal to the corresponding \(x\) entry. There are roughly 500 observations (counts) on each of the 24 days.

Details

A detailed description of the experiment can be found in Peirce (1873). A young man of about 18 with no prior experience was employed to respond to a signal “consisting of a sharp sound like a rap, the answer being made upon a telegraph-operator’s key nicely adjusted.” The response times, made with the aid of a Hipp cronoscope were recorded to the nearest millisecond. The data was analyzed by Peirce who concluded that after the first day, when the observer was entirely inexperienced, the curves representing the densities of the response times “differed very little from that derived from the theory of least squares,” i.e. from the Gaussian density.

The data was subsequently analysed by Samama, in a diploma thesis supervised by Maurice Frechet, who reported briefly the findings in Frechet (1924), and by Wilson and Hilferty (1929). In both instances the reanalysis showed that Laplace’s first law of error, the double exponential distribution, was a better representation for the data than was the Gaussian law. Koenker (2009) contains further discussion and an attempt to reproduce the Wilson and Hilferty analysis.

The data is available in two formats: The first in a "raw" form as 24 text files as scanned from the reprinted Peirce source, the second as an R dataset Peirce.rda containing the list. Only the latter is provided here, for the raw data and how to read see the more complete archive at: http://www.econ.uiuc.edu/~roger/research/frechet/frechet.html See the examples section below for some details on provisional attempt to reproduce part of the Wilson and Hilferty analysis. An open question regarding the dataset is: How did Wilson and Hilferty compute standard deviations for
the median as they appear in their table? The standard textbook suggestion of Yule (1917) yields far too small a bandwidth. The methods employed in the example section below, which rely on relatively recent proposals, are somewhat closer, but still deviate somewhat from the results reported by Wilson and Hilferty.

**Source**


**References**


**Examples**

```r
# Make table like Wilson and Hilferty
data("Peirce")
set.seed(10) #Dither the counts
for(i in 1:24){
y <- rep(Peirce[[i]]$x, Peirce[[i]]$y) + runif(sum(Peirce[[i]]$y), -.5, .5)
f1 <- summary(rq(y~1),se="iid")$coef[1:2]
n <- length(y)
f0 <- 1/(2 * sum(abs(y-f1[1])/n)) #Laplace proposal
f0 <- (1/(2 * f0))/ sqrt(n)
f2 <- summary(lm(y~1))$coef[1:2]
outm <- sum(y < (f1[1] - 3.1 * sqrt(n) * f2[2]))
outp <- sum(y > (f1[1] + 3.1 * sqrt(n) * f2[2]))
outt <- outm + outp
inm <- y > (f1[1] - 0.25 * sqrt(n) * f2[2])
inp <- y < (f1[1] + 0.25 * sqrt(n) * f2[2])
int <- sum(inm * inp)
Eint <- round(n * (pnorm(.25) - pnorm(-.25)))
excess <- round(100*(int - Eint)/Eint)
tab[,i] <- c(f1, f0, f2, outm, outp, outt, int, Eint, excess)
cnames <- c("med","sdmed1","sdmed0","mean","sdmean","below","above","outliers","inliers","Einliers","ExcessIns")
dimnames(tab) <- list(paste("Day",1:24),cnames)
}
```
plot.KhmaladzeTest  
Plot a KhmaladzeTest object

Description
Plot an object generated by KhmaladzeTest

Usage
## S3 method for class 'KhmaladzeTest'
plot(x, ...)

Arguments
x  
Object returned from KhmaladzeTest representing the fit of the model.
...
Optional arguments.

See Also
KhmaladzeTest

plot.rq  
plot the coordinates of the quantile regression process

Description
Function to plot quantile regression process.

Usage
## S3 method for class 'rq.process'
plot(x, nrow=3, ncol=2, ...)

Arguments
x  
an object produced by rq() fitting
nrow  
rows in mfrow
ncol  
columns in mfrow
...
optional arguments to plot

Author(s)
Roger Koenker rkoenker@uiuc.edu

See Also
rq
Visualizing sequences of quantile regressions

Description

A sequence of coefficient estimates for quantile regressions with varying \( \tau \) parameters is visualized.

Usage

```r
## S3 method for class 'rqs'
plot(x, parm = NULL, ols = TRUE,
     mfrow = NULL, mar = NULL, ylim = NULL, main = NULL, col = 1:2, lty = 1:2,
     cex = 0.5, pch = 20, type = "b", xlab = "", ylab = "", ...)  
```

Arguments

- `x` an object of class "rqs" as produce by `rq` (with a vector of \( \tau \) values).
- `parm` a specification of which parameters are to be plotted, either a vector of numbers or a vector of names. By default, all parameters are considered.
- `ols` logical. Should a line for the OLS coefficient (as estimated by `lm`) be added?
- `mfrow, mar, ylim, main` graphical parameters. Suitable defaults are chosen based on the coefficients to be visualized.
- `col, lty` graphical parameters. For each parameter, the first element corresponds to the `rq` coefficients and the second to the `lm` coefficients.
- `cex, pch, type, xlab, ylab, ...` further graphical parameters passed.

Details

The `plot` method for "rqs" objects visualizes the coefficients only, confidence bands can be added by using the `plot` method for the associated "summary.rqs" object.

Value

A matrix with all coefficients visualized is returned invisibly.

See Also

`rq`, `plot.summary.rqs`
Examples

```r
## fit Engel models (in levels) for tau = 0.1, ..., 0.9
data("engel")
fm <- rq(foodexp ~ income, data = engel, tau = 1:9/10)

## visualizations
plot(fm)
plot(fm, parm = 2, mar = c(5.1, 4.1, 2.1, 2.1), main = "", xlab = "tau",
ylab = "income coefficient", cex = 1, pch = 19)
```

---

**plot.rqss**

*Plot Method for rqss Objects*

Description

Takes a fitted rqss object produced by rqss() and plots the component smooth functions that make up the ANOVA decomposition. Since the components "omit the intercept" the estimated intercept is added back in – this facilitates the comparison of quantile fits particularly. For models with a partial linear component or several qss components it may be preferable to plot the output of predict.rqss. Note that these functions are intended to plot rqss objects only, attempting to plot summary.rqss objects just generates a warning message.

Usage

```r
## S3 method for class 'rqss'
plot(x, rug = TRUE, jit = TRUE, bands = NULL, coverage = 0.95,
     add = FALSE, shade = TRUE, select = NULL, pages = 0, titles = NULL,
     bcol = NULL, ...)
## S3 method for class 'qss1'
plot(x, rug = TRUE, jit = TRUE, add = FALSE, ...)
## S3 method for class 'qts1'
plot(x, rug = TRUE, jit = TRUE, add = FALSE, ...)
## S3 method for class 'qss2'
plot(x, render = "contour", ncol = 100, zcol = NULL, ...)
## S3 method for class 'summary.rqss'
plot(x, ...)
```

Arguments

- `x` : a fitted rqss object produced by `rqss()`.
- `...` : additional arguments for the plotting algorithm
- `rug` : if TRUE, a rugplot for the x-coordinate is plotted
- `jit` : if TRUE, the x-values of the rug plot are jittered
- `bands` : if TRUE, confidence bands for the smoothed effects are plotted, if "uniform" then uniform bands are plotted, if "both" then both the uniform and the pointwise bands are plotted.
coverage: desired coverage probability of confidence bands, if requested
select: vector of indices of qss objects to be plotted, by default all
pages: number of pages desired for the plots
render: a character specifying the rendering for bivariate fits; either "contour" (default) or "rgl". The latter requires package rgl.
add: if TRUE then add qss curve to existing (usually) scatterplot, otherwise initiate a new plot
shade: if TRUE then shade the confidence band
titles: title(s) as vector of character strings, by default titles are chosen for each plot as "Effect of CovariateName"
bcol: vector of two colors for confidence bands
ncol, zcol: Only for render = "rgl": number of colors and z values for color construction.

Details
For univariate qss components with Dorder = 0 the fitted function is piecewise constant, not piecewise linear. In this case the constraints are limited to increasing, decreasing or none. If bands == "uniform" then the bands are uniform bands based on the Hotelling (1939) tube approach. See also Naiman (1986), Johansen and Johnstone (1990), Sun and Loader (1994), and Krivobokova, Kneib, and Claeskens (2009), in particular the computation of the "tube length" is based on the last of these references. If bands is non null, and not "uniform" then pointwise bands are returned. Since bands for bivariate components are not (yet) supported, if requested such components will be returned as NULL.

Value
The function produces plots for the ANOVA components as a side effect. For "qss1" the "add = TRUE" can be used to overplot the fit on a scatterplot. When there are multiple pages required "par(ask = TRUE)" is turned on so that the plots may be examined sequentially. If bands != NULL then a list with three components for each qss component is returned (invisibly):
x: The x coordinates of the confidence bands
blo: The y coordinates of the lower confidence curve, if bands = "both" then this is a matrix with two columns
bhi: The y coordinates of the upper confidence curve, if bands = "both" then this is a matrix with two columns

Author(s)
Roger Koenker

References


See Also

rqss

Examples

```r
n <- 200
x <- sort(rchisq(n,4))
z <- x + rnorm(n)
y <- log(x)+ .1*(log(x))^2 + log(x)*rnorm(n)/4 + z
plot(x,y-z)

fN <- rqss(y~qss(x,constraint="N")+z)
plot(fN)

fI <- rqss(y~qss(x,constraint="I")+z)
plot(fI, col="blue")

fCI <- rqss(y~qss(x,constraint="CI")+z)
plot(fCI, col="red")
```

```r
## A bivariate example

data(CobarOre)
fCO <- rqss(z~qss(cbind(x,y),lambda=.08), data = CobarOre)
plot(fCO)
```

---

**plot.summary.rqs**

*Visualizing sequences of quantile regression summaries*

Description

A sequence of coefficient estimates for quantile regressions with varying tau parameters is visualized along with associated confidence bands.

Usage

```r
## S3 method for class 'summary.rqs'
plot(x, parm = NULL, level = 0.9, ols = TRUE,
     mfrow = NULL, mar = NULL, ylim = NULL, main = NULL,
     col = gray(c(0, 0.75)), border = NULL, lcol = 2, lty = 1:2,
     cex = 0.5, pch = 20, type = "b", xlab = "", ylab = "", ...
)```
Arguments

- **x**: an object of class "summary.rqs" as produce by applying the `summary` method to a `rq` object (with a vector of tau values).
- **parm**: a specification of which parameters are to be plotted, either a vector of numbers or a vector of names. By default, all parameters are considered.
- **level**: Confidence level of bands. When using the rank based confidence intervals in `summary`, which is the default method for sample sizes under 1000, you will need to control the level of the intervals by passing the parameter alpha to `summary.rq`, prior to calling `plot.summary.rqs`. Note also that alpha = 1 - level.
- **ols**: logical. Should a line for the OLS coefficient and their confidence bands (as estimated by `lm`) be added?
- **mfrow, mar, ylim, main**: graphical parameters. Suitable defaults are chosen based on the coefficients to be visualized. It can be useful to use a common vertical scale when plotting as a way of comparing confidence bands constructed by different methods. For this purpose one can specify a `ylim` as a 2 by `length(parm)` matrix.
- **col**: vector of color specification for `rq` coefficients and the associated confidence polygon.
- **border**: color specification for the confidence polygon. By default, the second element of `col` is used.
- **lcol, lty**: color and line type specification for OLS coefficients and their confidence bounds.
- **cex, pch, type, xlab, ylab, ...**: further graphical parameters passed to `points`.

Details

The plot method for "summary.rqs" objects visualizes the coefficients along with their confidence bands. The bands can be omitted by using the plot method for "rq" objects directly.

Value

A list with components `z`, an array with all coefficients visualized (and associated confidence bands), and `Ylim`, a 2 by `p` matrix containing the y plotting limits. The latter component may be useful for establishing a common scale for two or more similar plots. The list is returned invisibly.

See Also

- `rq`, `plot.rqs`

Examples

