Package ‘lspartition’

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Description

This package provides tools for statistical analysis using B-splines, wavelets, and piecewise polynomials as described in Cattaneo, Farrell and Feng (2019a): `lsprobust` for least squares point estimation with robust bias-corrected pointwise and uniform inference procedures; `lspkselect` for data-driven procedures for selecting the IMSE-optimal number of partitioning knots; `lsprobust.plot` for regression plots with robust confidence intervals and confidence bands; `lsplincom` for estimation and inference for linear combination of regression functions of different groups.

The companion software article, Cattaneo, Farrell and Feng (2019b), provides further implementation details and empirical illustrations.

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References


Description

`lspkselect` implements data-driven procedures to select the Integrated Mean Squared Error (IMSE) optimal number of partitioning knots for partitioning-based least squares regression estimators. Three series methods are supported: B-splines, compactly supported wavelets, and piecewise polynomials. See Cattaneo and Farrell (2013) and Cattaneo, Farrell and Feng (2019a) for complete details.

The command also provides a detailed introduction to the command, which is given in Cattaneo, Farrell and Feng (2019b). For more details, and related Stata and R packages useful for empirical analysis, visit https://sites.google.com/site/nppackages/.
Usage

lspkselect(y, x, m = NULL, m.bc = NULL, smooth = NULL,
    bsmooth = NULL, deriv = NULL, method = "bs", ktype = "uni",
    kselect = "imse-dpi", proj = TRUE, bc = "bc3", vce = "hc2",
    subset = NULL, rotnorm = TRUE)

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

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

Arguments

y
Outcome variable.

x
Independent variable. A matrix or data frame.

m
Order of basis used in the main regression. Default is \text{m}=2.

m.bc
Order of basis used to estimate leading bias. Default is \text{m.bc}=\text{m}+1.

smooth
Smoothness of B-splines for point estimation. When \text{smooth}=s, B-splines have \text{s}-order continuous derivatives. Default is \text{smooth}=\text{m}-2.

bsmooth
Smoothness of B-splines for bias correction. Default is \text{bsmooth}=\text{m.bc}-2.

deriv
Derivative order of the regression function to be estimated. A vector object of the same length as \text{ncol(x)}. Default is \text{deriv}=c(0,\ldots,0).

method
Type of basis used for expansion. Options are "bs" for B-splines, "wav" for compactly supported wavelets (Cohen, Daubechies and Vial, 1993), and "pp" for piecewise polynomials. Default is \text{method}="bs".

ktype
Knot placement. Options are "uni" for evenly spaced knots over the support of \text{x} and "qua" for quantile-spaced knots. Default is \text{ktype}="uni".

kselect
Method for selecting the number of inner knots used by \text{lspkselect}. Options are "imse-rot" for a rule-of-thumb (ROT) implementation of IMSE-optimal number of knots, "imse-dpi" for second generation direct plug-in (DPI) implementation of IMSE-optimal number of knots, and "all" for both. Default is \text{kselect}="imse-dpi".

proj
If \text{TRUE}, projection of leading approximation error onto the lower-order approximating space is included for bias correction (splines and piecewise polynomial only). Default is \text{proj}=\text{TRUE}.

bc
Bias correction method. Options are "bc1" for higher-order-basis bias correction, "bc2" for least squares bias correction, and "bc3" for plug-in bias correction. Defaults are "bc3" for splines and piecewise polynomials and "bc2" for wavelets.

vce
Procedure to compute the heteroskedasticity-consistent (HCK) variance-covariance matrix estimator with plug-in residuals. Options are

- "hc0" for unweighted residuals (HC0).
- "hc1" for HC1 weights.
"hc2" for HC2 weights