```r
## fit Engel models (in levels) for tau = 0.1, ..., 0.9
data("engel")
fm <- rq(foodexp ~ income, data = engel, tau = 1:9/10)
sfm <- summary(fm)
```
## visualizations
plot(sfm)
plot(sfm, parm = 2, mar = c(5.1, 4.1, 2.1, 2.1), main = "", xlab = "tau",
ylab = "income coefficient", cex = 1, pch = 19)

---

### predict.rq

**Quantile Regression Prediction**

**Description**
Prediction based on fitted quantile regression model

**Usage**

```r
## S3 method for class 'rq'
predict(object, newdata, type = "none", interval = c("none", "confidence"),
level = .95, na.action = na.pass, ...)
## S3 method for class 'rqs'
predict(object, newdata, type = "Qhat", stepfun = FALSE, na.action = na.pass, ...)
## S3 method for class 'rq.process'
predict(object, newdata, type = "Qhat", stepfun = FALSE, na.action = na.pass, ...)
```

**Arguments**

- `object` object of class `rq` or `rqs` or `rq.process` produced by `rq`
- `newdata` An optional data frame in which to look for variables with which to predict. If omitted, the fitted values are used.
- `interval` type of interval desired: default is 'none', when set to 'confidence' the function returns a matrix predictions with point predictions for each of the 'newdata' points as well as lower and upper confidence limits.
- `level` coverage probability for the 'confidence' intervals.
- `type` For `predict.rq`, the method for 'confidence' intervals, if desired. If 'percentile' then one of the bootstrap methods is used to generate percentile intervals for each prediction, if 'direct' then a version of the Portnoy and Zhou (1998) method is used, and otherwise an estimated covariance matrix for the parameter estimates is used. Further arguments to determine the choice of bootstrap method or covariance matrix estimate can be passed via the ...argument. For `predict.rqs` and `predict.rq.process` when `stepfun = TRUE`, type is "Qhat", "Fhat" or "fhat" depending on whether the user would like to have estimates of the conditional quantile, distribution or density functions respectively. As noted below the two former estimates can be monotonized with the function `rearrange`. When the "fhat" option is invoked, a list of conditional density functions is returned based on Silverman’s adaptive kernel method as implemented in `akj` and `approxfun`.
predict.rq

stepfun

If 'TRUE' return stepfunctions otherwise return matrix of predictions. These
functions can be estimates of either the conditional quantile or distribution func-
tions depending upon the type argument. When stepfun = FALSE a matrix of
point estimates of the conditional quantile function at the points specified by the
newdata argument.

na.action

function determining what should be done with missing values in 'newdata'.
The default is to predict 'NA'.

Further arguments passed to or from other methods.

Details

Produces predicted values, obtained by evaluating the quantile regression function in the frame
'newdata' (which defaults to 'model.frame(object)'). These predictions purport to estimate the con-
ditional quantile function of the response variable of the fitted model evaluated at the covariate
values specified in 'newdata' and the quantile(s) specified by the "tau" argument. Several methods
are provided to compute confidence intervals for these predictions.

Value

A vector or matrix of predictions, depending upon the setting of 'interval'. In the case that there
are multiple taus in object when object is of class 'rqs' setting 'stepfun = TRUE' will produce a
stepfun object or a list of stepfun objects. The function rearrange can be used to monotonize
these step-functions, if desired.

Author(s)

R. Koenker

References

based on regression quantiles Journal of Nonparametric Statistics, 9, 239-260

See Also

rq rearrange

Examples

data(airquality)
airq <- airquality[143:145,]
f <- rq(Ozone ~ ., data=airquality)
predict(f,newdata=airq)
f <- rq(Ozone ~ ., data=airquality, tau=1:19/20)
fp <- predict(f, newdata=airq, stepfun = TRUE)
fpr <- rearrange(fp)
plot(fp[2],main = "Conditional Ozone Quantile Prediction")
lines(fpr[,2], col="red")
legend(.2,20,c("raw","cooked"),lty = c(1,1),col=c("black","red"))
fp <- predict(f, newdata=airq, type = "Fhat", stepfun = TRUE)
predict.rqss <- rearrange(fp)
plot(fp[[2]], main = "Conditional Ozone Distribution Prediction")
lines(fpr[[2]], col="red")
legend(20,.4,c("raw","cooked"),lty = c(1,1),col=c("black","red"))

predict.rqss

Predict from fitted nonparametric quantile regression smoothing spline models

Description

Additive models for nonparametric quantile regression using total variation penalty methods can be fit with the rqss function. Univariate and bivariate components can be predicted using these functions.

Usage

## S3 method for class 'rqss'
predict(object, newdata, interval = "none", level = 0.95, ...)
## S3 method for class 'qss1'
predict(object, newdata, ...)
## S3 method for class 'qss2'
predict(object, newdata, ...)

Arguments

object is a fitted object produced by rqss
newdata a data frame describing the observations at which prediction is to be made. For qss components, newdata should lie in strictly within the convex hull of the fitting data. Newdata corresponding to the partially linear component of the model may require caution concerning the treatment of factor levels, if any.
interval If set to confidence then a level confidence interval for the predictions is returned.
level intended coverage probability for the confidence intervals
...
optional arguments

Details

For both univariate and bivariate prediction linear interpolation is done. In the bivariate case, this involves computing barycentric coordinates of the new points relative to their enclosing triangles. It may be of interest to plot individual components of fitted rqss models: this is usually best done by fixing the values of other covariates at reference values typical of the sample data and predicting the response at varying values of one qss term at a time. Direct use of the predict.qss1 and predict.qss2 functions is discouraged since it usually corresponds to predicted values at absurd reference values of the other covariates, i.e. zero.
Value

A vector of predictions, or in the case that interval = "confidence" a matrix whose first column is the vector of predictions and whose second and third columns are the lower and upper confidence limits for each prediction.

Author(s)

R. Koenker

See Also

rqss

Examples

n <- 200
lam <- 2
x <- sort(rchisq(n,4))
z <- exp(rnorm(n)) + x
y <- log(x)+ .1*(log(x))^2 + z/4 + log(x)*rnorm(n)/4
plot(x,y - z/4 + mean(z)/4)
Ifit <- rqss(y - qss(x,constraint="I") + z)
sfit <- rqss(y - qss(x,lambda = lam) + z)
xz <- data.frame(z = mean(z),
                 x = seq(min(x)+.01,max(x)-.01,by=.25))
lines(xz[["x"]], predict(Ifit, xz), col=2)
lines(xz[["x"]], predict(sfit, xz), col=3)
legend(10,2,c("Increasing","Smooth"),lty = 1, col = c(2,3))
title("Predicted Median Response at Mean Value of z")

## Bivariate example -- loads pkg "tripack"
require(tripack)
require(akima)
data(CobarOre)
fit <- rqss(z ~ qss(cbind(x,y), lambda=.08),
            data= CobarOre)
plot(fit, col="grey",
     main = "CobarOre data -- rqss(z ~ qss(cbind(x,y)))")
T <- with(CobarOre, tri.mesh(x, y))
set.seed(77)
ndum <- 100
xd <- with(CobarOre, runif(ndum, min(x), max(x)))
yd <- with(CobarOre, runif(ndum, min(y), max(y)))
table(s <- in.convex.hull(T, xd, yd))
pred <- predict(fit, data.frame(x = xd[s], y = yd[s]))
contour(interp(xd[s],yd[s], pred),
        col="red", add = TRUE)
print.KhmaladzeTest  Print a KhmaladzeTest object

Description
Print an object generated by KhmaladzeTest

Usage
### S3 method for class 'KhmaladzeTest'
print(x, ...)

Arguments
x  Object returned from KhmaladzeTest representing the fit of the model.
...  Optional arguments.

See Also
KhmaladzeTest

print.rq  Print an rq object

Description
Print an object generated by rq

Usage
### S3 method for class 'rq'
print(x, ...)
### S3 method for class 'rqs'
print(x, ...)

Arguments
x  Object returned from rq representing the fit of the model.
...  Optional arguments.

See Also
rq
print.summary.rq  

**Print Quantile Regression Summary Object**

### Description

Print summary of quantile regression object

### Usage

```r
## S3 method for class 'summary.rq'
print(x, digits=max(5, .Options$digits - 2), ...)
## S3 method for class 'summary.rqs'
print(x, ...)
```

### Arguments

- `x` This is an object of class "summary.rq" produced by a call to `summary.rq()`.
- `digits` Significant digits reported in the printed table.
- `...` Optional arguments passed to printing function

### See Also

- `summary.rq`

---

q489  

**Even Quicker Sample Quantiles**

### Description

The function `q489` computes a single sample quantile using a fortran implementation of the Floyd and Rivest (1975) algorithm. In contrast to the more elaborate function `kuantile` that uses the Kiweil (2005) implementation it does not attempt to replicate the nine varieties of quantiles as documented in the base function `quantile`

### Usage

```r
q489(x, tau = .5)
```

### Arguments

- `x` numeric vector
- `tau` the quantile of intereste.
Details

This is a direct translation of the Algol 68 implementation of Floyd and Rivest (1975), implemented in Ratfor. For the median, average case behavior requires $1.5n + O((n \log n)^{1/2})$ comparisons. In preliminary experiments it seems to be somewhat faster in large samples than the implementation kuantile of Kiwiel (2005). See Knuth (1998) for further details. No provision is made for non-uniqueness of the quantile, so, when $\tau n$ is an integer there may be some discrepancy.

Value

A scalar quantile of the same length as the vector p.

Author(s)

R.W.Floyd and R.L.Rivest, R implementation: Roger Koenker

References


See Also

quantile

Examples

```r
medx <- q489(rnorm(1001))
```

Description

This function solves a weighted quantile regression problem to find the optimal portfolio weights minimizing a Choquet risk criterion described in Bassett, Koenker, and Kordas (2002).

Usage

```r
qrisk(x, alpha = c(0.1, 0.3), w = c(0.7, 0.3), mu = 0.07,
R = NULL, r = NULL, lambda = 10000)
```
Arguments

- **x**: n by q matrix of historical or simulated asset returns
- **alpha**: vector of alphas receiving positive weights in the Choquet criterion
- **w**: weights associated with alpha in the Choquet criterion
- **mu**: targeted rate of return for the portfolio
- **R**: matrix of constraints on the parameters of the quantile regression, see below
- **r**: rhs vector of the constraints described by R
- **lambda**: Lagrange multiplier associated with the constraints

Details

The function calls `rq.fit.hogg` which in turn calls the constrained Frisch Newton algorithm. The constraints \( Rb=r \) are intended to apply only to the slope parameters, not the intercept parameters. The user is completely responsible to specify constraints that are consistent, i.e., that have at least one feasible point. See examples for imposing non-negative portfolio weights.

Value

- **pihat**: the optimal portfolio weights
- **muhat**: the in-sample mean return of the optimal portfolio
- **qrisk**: the in-sample Choquet risk of the optimal portfolio

Author(s)

R. Koenker

References


See Also

- `rq.fit.hogg`, `srisk`

Examples

```r
# Fig 1: ... of Choquet paper
mu1 <- .05; sig1 <- .02; mu2 <- .09; sig2 <- .07
x <- -10:40/100
u <- seq(min(c(x)),max(c(x)),length=100)
f1 <- dnorm(u,mu1,sig1)
F1 <- pnorm(u,mu1,sig1)
f2 <- dchisq(3-sqrt(6)*(u-mu1)/sig1,3)*(sqrt(6)/sig1)
F2 <- pchisq(3-sqrt(6)*(u-mu1)/sig1,3)
f3 <- dnorm(u,mu2,sig2)
```
F3 <- pnorm(u,mu2,sig2)
F4 <- dchisq(3+sqrt(6)*(u-mu2)/sig2,3)*(sqrt(6)/sig2)
F4 <- pchisq(3+sqrt(6)*(u-mu2)/sig2,3)
plot(rep(u,4),c(f1,f2,f3,f4),type="n",xlab="return",ylab="density")
lines(u,f1,lty=1,col="blue")
lines(u,f2,lty=2,col="red")
lines(u,f3,lty=3,col="green")
lines(u,f4,lty=4,col="brown")
legend(.25,25,paste("Asset ",1:4),lty=1:4,col=c("blue","red","green","brown"))

#Now generate random sample of returns from these four densities.
n <- 1000
if(TRUE){ #generate a new returns sample if TRUE
  x1 <- rnorm(n)
  x1 <- (x1-mean(x1))/sqrt(var(x1))
  x1 <- x1*sig1 + mu1
  x2 <- -rchisq(n,3)
  x2 <- (x2-mean(x2))/sqrt(var(x2))
  x2 <- x2*sig1 + mu1
  x3 <- rnorm(n)
  x3 <- (x3-mean(x3))/sqrt(var(x3))
  x3 <- x3*sig2 + mu2
  x4 <- rchisq(n,3)
  x4 <- (x4-mean(x4))/sqrt(var(x4))
  x4 <- x4*sig2 + mu2
}
library(quantreg)
x <- cbind(x1,x2,x3,x4)
qfit <- qrisk(x)
sfit <- srisk(x)
# Try new distortion function
qfit1 <- qrisk(x, alpha = c(.05,.1), w = c(.9,.1), mu = 0.09)
# Constrain portfolio weights to be non-negative
qfit2 <- qrisk(x, alpha = c(.05,.1), w = c(.9,.1), mu = 0.09,
               R = rbind(rep(-1,3), diag(3)), r = c(-1, rep(0,3)))

---

qss  
Additive Nonparametric Terms for rqss Fitting

Description

In the formula specification of rqss nonparametric terms are specified with qss. Both univariate and bivariate specifications are possible, and qualitative constraints may also be specified for the qss terms.

Usage

qss(x, constraint = "N", lambda = 1, ndum = 0, dummies = NULL,
    Dorder = 1, w = rep(1, length(x)))
Arguments

x The covariate determining the nonparametric component, if x is a matrix with two columns then the qss function will construct a penalized triogram term.

lambda The smoothing parameter governing the tradeoff between fidelity and the penalty component for this term. Larger lambdas produce smoother fits. In future versions there should be an automatic mechanism for default choice of the lambdas. For now, this is the responsibility of the user.

constraint Optional specification of qualitative constraints on the fitted univariate qss functions, take the values: "N","I","D","V","C" "VI","VD","CI","CD" for none, increasing, decreasing, convex, concave, convex and increasing, etc. And for bivariate qss components can take the values "N","V","C" for none, convex, and concave. Note that confidence bands for constrained fits of this sort, while available from plot.rqss as of yet lack a formal justification.

ndum number of dummy vertices: this is only relevant for qss2 terms. In addition to vertices at the observed (x,y) points ndum dummy vertices are generated – distributed uniformly over the rectangle given by the Cartesian product of the ranges of x and y – observations that fall in the convex hull of the observations are retained. So the actual number of dummy vertices used is smaller than ndum. The values of these vertices are returned in the list dummies, so that they can be reused.

Dorder Order of the total variation penalty, the default of 1 implies a penalty on the first derivative of the fitted function, a value of 0 implies total variation of the fitted function itself will be penalized. Note that only monotonicity constraints, "I" and "D" are allowed when Dorder = 0, and result in estimates that are equivalent to a form of isotonic regression when lambda is sufficiently near zero. Results in this case from the package isotone may differ slightly when plotted due to multiple solutions so it is prudent to evaluate the objective function for both solutions.

dummies list of dummy vertices as generated, for example by triogram.fidelity when ndum > 0. Should be a list with x and y components. These points should lie inside the convex hull of the real xy points, but no explicit checking of this assertion is currently done.

w weights not yet unimplemented

Details

The various pieces returned are stored in sparse matrix.csr form. See rqss for details on how they are assembled. To preserve the sparsity of the design matrix the first column of each qss term is dropped. This differs from the usual convention that would have forced qss terms to have mean zero. This convention has implications for prediction that need to be recognized. The penalty components for qss terms are based on total variation penalization of the first derivative (and gradient, for bivariate x) as described in the references appearing in the help for rqss. When Dorder = 0, fitting is like the taut string methods of Davies (2014), except for the fact that fidelity is quantilesque rather than quadratic, and that no provision is made for automatic selection of the smoothing parameter.

For the bivariate case, package tripack (and for plotting also akima) are required (automatically, by the R code).
Value
F Fidelity component of the design matrix
dummies List of dummy vertices
A Penalty component of the design matrix
R Constraint component of the design matrix
r Constraint component of the rhs

Author(s)
Roger Koenker

References

See Also
rqss

QTECox Function to obtain QTE from a Cox model

Description
Computes quantile treatment effects comparable to those of crq model from a coxph object.

Usage
QTECox(x, smooth = TRUE)

Arguments
x An object of class coxph produced by coxph.
smooth Logical indicator if TRUE (default) then Cox survival function is smoothed.

Details
Estimates of the Cox QTE, \( \frac{dQ(t|x)}{dx_j} \) at \( x = \bar{x} \), can be expressed as a function of t as follows:

\[
\frac{dQ(t|x)}{dx_j} = \frac{dt}{dx_j} \frac{dQ(t|x)}{dt}
\]

The Cox survival function, \( S(y|x) = \exp\{-H_0(y) \exp(b'x)\} \)

\[
\frac{dS(y|x)}{dx_j} = S(y|x) \log\{S(y|x)\} h_j
\]
where $\frac{dQ(t|x)}{dx_j}$ can be estimated by $\frac{\Delta(t)}{\Delta(S)}(1-t)$ where $SS$ and $St$ denote the surv and time components of the survfit object. Note that since $t = 1 - S(y|x)$, the above is the value corresponding to the argument $S(1-t)$; and furthermore

$$\frac{dt}{dx_j} = -\frac{dS(y|x)}{dx_j} = -(1-t)\log(1-t)b_j$$

Thus the QTE at the mean of x’s is:

$$(1 - S) = \frac{\Delta(t)}{\Delta(S)} S \log(S) b_j$$

Since $\Delta S$ is negative and $\log(S)$ is also negative this has the same sign as $b_j$. The crq model fits the usual AFT form Surv(log(Time),Status), then

$$\frac{d\log(Q(t|x))}{dx_j} = \frac{dQ(t|x)}{dx_j} / Q(t|x)$$

This is the matrix form returned.

Value

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>taus</td>
<td>points of evaluation of the QTE.</td>
</tr>
<tr>
<td>QTE</td>
<td>matrix of QTEs, the ith column contains the QTE for the ith covariate effect. Note that there is no intercept effect. see plot.summary.crqs for usage.</td>
</tr>
</tbody>
</table>

Author(s)

Roger Koenker Stephen Portnoy & Tereza Neocleous

References


See Also

crq
**ranks**  
*Quantile Regression Ranks*

**Description**

Function to compute ranks from the dual (regression rankscore) process.

**Usage**

```r
ranks(v, score="wilcoxon", tau=0.5, trim = NULL)
```

**Arguments**

- `v`: object of class "rq.process" generated by `rq()`
- `score`: The score function desired. Currently implemented score functions are "wilcoxon", "normal", and "sign" which are asymptotically optimal for the logistic, Gaussian and Laplace location shift models respectively. The "normal" score function is also sometimes called van der Waerden scores. Also implemented are the "tau" which generalizes sign scores to an arbitrary quantile, "interquartile" which is appropriate for tests of scale shift, `normalscale` for Gaussian scale shift, `halfnormalscale` for Gaussian scale shift only to the right of the median, and `lehmann` for Lehmann local alternatives. See Koenker (2010) for further details on the last three of these scores.
- `tau`: the optional value of tau if the "tau" score function is used.
- `trim`: optional trimming proportion parameter(s) – only applicable for the Wilcoxon score function – when one value is provided there is symmetric trimming of the score integral to the interval (trim,1-trim), when there are two values provided, then the trimming restricts the integration to (trim[1],trim[2]).

**Details**

See GJKP(1993) for further details.

**Value**

The function returns two components. One is the ranks, the other is a scale factor which is the $L_2$ norm of the score function. All score functions should be normalized to have mean zero.

**References**


Koenker, R. Rank Tests for Heterogeneous Treatment Effects with Covariates, preprint.

**See Also**

`rq, rq.test.rank anova`
Examples
data(stackloss)
ranks(rq(stack.loss ~ stack.x, tau=-1))

---

rearrange  Rearrangement

Description
Monotonize a step function by rearrangement

Usage
rearrange(f, xmin, xmax)

Arguments
- f: object of class stepfun
- xmin: minimum of the support of the rearranged f
- xmax: maximum of the support of the rearranged f

Details
Given a stepfunction $Q(u)$, not necessarily monotone, let $F(y) = \int \{Q(u) \leq y\} du$ denote the associated cdf obtained by randomly evaluating $Q$ at $U \sim U[0, 1]$. The rearranged version of $Q$ is $Q^*(u) = \inf\{u : F(y) \geq u\}$. The rearranged function inherits the right or left continuity of the original stepfunction.

Value
Produces transformed stepfunction that is monotonic increasing.

Author(s)
R. Koenker

References

See Also
rq, rearrange
Examples

data(engel)
z <- rq(foodexp ~ income, tau = -1, data = engel)
zp <- predict(z, newdata = list(income = quantile(engel$income, .03)), stepfun = TRUE)
plot(zp, do.points = FALSE, xlab = expression(tau),
     ylab = expression(Q(tau)), main = "Engel Food Expenditure Quantiles")
plot(rearrange(zp), do.points = FALSE, add = TRUE, col.h = "red", col.v = "red")
legend(.6, 300, c("Before Rearrangement", "After Rearrangement"), lty = 1, col = c("black", "red"))

residuals.nlrq

Return residuals of an nlrq object

Description

Set algorithmic parameters for nlrq (nonlinear quantile regression function)

Usage

## S3 method for class 'nlrq'
residuals(object, type = c("response", "rho"), ...)

Arguments

object

an 'nlrq' object as returned by function 'nlrq'

type

the type of residuals to return: "response" is the distance between observed and predicted values; "rho" is the weighted distance used to calculate the objective function in the minimisation algorithm as tau * pmax(resid, 0) + (1 - tau) * pmin(resid, 0), where resid are the simple residuals as above (with type="response").

...

further arguments passed to or from other methods.

See Also

nlrq

rq

Quantile Regression

Description

Returns an object of class "rq" "rqs" or "rq.process" that represents a quantile regression fit.

Usage

rq(formula, tau=.5, data, subset, weights, na.action,
    method="br", model = TRUE, contrasts, ...)
Arguments

formula

A formula object, with the response on the left of a ~ operator, and the terms, separated by + operators, on the right.

tau

The quantile(s) to be estimated, this is generally a number strictly between 0 and 1, but if specified strictly outside this range, it is presumed that the solutions for all values of tau in (0,1) are desired. In the former case an object of class "rq" is returned, in the latter, an object of class "rq.process" is returned. As of version 3.50, tau can also be a vector of values between 0 and 1; in this case an object of class "rqs" is returned containing among other things a matrix of coefficient estimates at the specified quantiles.

data

A data.frame in which to interpret the variables named in the formula, or in the subset and the weights argument. If this is missing, then the variables in the formula should be on the search list. This may also be a single number to handle some special cases – see below for details.

subset

An optional vector specifying a subset of observations to be used in the fitting process.

weights

Vector of observation weights; if supplied, the algorithm fits to minimize the sum of the weights multiplied into the absolute residuals. The length of weights must be the same as the number of observations. The weights must be nonnegative and it is strongly recommended that they be strictly positive, since zero weights are ambiguous.

na.action

A function to filter missing data. This is applied to the model.frame after any subset argument has been used. The default (with na.fail) is to create an error if any missing values are found. A possible alternative is na.omit, which deletes observations that contain one or more missing values.

model

If TRUE then the model frame is returned. This is essential if one wants to call summary subsequently.

method

The algorithmic method used to compute the fit. There are several options:

1. "br" The default method is the modified version of the Barrodale and Roberts algorithm for $l_1$-regression, used by l1fit in S, and is described in detail in Koenker and d'Orey(1987, 1994), default = "br". This is quite efficient for problems up to several thousand observations, and may be used to compute the full quantile regression process. It also implements a scheme for computing confidence intervals for the estimated parameters, based on inversion of a rank test described in Koenker(1994).

2. "fn" For larger problems it is advantageous to use the Frisch–Newton interior point method "fn". This is described in detail in Portnoy and Koenker(1997).

3. "pfn" For even larger problems one can use the Frisch–Newton approach after preprocessing "pfn". Also described in detail in Portnoy and Koenker(1997), this method is primarily well-suited for large n, small p problems, that is when the parametric dimension of the model is modest.

4. "sfn" For large problems with large parametric dimension it is often advantageous to use method "sfn" which also uses the Frisch-Newton algorithm, but exploits sparse algebra to compute iterates. This is especially helpful when the model includes factor variables that, when expanded, generate
design matrices that are very sparse. At present options for inference, i.e. summary methods are somewhat limited when using the "sfn" method. Only the option se = "nid" is currently available, but I hope to implement some bootstrap options in the near future.

5. "fnc" Another option enables the user to specify linear inequality constraints on the fitted coefficients; in this case one needs to specify the matrix R and the vector r representing the constraints in the form Rb ≥ r. See the examples below.

6. "conquer" For very large problems especially those with large parametric dimension, this option provides a link to the conquer of He, Pan, Tan, and Zhou (2020). Calls to summary when the fitted object is computed with this option invoke the multiplier bootstrap percentile method of the conquer package and can be considerably quicker than other options when the problem size is large. Further options for this fitting method are described in the conquer package. Note that this option employs a smoothing form of the usual QR objective function so solutions may be expected to differ somewhat from those produced with the other options.

7. "pfnb" This option is intended for applications with large sample sizes and/or moderately fine tau grids. It uses a form of preprocessing to accelerate the solution process. The loop over taus occurs inside the Fortran call and there should be more efficient than other methods in large problems.

8. "qfnb" This option is like the preceeding one except that it doesn’t use the preprocessing option.

9. "ppro" This option is an R prototype of the pfnb and is offered for historical/interpretative purposes, but probably should be considered deprecated.

10. "lasso" There are two penalized methods: "lasso" and "scad" that implement the lasso penalty and Fan and Li smoothly clipped absolute deviation penalty, respectively. These methods should probably be regarded as experimental.

contrasts a list giving contrasts for some or all of the factors default = NULL appearing in the model formula. The elements of the list should have the same name as the variable and should be either a contrast matrix (specifically, any full-rank matrix with as many rows as there are levels in the factor), or else a function to compute such a matrix given the number of levels.

... additional arguments for the fitting routines (see rq.fit.br and rq.fit.fnb, etc. and the functions they call).

Details

For further details see the vignette available from R with vignette("rq",package="quantreg") and/or the Koenker (2005). For estimation of nonlinear (in parameters) quantile regression models there is the function nlrq and for nonparametric additive quantile regression there is the function rqss. Fitting of quantile regression models with censored data is handled by the crq function.

Value

See rq.object and rq.process.object for details. Inferential matters are handled with summary. There are extractor methods logLik and AIC that are potentially relevant for model selection.
Method

The function computes an estimate on the tau-th conditional quantile function of the response, given
the covariates, as specified by the formula argument. Like `lm()`, the function presumes a linear
specification for the quantile regression model, i.e. that the formula defines a model that is linear in
parameters. For non-linear (in parameters) quantile regression see the package `nlrq()`. The function
minimizes a weighted sum of absolute residuals that can be formulated as a linear programming
problem. As noted above, there are several different algorithms that can be chosen depending on
problem size and other characteristics. For moderate sized problems ($n \ll 5,000, p \ll 20$) it is
recommended that the default "br" method be used. There are several choices of methods for com-
puting confidence intervals and associated test statistics. See the documentation for `summary.rq`
for further details and options.

References

[4] Xuming He and Xiaoou Pan and Kean Ming Tan and Wen-Xin Zhou, (2020) conquer: Convolution-
Type Smoothed Quantile Regression. https://CRAN.R-project.org/package=conquer
ity of Squared-error vs Absolute Error Estimators, (with discussion). *Statistical Science*, **12**, 279-
300.

See Also

FAQ, `summary.rq`, `nlrq`, `rq.fit`, `rq.wfit`, `rqss`, `rq.object`, `rq.process.object`

Examples

data(stackloss)
rq(stack.loss ~ stack.x,.5) #median (l1) regression fit for the stackloss data.
rq(stack.loss ~ stack.x,.25) #the 1st quartile,
  #note that 8 of the 21 points lie exactly on this plane in 4-space!
rq(stack.loss ~ stack.x, tau=-1) #this returns the full rq process
rq(rnorm(50) ~ 1, ci=FALSE) #ordinary sample median --no rank inversion ci
rq(rnorm(50) ~ 1, weights=runif(50),ci=FALSE) #weighted sample median
#plot of engel data and some rq lines see KB(1982) for references to data
data(engel)
attach(engel)
plot(income,foodexp,xlab="Household Income",ylab="Food Expenditure",type = "n", cex=.5)
points(income,foodexp,cex=.5,col="blue")
```r
taus <- c(.05, .1, .25, .75, .9, .95)
xx <- seq(min(income), max(income), 100)
f <- coef(rq((foodexp) ~ (income), tau = taus))
yy <- cbind(1, xx) %*% f
for(i in 1:length(taus)){
  lines(xx, yy[, i], col = "gray")
}
abline(lm(foodexp ~ income), col = "red", lty = 2)
abline(rq(foodexp ~ income), col = "blue")
legend(3000, 500, c("mean (LSE) fit", "median (LAE) fit"),
  col = c("red", "blue"), lty = c(2, 1))
# Example of plotting of coefficients and their confidence bands
plot(summary(rq(foodexp ~ income, tau = 1:49/50, data = engel)))
# Example to illustrate inequality constrained fitting
n <- 100
p <- 5
X <- matrix(rnorm(n * p), n, p)
y <- .95 * apply(X, 1, sum) + rnorm(n)
# constrain slope coefficients to lie between zero and one
R <- cbind(0, rbind(diag(p), -diag(p)))
r <- c(rep(0, p), -rep(1, p))
rq(y ~ X, R = R, r = r, method = "fnc")
```

---

**rq.fit**  
*Function to choose method for Quantile Regression*

### Description

Function to choose method for quantile regression.

### Usage

```r
rq.fit(x, y, tau = 0.5, method = "br", ...)  
```

### Arguments

- **x**: the design matrix
- **y**: the response variable
- **tau**: the quantile desired, if tau lies outside (0,1) the whole process is estimated.
- **method**: method of computation: "br" is Barrodale and Roberts exterior point method, "fn" is the Frisch-Newton interior point method.
- **...**: Optional arguments passed to fitting routine.

### See Also

rq, rq.fit.br, rq.fit.fnb
Description

This function controls the details of QR fitting by the simplex approach embodied in the algorithm of Koenker and d’Orey based on the median regression algorithm of Barrodale and Roberts. Typically, options controlling the construction of the confidence intervals would be passed via the ...() argument of rq().

Usage

rq.fit.br(x, y, tau=0.5, alpha=0.1, ci=FALSE, iid=TRUE, interp=TRUE, tcrit=TRUE)

Arguments

x the design matrix
y the response variable
tau the quantile desired, if tau lies outside (0,1) the whole process is estimated.
alpha the nominal noncoverage probability for the confidence intervals, i.e. 1-alpha is the nominal coverage probability of the intervals.
ci logical flag if T then compute confidence intervals for the parameters using the rank inversion method of Koenker (1994). See rq() for more details. If F then return only the estimated coefficients. Note that for large problems the default option ci=T and p=1.
iid logical flag if T then the rank inversion is based on an assumption of iid error model, if F then it is based on an nid error assumption. See Koenker and Machado (1999) for further details on this distinction.
interp As with typical order statistic type confidence intervals the test statistic is discrete, so it is reasonable to consider intervals that interpolate between values of the parameter just below the specified cutoff and values just above the specified cutoff. If interp = F then the 2 “exact” values above and below on which the interpolation would be based are returned.
tcrit Logical flag if T - Student t critical values are used, if F then normal values are used.

Details

If tau lies in (0,1) then an object of class “rq” is returned with various related inference apparatus. If tau lies outside [0,1] then an object of class rq.process is returned. In this case parametric programming methods are used to find all of the solutions to the QR problem for tau in (0,1), the p-variate resulting process is then returned as the array sol containing the primal solution and dsol containing the dual solution. There are roughly O(n log n) distinct solutions, so users should be aware that these arrays may be large and somewhat time consuming to compute for large problems.
Value

Returns an object of class "rq" for tau in (0,1), or else of class "rq.process". Note that rq.fit.br when called for a single tau value will return the vector of optimal dual variables. See rq.object and rq.process.object for further details.

References


See Also

rq, rq.fit.fnb

Examples

data(stackloss)
 rq.fit.br(stack.x, stack.loss, tau=.73 , interp=FALSE)

---

**rq.fit.conquer**

Optional Fitting Method for Quantile Regression

Description

This fitting method provides a link to the gradient descent for convolution smoothed quantile regression problem implemented in the conquer package of He et al (2020).

Usage

rq.fit.conquer (x, y, tau=0.5, kernel = c("Gaussian", "uniform", "parabolic", "triangular"), h = 0, tol = 1e-04, iteMax = 5000, ci = FALSE, alpha = 0.05, B = 200)

Arguments

- **x**: design matrix usually supplied via rq(), expected to have a intercept as the first column
- **y**: response vector usually supplied via rq()
- **tau**: quantile of interest
- **kernel**: A character string specifying the choice of kernel function. Default is "Gaussian". Other choices are "uniform", "parabolic" or "triangular".
- **h**: The bandwidth parameter for kernel smoothing of the QR objective function. Default is max((log(n) + p) / n)^0.4, 0.05. The default is used if the input value is less than 0.05.
rq.fit.fnb

Tolerance level of the gradient descent algorithm. The gradient descent algorithm terminates when the maximal entry of the gradient is less than "tol". Default is 1e-05.

iteMax
Maximum number of iterations. Default is 5000.

ci
A logical flag. Default is FALSE. If "ci = TRUE", then three types of confidence intervals (percentile, pivotal and normal) will be constructed via multiplier bootstrap. This option is subsumed in normal use by the summary.rq functionality.

alpha
Nominal level for confidence intervals, may be passed via the call to summary

B
Number of bootstrap replications. May be passed via summary.

Details
See documentation in the conquer package.

Value
Returns an object of class "rq".

References
Xuming He and Xiaou Pan and Kean Ming Tan and Wen-Xin Zhou, (2020) conquer: Convolution-Type Smoothed Quantile Regression, https://CRAN.R-project.org/package=conquer

See Also
rq

Description
This is a lower level routine called by rq() to compute quantile regression methods using the Frisch-Newton algorithm.

Usage
rq.fit.fnb(x, y, tau=0.5, rhs = (1-tau)*apply(x,2,sum), beta=0.99995, eps=1e-06)

Arguments
x
The design matrix

y
The response vector

tau
The quantile of interest, must lie in (0,1)

rhs
The right hand size of the dual equality constraint, modify at your own risk.

beta
technical step length parameter – alter at your own risk!
tolerance parameter for convergence. In cases of multiple optimal solutions there may be some discrepancy between solutions produced by method "fn" and method "br". This is due to the fact that "fn" tends to converge to a point near the centroid of the solution set, while "br" stops at a vertex of the set.

Details

The details of the algorithm are explained in Koenker and Portnoy (1997). The basic idea can be traced back to the log-barrier methods proposed by Frisch in the 1950's for constrained optimization. But the current implementation is based on proposals by Mehrotra and others in the recent (explosive) literature on interior point methods for solving linear programming problems. This function replaces an earlier one rq.fit.fn, which required the initial dual values to be feasible. This version allows the user to specify an infeasible starting point for the dual problem, that is one that may not satisfy the dual equality constraints. It still assumes that the starting value satisfies the upper and lower bounds.

Value

returns an object of class "rq", which can be passed to summary.rq to obtain standard errors, etc.

References


See Also

rq, rq.fit.br, rq.fit.pfn

Description

This is a lower level routine called by rq() to compute quantile regression methods using the Frisch-Newton algorithm. It allows the call to specify linear inequality constraints to which the fitted coefficients will be subjected. The constraints are assumed to be formulated as Rb >= r.

Usage

rq.fit.fnc(x, y, R, r, tau=0.5, beta=0.9995, eps=1e-06)
Arguments

- **x**: The design matrix
- **y**: The response vector
- **R**: The matrix describing the inequality constraints
- **r**: The right hand side vector of inequality constraints
- **tau**: The quantile of interest, must lie in (0,1)
- **beta**: technical step length parameter – alter at your own risk!
- **eps**: tolerance parameter for convergence. In cases of multiple optimal solutions there may be some discrepancy between solutions produced by method "fn" and method "br". This is due to the fact that "fn" tends to converge to a point near the centroid of the solution set, while "br" stops at a vertex of the set.

Details

The details of the algorithm are explained in Koenker and Ng (2002). The basic idea can be traced back to the log-barrier methods proposed by Frisch in the 1950's for constrained optimization. But the current implementation is based on proposals by Mehrotra and others in the recent (explosive) literature on interior point methods for solving linear programming problems. See "rq" helpfile for an example. It is an open research problem to provide an inference apparatus for inequality constrained quantile regression.

Value

returns an object of class "rq", which can be passed to `summary.rq` to obtain standard errors, etc.

References


See Also

rq, rq.fit.br, rq.fit.pfn

Description

Function to estimate a regression model by minimizing the weighted sum of several quantile regression functions. See Koenker(1984) for an asymptotic look at these estimators. This is a slightly generalized version of what Zou and Yuan (2008) call composite quantile regression in that it permits weighting of the components of the objective function and also allows further linear inequality constraints on the coefficients.
Usage

rq.fit.hogg(x, y, taus = c(0.1, 0.3, 0.5), weights = c(0.7, 0.2, 0.1),
R = NULL, r = NULL, beta = 0.99995, eps = 1e-06)

Arguments

x    design matrix
y    response vector
taus quantiles getting positive weight
weights weights assigned to the quantiles
R    optional matrix describing linear inequality constraints
r    optional vector describing linear inequality constraints
beta step length parameter of the Frisch Newton Algorithm
eps  tolerance parameter for the Frisch Newton Algorithm

Details

Mimimizes a weighted sum of quantile regression objective functions using the specified taus. The model permits distinct intercept parameters at each of the specified taus, but the slope parameters are constrained to be the same for all taus. This estimator was originally suggested to the author by Bob Hogg in one of his famous blue notes of 1979. The algorithm used to solve the resulting linear programming problems is either the Frisch Newton algorithm described in Portnoy and Koenker (1997), or the closely related algorithm described in Koenker and Ng(2002) that handles linear inequality constraints. See qrisk for illustration of its use in portfolio allocation.

Linear inequality constraints of the form $Rb \geq r$ can be imposed with the convention that $b$ is a $m + p$ where $m$ is the length(taus) and $p$ is the column dimension of $x$ without the intercept.

Value

coefficients estimated coefficients of the model

Author(s)

Roger Koenker

References


See Also

qrisk

---

**rq.fit.lasso**  
*Lasso Penalized Quantile Regression*

**Description**

The fitting method implements the lasso penalty for fitting quantile regression models. When the argument `lambda` is a scalar the penalty function is the L1 norm of the last (p-1) coefficients, under the presumption that the first coefficient is an intercept parameter that should not be subject to the penalty. When `lambda` is a vector it should have length equal the column dimension of the matrix `x` and then defines a coordinatewise specific vector of lasso penalty parameters. In this case `lambda` entries of zero indicate covariates that are not penalized. If `lambda` is not specified, a default value is selected according to the proposal of Belloni and Chernozhukov (2011). See `LassoLambdaHat` for further details. There should be a sparse version of this, but isn’t (yet). There should also be a preprocessing version, but isn’t (yet).

**Usage**

```r
rq.fit.lasso(x, y, tau = 0.5, lambda = NULL, beta = .99995, eps = 1e-06)
```

**Arguments**

- `x`  
  the design matrix
- `y`  
  the response variable
- `tau`  
  the quantile desired, defaults to 0.5.
- `lambda`  
  the value of the penalty parameter(s) that determine how much shrinkage is done. This should be either a scalar, or a vector of length equal to the column dimension of the `x` matrix. If unspecified, a default value is chosen according to the proposal of Belloni and Chernozhukov (2011).
- `beta`  
  step length parameter for Frisch-Newton method.
- `eps`  
  tolerance parameter for convergence.

**Value**

Returns a list with a coefficient, residual, tau and lambda components. When called from "rq" (as intended) the returned object has class "lassorqs".

**Author(s)**

R. Koenker
References


See Also

rq

Examples

```r
n <- 60
p <- 7
rho <- .5
beta <- c(3,1.5,0,2,0,0,0)
R <- matrix(0,p,p)
for(i in 1:p){
  for(j in 1:p){
    R[i,j] <- rho^abs(i-j)
  }
}
set.seed(1234)
x <- matrix(rnorm(n*p),n,p) %*% t(chol(R))
y <- x %*% beta + rnorm(n)
f <- rq(y ~ x, method="lasso",lambda = 30)
g <- rq(y ~ x, method="lasso",lambda = c(rep(0,4),rep(30,4)))
```

---

**Description**

A preprocessing algorithm for the Frisch Newton algorithm for quantile regression. This is one possible method for rq().

**Usage**

```r
rq.fit.pfn(x, y, tau=0.5, Mm.factor=0.8, max.bad.fixups=3, eps=1e-06)
```

**Arguments**

- `x`  
  design matrix usually supplied via rq()

- `y`  
  response vector usually supplied via rq()

- `tau`  
  quantile of interest

- `Mm.factor`  
  constant to determine sub sample size m

- `max.bad.fixups`  
  number of allowed mispredicted signs of residuals

- `eps`  
  convergence tolerance
Details
Preprocessing algorithm to reduce the effective sample size for QR problems with (plausibly) iid samples. The preprocessing relies on subsampling of the original data, so situations in which the observations are not plausibly iid, are likely to cause problems. The tolerance eps may be relaxed somewhat.

Value
Returns an object of type rq

Author(s)
Roger Koenker <rkoenker@uiuc.edu>

References

See Also
rq

---

Description
This is a lower level routine called by rq() to compute quantile regression parameters using the Frisch-Newton algorithm. It uses a form of preprocessing to accelerate the computations for situations in which several taus are required for the same model specification.

Usage
rq.fit.pfnb(x, y, tau, m0 = NULL, eps = 1e-06)

Arguments
x The design matrix
y The response vector
tau The quantiles of interest, must lie in (0,1), be sorted and preferably equally spaced.
m0 An initial reduced sample size by default is set to be round((n * (log(p) + 1) )^(2/3) this could be explored further to aid performance in extreme cases.
eps A tolerance parameter intended to bound the confidence band entries away from zero.
Details

The details of the Frisch-Newton algorithm are explained in Koenker and Portnoy (1997), as is the preprocessing idea which is related to partial sorting and the algorithms such as kuantile for univariate quantiles that operate in time $O(n)$. The preprocessing idea of exploiting nearby quantile solutions to accelerate estimation of adjacent quantiles is proposed in Chernozhukov et al (2020). This version calls a fortran version of the preprocessing algorithm that accepts multiple taus. The preprocessing approach is also implemented for a single tau in rq.fit.pfn which may be regarded as a prototype for this function since it is written entirely in R and therefore is easier to experiment with.

Value

returns a list with elements consisting of

1. coefficients a matrix of dimension ncol(x) by length(taus)
2. nit a 5 by m matrix of iteration counts: first two coordinates of each column are the number of interior point iterations, the third is the number of observations in the final glopped sample size, and the last two are the number of fixups and bad-fixups respectively. This is intended to aid fine tuning of the initial sample size, m0.
3. info an m-vector of convergence flags

References


See Also

rq, rq.fit.br, rq.fit.pfn

rq.fit.ppro

Preprocessing fitting method for QR

Description

Preprocessing method for fitting quantile regression models that exploits the fact that adjacent tau’s should have nearly the same sign vectors for residuals.

Usage

rq.fit.ppro(x, y, tau, weights = NULL, Mm.factor = 0.8, eps = 1e-06, ...)
**Arguments**

- **x**: Design matrix
- **y**: Response vector
- **tau**: Quantile vector of interest
- **weights**: Case weights
- **Mm.factor**: Constant determining initial sample size
- **eps**: Convergence tolerance
- **...**: Other arguments

**Details**

See references for further details.

**Value**

Returns a list with components:

- **coefficients**: Matrix of coefficient estimates
- **residuals**: Matrix of residual estimates
- **rho**: Vector of objective function values
- **weights**: Vector of case weights

**Author(s)**

Blaise Melly and Roger Koenker

**References**


**See Also**

rq.fit.pfn, boot.rq.pxy
Description

This is a lower level routine called by \texttt{rq()} to compute quantile regression parameters using the Frisch-Newton algorithm. In contrast to method "fn" it computes solutions for all the specified taus inside a fortran loop. See \texttt{rq.fit.pfnb} for further details on a more efficient preprocessing method.

Usage

\texttt{rq.fit.qfnb(x, y, tau)}

Arguments

- \texttt{x} The design matrix
- \texttt{y} The response vector
- \texttt{tau} The quantiles of interest, must lie in (0,1), be sorted and preferably equally spaced.

Details

The details of the Frisch-Newton algorithm are explained in Koenker and Portnoy (1997). The basic idea can be traced back to the log-barrier methods proposed by Frisch in the 1950's for linear programming. But the current implementation is based on proposals by Mehrotra and others in the recent (explosive) literature on interior point methods for solving linear programming problems. This function replaces an earlier one \texttt{rq.fit.fn}, which required the initial dual values to be feasible. The current version allows the user to specify an infeasible starting point for the dual problem, that is one that may not satisfy the dual equality constraints. It still assumes that the starting value satisfies the upper and lower bounds.

Value

returns a list with elements consisting of

1. coefficients a matrix of dimension ncol(x) by length(taus)
2. nit a 3-vector of iteration counts
3. info a convergence flag

References


See Also

\texttt{rq}, \texttt{rq.fit.br}, \texttt{rq.fit.pfn}
Description

The fitting method implements the smoothly clipped absolute deviation penalty of Fan and Li for fitting quantile regression models. When the argument lambda is a scalar the penalty function is the scad modified l1 norm of the last (p-1) coefficients, under the presumption that the first coefficient is an intercept parameter that should not be subject to the penalty. When lambda is a vector it should have length equal the column dimension of the matrix x and then defines a coordinatewise specific vector of scad penalty parameters. In this case lambda entries of zero indicate covariates that are not penalized. There should be a sparse version of this, but isn't (yet).

Usage

rq.fit.scad(x, y, tau = 0.5, alpha = 3.2, lambda = 1, start="rq", beta = .9995, eps = 1e-06)

Arguments

- **x**: the design matrix
- **y**: the response variable
- **tau**: the quantile desired, defaults to 0.5.
- **alpha**: tuning parameter of the scad penalty.
- **lambda**: the value of the penalty parameter that determines how much shrinkage is done. This should be either a scalar, or a vector of length equal to the column dimension of the x matrix.
- **start**: starting method, default method 'rq' uses the unconstrained rq estimate, while method 'lasso' uses the corresponding lasso estimate with the specified lambda.
- **beta**: step length parameter for Frisch-Newton method.
- **eps**: tolerance parameter for convergence.

Details

The algorithm is an adaptation of the "difference convex algorithm" described in Wu and Liu (2008). It solves a sequence of (convex) QR problems to approximate solutions of the (non-convex) scad problem.

Value

Returns a list with a coefficient, residual, tau and lambda components. When called from "rq" as intended the returned object has class "scadrqs".

Author(s)

R. Koenker
References


See Also

rq

Examples

```r
n <- 60
p <- 7
rho <- .5
beta <- c(3,1.5,0,2,0,0,0)
R <- matrix(0,p,p)
for(i in 1:p){
  for(j in 1:p){
    R[i,j] <- rho*abs(i-j)
  }
}
set.seed(1234)
x <- matrix(rnorm(n*p),n,p) %*% t(chol(R))
y <- x %*% beta + rnorm(n)
f <- rq(y ~ x, method="scad",lambda = 30)
g <- rq(y ~ x, method="scad", start = "lasso", lambda = 30)
```

---

rq.fit.sfn  
*Sparse Regression Quantile Fitting*

Description

Fit a quantile regression model using a sparse implementation of the Frisch-Newton interior-point algorithm.

Usage

```r
rq.fit.sfn(a, y, tau = 0.5, rhs = (1-tau)*c(t(a) %*% rep(1,length(y)))), control)
```

Arguments

- `a`: structure of the design matrix X stored in csr format
- `y`: response vector
- `tau`: desired quantile
- `rhs`: the right-hand-side of the dual problem; regular users shouldn’t need to specify this, but in special cases can be quite usefully altered to meet special needs. See e.g. Section 6.8 of Koenker (2005).
- `control`: control parameters for fitting routines: see sfn.control
Details

This is a sparse implementation of the Frisch-Newton algorithm for quantile regression described in Portnoy and Koenker (1997). The sparse matrix linear algebra is implemented through the functions available in the R package SparseM.

Value

- **coef**: Regression quantile coefficients
- **ierr**: Error code for the internal Fortran routine srqfnc:
  - 1: insufficient work space in call to extract
  - 2: nnzd > nnzdmx
  - 3: insufficient storage in iwork when calling ordmmd
  - 4: insufficient storage in iwork when calling sfinit
  - 5: nnzl > nnzlmax when calling sfinit
  - 6: nsub > nsubmax when calling sfinit
  - 7: insufficient work space in iwork when calling symfct
  - 8: inconsistency in input when calling symfct
  - 9: tmpsz > tmpmax when calling bfinit; increase tmpmax
  - 10: nonpositive diagonal encountered, not positive definite
  - 11: insufficient work storage in tmpvec when calling blkfct
  - 12: insufficient work storage in iwork when calling blkfct
  - 17: tiny diagonals replaced with Inf when calling blkfct
- **it**: Iteration count
- **time**: Amount of time used in the computation

Author(s)

Pin Ng

References


See Also

- `rq.fit.sfnc` for the constrained version, `SparseM` for a sparse matrix package for R
Examples

```r
# An artificial example:
n <- 200
p <- 50
set.seed(101)
X <- rnorm(n*p)
X[abs(X) < 2.0] <- 0
X <- cbind(1, matrix(X, n, p))
y <- 0.5 * apply(X,1,sum) + rnorm(n) # true beta = (0.5, 0.5, ...)

sX <- as.matrix.csr(X)
try(rq.o <- rq.fit.sfn(sX, y)) #-> not enough tmp memory
(tmpmax <- floor(1e5 + exp(-12.1)*(sX@ia[p+1]-1)^2.35))
## now ok:
rq.o <- rq.fit.sfn(sX, y, control = list(tmpmax = tmpmax))
```

---

**rq.fit.sfnc**

*Sparse Constrained Regression Quantile Fitting*

**Description**

Fit constrained regression quantiles using a sparse implementation of the Frisch-Newton Interior-point algorithm.

**Usage**

```r
rq.fit.sfnc(x, y, R, r, tau = 0.5,
            rhs = (1-tau)*c(t(x) %*% rep(1,length(y))),control)
```

**Arguments**

- `x`: structure of the design matrix X stored in csr format
- `y`: response vector
- `R`: constraint matrix stored in csr format
- `r`: right-hand-side of the constraint
- `tau`: desired quantile
- `rhs`: the right-hand-side of the dual problem; regular users shouldn’t need to specify this.
- `control`: control parameters for fitting see sfn.control

**Details**

This is a sparse implementation of the Frisch-Newton algorithm for constrained quantile regression described in Koenker and Portnoy (1996). The sparse matrix linear algebra is implemented through the functions available in the R package **SparseM**.
Value

- **coef**: Regression quantile coefficients
- **ierr**: Error code for the internal Fortran routine `srqfn`:
  1: insufficient work space in call to `extract`
  3: insufficient storage in `iwork` when calling `ordmmd`
  4: insufficient storage in `iwork` when calling `sfinit`
  5: `nnzl` > `nnzmax` when calling `sfinit`
  6: `nsub` > `nsubmax` when calling `sfinit`
  7: insufficient work space in `iwork` when calling `symfct`
  8: inconsistency in input when calling `symfct`
  9: `tmpsz` > `tmpmax` when calling `symfct`; increase `tmpmax`
  10: nonpositive diagonal encountered when calling `blkfct`
  11: insufficient work storage in `tmpvec` when calling `blkfct`
  12: insufficient work storage in `iwork` when calling `blkfct`
  13: `nnzd` > `nnzdmax` in `e,je` when calling `amub`
  14: `nnzd` > `nnzdmax` in `g,jg` when calling `amub`
  15: `nnzd` > `nnzdmax` in `h,jh` when calling `aplb`
  15: tiny diagonals replaced with Inf when calling `blkfct`

- **it**: Iteration count
- **time**: Amount of time used in the computation

Author(s)

Pin Ng

References


See Also

- `rq.fit.sfnc` for the unconstrained version, `SparseM` for the underlying sparse matrix R package.

Examples

```r
## An artificial example :
set.seed(17)
X <- rnorm(n * p)
X[abs(X) < 2.0] <- 0
X <- cbind(1, matrix(X, n, p))
y <- 0.5 * apply(X, 1, sum) + rnorm(n) # true beta = (0.5, 0.5, ...)
R <- rbind(diag(p+1), -diag(p+1))
```
\begin{verbatim}
r <- c(rep(0, p+1), rep(-1, p+1))
sX <- as.matrix.csr(X)
sR <- as.matrix.csr(R)
try(rq.o <- rq.fit.sfnc(sX, y, sR, r)) #-> not enough tmp memory
(tmpmax <- floor(1e5 + exp(-12.1)*(sX@ia[p+1]-1)^2.35))
## now ok:
rq.o <- rq.fit.sfnc(sX, y, sR, r, control = list(tmpmax = tmpmax))
\end{verbatim}

---

**rq.object**

### Description

These are objects of class "rq". They represent the fit of a linear conditional quantile function model.

### Details

The coefficients, residuals, and effects may be extracted by the generic functions of the same name, rather than by the \$ operator. For pure \texttt{rq} objects this is less critical than for some of the inheritor classes. In particular, for fitted \texttt{rq} objects using "lasso" and "scad" penalties, \texttt{logLik} and AIC functions compute degrees of freedom of the fitted model as the number of estimated parameters whose absolute value exceeds a threshold \texttt{edfThresh}. By default this threshold is 0.0001, but this can be passed via the AIC function if this value is deemed unsatisfactory. The function AIC is a generic function in R, with parameter \texttt{k} that controls the form of the penalty: the default value of \texttt{k} is 2 which yields the classical Akaike form of the penalty, while \texttt{k <= 0} yields the Schwarz (BIC) form of the penalty. Note that the extractor function \texttt{coef} returns a vector with missing values omitted.

### Generation

This class of objects is returned from the \texttt{rq} function to represent a fitted linear quantile regression model.

### Methods

The "rq" class of objects has methods for the following generic functions: \texttt{coef}, \texttt{effects}, \texttt{formula}, \texttt{labels}, \texttt{model.frame}, \texttt{model.matrix}, \texttt{plot}, \texttt{logLik}, \texttt{AIC}, \texttt{extractAIC}, \texttt{predict}, \texttt{print}, \texttt{print.summary}, \texttt{residuals}, \texttt{summary}

### Structure

The following components must be included in a legitimate \texttt{rq} object.
coefficients the coefficients of the quantile regression fit. The names of the coefficients are the names of the single-degree-of-freedom effects (the columns of the model matrix). If the model was fitted by method "br" with ci=TRUE, then the coefficient component consists of a matrix whose first column consists of the vector of estimated coefficients and the second and third columns are the lower and upper limits of a confidence interval for the respective coefficients.

residuals the residuals from the fit.

dual the vector dual variables from the fit.
rho The value(s) of objective function at the solution.

contrasts a list containing sufficient information to construct the contrasts used to fit any factors occurring in the model. The list contains entries that are either matrices or character vectors. When a factor is coded by contrasts, the corresponding contrast matrix is stored in this list. Factors that appear only as dummy variables and variables in the model that are matrices correspond to character vectors in the list. The character vector has the level names for a factor or the column labels for a matrix.

model optionally the model frame, if model=TRUE.

x optionally the model matrix, if x=TRUE.

y optionally the response, if y=TRUE.

See Also

rq, coefficients.

---

rq.process.object  Linear Quantile Regression Process Object

Description

These are objects of class rq.process. They represent the fit of a linear conditional quantile function model.

Details

These arrays are computed by parametric linear programming methods using using the exterior point (simplex-type) methods of the Koenker–d’Orey algorithm based on Barrodale and Roberts median regression algorithm.

Generation

This class of objects is returned from the rq function to represent a fitted linear quantile regression model.

Methods

The "rq.process" class of objects has methods for the following generic functions: effects, formula, labels, model.frame, model.matrix, plot, predict, print, print.summary, summary.
Structure

The following components must be included in a legitimate \texttt{rq.process} object.

\texttt{sol} The primal solution array. This is a (p+3) by J matrix whose first row contains the 'breakpoints' \( \tau_1, \tau_2, \ldots, \tau_J \), of the quantile function, i.e. the values in [0,1] at which the solution changes, row two contains the corresponding quantiles evaluated at the mean design point, i.e. the inner product of \( \bar{x} \) and \( b(\tau_i) \), the third row contains the value of the objective function evaluated at the corresponding \( \tau_j \), and the last p rows of the matrix give \( b(\tau_i) \). The solution \( b(\tau_i) \) prevails from \( \tau_i \) to \( \tau_i + 1 \). Portnoy (1991) shows that \( J = O_p(n \log n) \).

\texttt{dsol} The dual solution array. This is a n by J matrix containing the dual solution corresponding to sol, the ij-th entry is 1 if \( y_i > x_i b(\tau_j) \), is 0 if \( y_i < x_i b(\tau_j) \), and is between 0 and 1 otherwise, i.e. if the residual is zero. See Gutenbrunner and Jureckova(1991) for a detailed discussion of the statistical interpretation of dsol. The use of dsol in inference is described in Gutenbrunner, Jureckova, Koenker, and Portnoy (1994).

References


See Also

\texttt{rq}.

\texttt{rq.wfit} Function to choose method for Weighted Quantile Regression

Description

Weight the data and then call the chosen fitting algorithm.

Usage

\texttt{rq.wfit(x, y, tau=0.5, weights, method="br", ...)}
Arguments

- **x**: the design matrix
- **y**: the response variable
- **tau**: the quantile desired, if tau lies outside (0,1) the whole process is estimated.
- **weights**: weights used in the fitting
- **method**: method of computation: "br" is Barrodale and Roberts exterior point "fn" is the Frisch-Newton interior point method.
- ... Optional arguments passed to fitting routine.

See Also

`rq`, `rq.fit.br`, `rq.fit.fnb`

**rqProcess**  
*Compute Standardized Quantile Regression Process*

**Description**

Computes a standardize quantile regression process for the model specified by the formula, on the partition of [0,1] specified by the taus argument, and standardized according to the argument nullH. Intended for use in `KhmaladzeTest`.

**Usage**

`rqProcess(formula, data, taus, nullH = "location", ...)`

**Arguments**

- **formula**: model formula
- **data**: data frame to be used to interpret formula
- **taus**: quantiles at which the process is to be evaluated, if any of the taus lie outside (0,1) then the full process is computed for all distinct solutions.
- **nullH**: Null hypothesis to be used for standardization
- ... optional arguments passed to `summary rq`

**Details**

The process computes standardized estimates based on the hypothesis specified in the nullH argument. The Vhat component is rescaled by the Cholesky decomposition of the tau specific covariance matrix, the vhat component is rescaled by the marginal standard errors. The nature of the covariance matrix used for the standardization is controlled arguments passed via the ... argument to `summary rq`. If the full process is estimated then these covariance options aren’t available and only a simple iid-error form of the covariance matrix is used.
**Value**

- `taus` The points of evaluation of the process
- `qtaus` Values of xbar'betahat(taus)
- `Vhat` Joint parametric QR process
- `vhat` Marginal parametric QR processes

**Author(s)**

R. Koenker

**See Also**

`KhmaladzeTest`

---

**rqs.fit**

*Function to fit multiple response quantile regression models*

**Description**

Function intended for multiple response quantile regression called from `boot.rq` for wild bootstrap option.

**Usage**

```
  rqs.fit(x, y, tau=0.5, tol = 0.0001)
```

**Arguments**

- `x` the design matrix an n by p matrix.
- `y` the response variable as a n by m matrix
- `tau` the quantile desired, if tau lies outside (0,1)
- `tol` tolerance parameter for Barrodale and Roberts exterior point method.

**See Also**

`boot.rq`
Fitting function for additive quantile regression models with possible univariate and/or bivariate
nonparametric terms estimated by total variation regularization. See `summary.rqss` and `plot.rqss`
for further details on inference and confidence bands.

### Usage

```r
rqss(formula, tau = 0.5, data = parent.frame(), weights, subset, na.action,
    method = "sfn", lambda = NULL, contrasts = NULL, ztol = 1e-5, control, ...)
```

### Arguments

- **formula**: a formula object, with the response on the left of a `~` operator, and terms,
  separated by `+` operators, on the right. The terms may include `qss` terms that
  represent additive nonparametric components. These terms can be univariate or
  bivariate. See `qss` for details on how to specify these terms.

- **tau**: the quantile to be estimated, this must be a number between 0 and 1,

- **data**: a data.frame in which to interpret the variables named in the formula, or in the
  subset and the weights argument.

- **weights**: vector of observation weights; if supplied, the algorithm fits to minimize the sum
  of the weights multiplied into the absolute residuals. The length of weights must
  be the same as the number of observations. The weights must be nonnegative and it is strongly recommended that they be strictly positive, since zero weights are ambiguous.

- **subset**: an optional vector specifying a subset of observations to be used in the fitting.
  This can be a vector of indices of observations to be included, or a logical vector.

- **na.action**: a function to filter missing data. This is applied to the model.frame after any
  subset argument has been used. The default (with `na.fail`) is to create an error
  if any missing values are found. A possible alternative is `na.omit`, which deletes
  observations that contain one or more missing values.

- **method**: the algorithmic method used to compute the fit. There are currently two options.
  Both are implementations of the Frisch–Newton interior point method described
  in detail in Portnoy and Koenker(1997). Both are implemented using sparse
  Cholesky decomposition as described in Koenker and Ng (2003).
  Option "sfnc" is used if the user specifies inequality constraints. Option "sfn"
  is used if there are no inequality constraints. Linear inequality constraints on the
  fitted coefficients are specified by a matrix `R` and a vector `r`, specified inside the
  `qss` terms, representing the constraints in the form `Rb ≥ r`.
  The option `method = "lasso"` allows one to penalize the coefficients of the co-
  variates that have been entered linearly as in `rq.fit.lasso`; when this is spec-
  ified then there should be an additional `lambda` argument specified that deter-
  mines the amount of shrinkage.
lambda can be either a scalar, in which case all the slope coefficients are assigned this value, or alternatively, the user can specify a vector of length equal to the number of linear covariates plus one (for the intercept) and these values will be used as coordinate dependent shrinkage factors.

contrasts a list giving contrasts for some or all of the factors default = NULL appearing in the model formula. The elements of the list should have the same name as the variable and should be either a contrast matrix (specifically, any full-rank matrix with as many rows as there are levels in the factor), or else a function to compute such a matrix given the number of levels.

ztol A zero tolerance parameter used to determine the number of zero residuals in the fitted object which in turn determines the effective dimensionality of the fit.

control control argument for the fitting routines (see sfn.control)

... Other arguments passed to fitting routines

Details

Total variation regularization for univariate and bivariate nonparametric quantile smoothing is described in Koenker, Ng and Portnoy (1994) and Koenker and Mizera(2003) respectively. The additive model extension of this approach depends crucially on the sparse linear algebra implementation for R described in Koenker and Ng (2003). There are extractor methods logLik and AIC that is relevant to lambda selection. A more detailed description of some recent developments of these methods is available from within the package with vignette("rq"). Since this function uses sparse versions of the interior point algorithm it may also prove to be useful for fitting linear models without qss terms when the design has a sparse structure, as for example when there is a complicated factor structure.

If the MatrixModels and Matrix packages are both loadable then the linear-in-parameters portion of the design matrix is made in sparse matrix form; this is helpful in large applications with many factor variables for which dense formation of the design matrix would take too much space.

Although modeling with rqss typically imposes smoothing penalties on the total variation of the first derivative, or gradient, of the fitted functions, for univariate smoothing, it is also possible to penalize total variation of the function itself using the option Dorder = 0 inside qss terms. In such cases, estimated functions are piecewise constant rather than piecewise linear. See the documentation for qss for further details.

Value

The function returns a fitted object representing the estimated model specified in the formula. See rqss.object for further details on this object, and references to methods to look at it.

Note

If you intend to embed calls to rqss inside another function, then it is advisable to pass a data frame explicitly as the data argument of the rqss call, rather than relying on the magic of R scoping rules.

Author(s)

Roger Koenker
References


See Also

`qss`

Examples

```r
n <- 200
x <- sort(rchisq(n,4))
z <- x + rnorm(n)
y <- log(x)+ .1*(log(x))^2 + log(x)*rnorm(n)/4 + z
plot(x, y-z)
f.N <- rqss(y ~ qss(x, constraint= "N") + z)
f.I <- rqss(y ~ qss(x, constraint= "I") + z)
f.CI <- rqss(y ~ qss(x, constraint= "CI") + z)
lines(x[-1], f.N$coef[1] + f.N$coef[-(1:2)])
lines(x[-1], f.I$coef[1] + f.I$coef[-(1:2)], col="blue")
lines(x[-1], f.CI$coef[1] + f.CI$coef[-(1:2)], col="red")

## A bivariate example
data(CobarOre)
fCO <- rqss(z ~ qss(cbind(x,y), lambda= .08), data=CobarOre)
plot(fCO)
```

rqss.object

*RQSS Objects and Summarization Thereof*

Description

Functions to reveal the inner meaning of objects created by rqss fitting.

Usage

```r
## S3 method for class 'rqss'
logLik(object, ...)
## S3 method for class 'rqss'
AIC(object, ..., k=2)
```
Arguments

- **object**: an object returned from `rqss` fitting, describing an additive model estimating a conditional quantile function. See `qss` for details on how to specify these terms.
- **x**: an `rqss` object, as above.
- **k**: a constant factor governing the weight attached to the penalty term on effective degrees of freedom of the fit. By default k = 2 corresponding to the Akaike version of the penalty, negative values indicate that the k should be set to log(n) as proposed by Schwarz (1978).
- **...**: additional arguments

Details

Total variation regularization for univariate and bivariate nonparametric quantile smoothing is described in Koenker, Ng and Portnoy (1994) and Koenker and Mizera (2003) respectively. The additive model extension of this approach depends crucially on the sparse linear algebra implementation for R described in Koenker and Ng (2003). Eventually, these functions should be expanded to provide an automated lambda selection procedure.

Value

The function `summary.rqss` returns a list consisting of the following components:

- **fidelity**: Value of the quantile regression objective function.
- **penalty**: A list consisting of the values of the total variation smoothing penalty for each of additive components.
- **edf**: Effective degrees of freedom of the fitted model, defined as the number of zero residuals of the fitted model, Koenker Mizera (2003) for details.
- **qssedfs**: A list of effective degrees of freedom for each of the additive components of the fitted model, defined as the number of non-zero elements of each penalty component of the residual vector.
- **lamdas**: A list of the lambdas specified for each of the additive components of the model.

Author(s)

Roger Koenker
References


See Also

plot rqss

Examples

```r
require(MatrixModels)

n <- 200
x <- sort(rchisq(n,4))
z <- x + rnorm(n)
y <- log(x)+ .1*(log(x))^2 + log(x)*rnorm(n)/4 + z
plot(x, y-z)

f.N <- rqss(y ~ qss(x, constraint= "N") + z)
plot(x, y-z)
lines(x[-1], f.N$coef[1] + f.N$coef[-(1:2)])
lines(x[-1], f.I$coef[1] + f.I$coef[-(1:2)], col="blue")
lines(x[-1], f.CI$coef[1] + f.CI$coef[-(1:2)], col="red")

## A bivariate example

data(CobarOre)
fCO <- rqss(z ~ qss(cbind(x,y), lambda= .08), data=CobarOre)
plot(fCO)
```

sfn.control

Set Control Parameters for Sparse Fitting

Description

Auxiliary function for setting storage dimensions and other parameters rq.fit.sfn[c]

Usage

```r
sfn.control(nsubmax = NULL, tmpmax = NULL, nnz1max = NULL, cachsz = 64,
small = 1e-06, maxiter = 100, warn.mesg = TRUE)
```
Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>nsubmax</td>
<td>upper bound for dimension of lindx</td>
</tr>
<tr>
<td>tmpmax</td>
<td>upper bound for dimension of tmpvec</td>
</tr>
<tr>
<td>nnz1max</td>
<td>upper bound for non-zero entries of L stored in</td>
</tr>
<tr>
<td></td>
<td>lnz, including diagonal</td>
</tr>
<tr>
<td>cachsz</td>
<td>size of cache in kbytes on target machine</td>
</tr>
<tr>
<td>small</td>
<td>convergence tolerance for interior point algorithm</td>
</tr>
<tr>
<td>maxiter</td>
<td>maximal number of interior point iterations.</td>
</tr>
<tr>
<td>warn.mesg</td>
<td>logical flag controlling printing of warnings.</td>
</tr>
</tbody>
</table>

Details

Sparse fitting requires a number of temporary storage arrays whose size depends on problem specific features in somewhat mysterious ways, parameters controlling these sizes and some other fitting aspects can be controlled by specifying elements of this control object.

Value

List with components named as the arguments given above.

Author(s)

Roger Koenker

See Also

See Also rq.fit.sfn

srisk  

Markowitz (Mean-Variance) Portfolio Optimization

Description

This function estimates optimal mean-variance portfolio weights from a matrix of historical or simulated asset returns.

Usage

srisk(x, mu = 0.07, lambda = 1e+08, alpha = 0.1, eps = 1e-04)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Matrix of asset returns</td>
</tr>
<tr>
<td>mu</td>
<td>Required mean rate of return for the portfolio</td>
</tr>
<tr>
<td>lambda</td>
<td>Lagrange multiplier associated with mean return constraint</td>
</tr>
<tr>
<td>alpha</td>
<td>Choquet risk parameter, unimplemented</td>
</tr>
<tr>
<td>eps</td>
<td>tolerance parameter for mean return constraint</td>
</tr>
</tbody>
</table>
Details

The portfolio weights are estimated by solving a constrained least squares problem.

Value

- \( \hat{p} \): Optimal portfolio weights
- \( \hat{\mu} \): Mean return in sample
- \( \hat{\sigma} \): Standard deviation of returns in sample

Author(s)

R. Koenker

See Also

- qrisk

Description

Returns a summary object for a censored quantile regression fit. A null value will be returned if printing is invoked.

Usage

```r
# S3 method for class 'crq'
summary(object, taus = 1:4/5, alpha = .05, se="boot", covariance=TRUE, ...)
# S3 method for class 'summary.crq'
print(x, digits = max(5, .Options$digits - 2), ...)
# S3 method for class 'summary.crqs'
print(x, ...)
# S3 method for class 'summary.crqs'
plot(x, nrow = 3, ncol = 3, CoxPHit = NULL, ...)
```

Arguments

- `object`: An object of class "crq" produced by a call to `crq()`.
- `taus`: Quantiles to be summarized. Specifying only one value can produce annoying error messages harmful to your mental health.
- `x`: An object of class "crq" produced by a call to `crq()`.
- `se`: specifies the method used to compute standard standard errors. but the only available method (so far) is "boot". Further arguments to `boot.crq` and `boot.rq` can be passed with the ... argument.
covariance logical flag to indicate whether the full covariance matrix of the estimated parameters should be returned.
nrow Number of rows of the plot layout.
col Number of columns of the plot layout.
alpha Confidence level for summary intervals.
digits Number of digits to be printed in summary display.
CoxPHit An object of class coxph produced by coxph.
... Optional arguments to summary, e.g. to specify bootstrap methods sample sizes, etc. see boot.rq and boot.crq

Details

For the Powell method the resampling strategy used by the se = "boot" method is based on the Bilias, Chen and Ying (2000) proposal. For the Portnoy and Peng-Huang methods the bootstrapping is by default actually based on a delete-d jackknife, as described in Portnoy (2013), but resampling xy pairs using either conventional multinomial resampling or using exponential weighting as in Bose and Chatterjee (2003) can be used by specifying the bmethod argument. Note that the default number of replications is set at \( R = 100 \) a value that is obviously too small for most applications. This is done merely to speed up the examples in the documentation and facilitate testing. Larger, more appropriate values of \( R \) can be passed to the bootstrapping functions via the ... argument of the summary method. It is important to recognize that when some of the bootstrap replications are NA they are simply ignored in the computation of the confidence bands and standard errors as currently reported. The number of these NAs is returned as part of the summary.crq object, and when printed is also reported.

Value

For method "Powell" an object of class summary.crq is returned with the following components:

coefficients a p by 4 matrix consisting of the coefficients, their estimated standard errors, their t-statistics, and their associated p-values.
cov the estimated covariance matrix for the coefficients in the model, provided that covariance = TRUE appears in the calling sequence.
rdf the residual degrees of freedom
tau the quantile estimated

For the other methods an object of class summary.crq is returned with the following components:

coefficients a list of p by 6 matrix consisting of the coefficients, upper and lower bounds for a (1-alpha) level confidence interval, their estimated standard errors, their t-statistics, and their associated p-values, one component for each element of the specified taus vector.
cov the estimated covariance matrix for the coefficients in the model, provided that covariance = TRUE in the called sequence.
References


See Also

crq, QTECox

---

**summary.rq**  
*Summary methods for Quantile Regression*

**Description**

Returns a summary list for a quantile regression fit. A null value will be returned if printing is invoked.

**Usage**

```r
## S3 method for class 'rq'
summary(object, se = NULL, covariance=FALSE, hs = TRUE, U = NULL, gamma = 0.7, ...)
## S3 method for class 'rqs'
summary(object, ...)
```

**Arguments**

- `object` This is an object of class "rq" or "rqs" produced by a call to `rq()`, depending on whether one or more taus are specified.
- `se` specifies the method used to compute standard standard errors. There are currently seven available methods:
  1. "rank" which produces confidence intervals for the estimated parameters by inverting a rank test as described in Koenker (1994). This method involves solving a parametric linear programming problem, and for large sample sizes can be extremely slow, so by default it is only used when the sample size is less than 1000, see below. The default option assumes that the errors are iid, while the option iid = FALSE implements a proposal of Koenker Machado (1999). See the documentation for `rq.fit.br` for additional arguments.
  2. "iid" which presumes that the errors are iid and computes an estimate of the asymptotic covariance matrix as in KB(1978).
summary.rq

3. "nid" which presumes local (in tau) linearity (in x) of the the conditional quantile functions and computes a Huber sandwich estimate using a local estimate of the sparsity. If the initial fitting was done with method "sfn" then use of se = "nid" is recommended. However, if the cluster option is also desired then se = "boot" can be used and bootstrapping will also employ the "sfn" method.

4. "ker" which uses a kernel estimate of the sandwich as proposed by Powell(1991).

5. "boot" which implements one of several possible bootstrapping alternatives for estimating standard errors including a variate of the wild bootstrap for clustered response. See boot.rq for further details.

6. "BLB" which implements the bag of little bootstraps method proposed in Kleiner, et al (2014). The sample size of the little bootstraps is controlled by the parameter gamma, see below. At present only bs = "xy" is sanction, and even that is experimental. This option is intended for applications with very large n where other flavors of the bootstrap can be slow.

7. "conquer" which is invoked automatically if the fitted object was created with method = "conquer", and returns the multiplier bootstrap percentile confidence intervals described in He et al (2020).


If se = NULL (the default) and covariance = FALSE, and the sample size is less than 1001, then the "rank" method is used, otherwise the "nid" method is used.

covariance logical flag to indicate whether the full covariance matrix of the estimated parameters should be returned.

hs Use Hall Sheather bandwidth for sparsity estimation If false revert to Bofinger bandwidth.

U Resampling indices or gradient evaluations used for bootstrap, see boot.rq.

gamma parameter controlling the effective sample size of the bag of little bootstrap samples that will be \( b = n^{\gamma} \) where \( n \) is the sample size of the original model.

... Optional arguments to summary, e.g. bs = method to use bootstrapping, see boot.rq.

When using the "rank" method for confidence intervals, which is the default method for sample sizes less than 1000, the type I error probability of the intervals can be controlled with the alpha parameter passed via "...", thereby controlling the width of the intervals plotted by plot.summary.rqs. Similarly, the arguments alpha, mofn and kex can be passed when invoking the "extreme" option for "se" to control the percentile interval reported, given by estimated quantiles \([\alpha/2, 1 - \alpha/2]\); kex is a tuning parameter for the extreme value confidence interval construction. The size of the bootstrap subsamples for the "extreme" option can also be controlled by passing the argument mofn via "...".

Default values for kex, mofn and alpha are 20, floor(n/5) and 0.1, respectively.

Details

When the default summary method is used, it tries to estimate a sandwich form of the asymptotic covariance matrix and this involves estimating the conditional density at each of the sample ob-
servations, negative estimates can occur if there is crossing of the neighboring quantile surfaces used to compute the difference quotient estimate. A warning message is issued when such negative estimates exist indicating the number of occurrences – if this number constitutes a large proportion of the sample size, then it would be prudent to consider an alternative inference method like the bootstrap. If the number of these is large relative to the sample size it is sometimes an indication that some additional nonlinearity in the covariates would be helpful, for instance quadratic effects. Note that the default se method is rank, unless the sample size exceeds 1001, in which case the rank method is used. There are several options for alternative resampling methods. When summary.rqs is invoked, that is when summary is called for a rqs object consisting of several taus, the B components of the returned object can be used to construct a joint covariance matrix for the full object.

Value

a list is returned with the following components, when object is of class "rqs" then there is a list of such lists.

coefficients a p by 4 matrix consisting of the coefficients, their estimated standard errors, their t-statistics, and their associated p-values, in the case of most "se" methods. For methods "rank" and "extreme" potentially asymmetric confidence intervals are return in lieu of standard errors and p-values.

cov the estimated covariance matrix for the coefficients in the model, provided that cov=TRUE in the called sequence. This option is not available when se = "rank".

Hinv inverse of the estimated Hessian matrix returned if cov=TRUE and se %in% c("nid","ker") , note that for se = "boot" there is no way to split the estimated covariance matrix into its sandwich constituent parts.

J Unscaled Outer product of gradient matrix returned if cov=TRUE and se != "iid". The Huber sandwich is cov = tau (1-tau) Hinv %*% J %*% Hinv. as for the Hinv component, there is no J component when se == "boot". (Note that to make the Huber sandwich you need to add the tau (1-tau) mayonnaise yourself.)

B Matrix of bootstrap realizations.

U Matrix of bootstrap randomization draws.

References


See Also

rq bandwidth.rq

Examples

data(stackloss)
y <- stack.loss
x <- stack.x
summary(rq(y ~ x, method="fn")) # Compute se's for fit using "nid" method.
summary(rq(y ~ x, ci=FALSE), se="ker")
# default "br" alg, and compute kernel method se's

summary.rqss  Summary of rqss fit

Description

Summary Method for a fitted rqss model.

Usage

## S3 method for class 'rqss'
summary(object, cov = FALSE, ztol = 1e-5, ...)

Arguments

object an object returned from rqss fitting, describing an additive model estimating a
conditional quantile function. See qss for details on how to specify these terms.
cov if TRUE return covariance matrix for the parametric components as Vcov and a
list of covariance matrices for the nonparametric components as Vqss
ztol Zero tolerance parameter used to determine the number of zero residuals indi-
cating the estimated parametric dimension of the model, the so-called effective
degrees of freedom.
... additional arguments

Details

This function is intended to explore inferential methods for rqss fitting. The function is modeled
after summary.gam in Simon Wood's (2006) mgcv package. (Of course, Simon should not be
blamed for any deficiencies in the current implementation. The basic idea is to condition on the
lambda selection and construct quasi-Bayesian credibility intervals based on normal approximation
of the "posterior," as computed using the Powell kernel estimate of the usual quantile regression
sandwich. See summary.rq for further details and references. The function produces a conventional
coefficient table with standard errors t-statistics and p-values for the coefficients on the parametric
part of the model, and another table for additive nonparametric effects. The latter reports F statistics
intended to evaluate the significance of these components individually. In addition the fidelity (value
of the QR objective function evaluated at the fitted model), the effective degrees of freedom, and
the sample size are reported.
Value

coef
Table of estimated coefficients and their standard errors, t-statistics, and p-values for the parametric components of the model.

qsstab
Table of approximate F statistics, effective degrees of freedom and values of the penalty terms for each of the additive nonparametric components of the model, and the lambda values assigned to each.

fidelity
Value of the quantile regression objective function.

tau
Quantile of the estimated model

formula
formula of the estimated model

edf
Effective degrees of freedom of the fitted model, defined as the number of zero residuals of the fitted model, see Koenker Mizera (2003) for details.

n
The sample size used to fit the model.

Vcov
Estimated covariance matrix of the fitted parametric component

Vqss
List of estimated covariance matrices of the fitted nonparametric component

Author(s)
Roger Koenker

References


See Also

plot.rqss

Examples

n <- 200
x <- sort(rchisq(n,4))
z <- x + rnorm(n)
y <- log(x) + .1*(log(x))^2 + log(x)*rnorm(n)/4 + z
f <- rqss(y ~ qss(x) + z)
summary(f)
**Description**

Defunct Function to produce a table of quantile regression results for a group of specified quantiles. See `rq` which now permits multiple taus.

**Usage**

```r
table.rq(x, ...)
```

**Arguments**

- `x` input
- `...` other optional arguments

**Value**

None.

**See Also**

`rq`.

---

**uis**  
**UIS Drug Treatment study data**

**Description**

There are 628 data points in the original data, 575 of which have no missing values.

Variable descriptions:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Codes/Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Identification Code</td>
<td>1 - 628</td>
</tr>
<tr>
<td>AGE</td>
<td>Age at Enrollment</td>
<td>Years</td>
</tr>
<tr>
<td>BECK</td>
<td>Beck Depression Score</td>
<td>0.000 - 54.000</td>
</tr>
<tr>
<td>HC</td>
<td>Heroin/Cocaine Use During 3 Months Prior to Admission</td>
<td>1 = Heroin &amp; Cocaine, 2 = Heroin Only, 3 = Cocaine Only, 4 = Neither Heroin nor Cocaine</td>
</tr>
<tr>
<td>IV</td>
<td>History of IV Drug Use</td>
<td>1 = Never, 2 = Previous, 3 = Recent</td>
</tr>
<tr>
<td>NDT</td>
<td>Number of Prior Drug Treatments</td>
<td>0 - 40</td>
</tr>
</tbody>
</table>
RACE | Subject’s Race | 0 = White  
| | | 1 = Non-White  
TREAT | Treatment Randomization Assignment | 0 = Short  
| | | 1 = Long  
SITE | Treatment Site | 0 = A  
| | | 1 = B  
LEN.T | Length of Stay in Treatment (Admission Date to Exit Date) | Days  
TIME | Time to Drug Relapse (Measured from Admission Date) | Days  
CENSOR | Event for Treating Lost to Follow-Up as Returned to Drugs | 1 = Returned to Drugs  
| | | or Lost to Follow-Up  
| | | 0 = Otherwise  
Y | log of TIME |  
ND1 | Component of NDT |  
ND2 | Component of NDT |  
LNDT |  
FRAC | Compliance fraction | LEN.T/90 for short trt  
| | | LEN.T/180 for long trt  
IV3 | Recent IV use | 1 = Yes  
| | | 0 = No  

**Usage**

`data(uis)`

**Format**

A data frame with dimension 575 by 18.

**Source**

Table 1.3 of Hosmer,D.W. and Lemeshow, S. (1998)

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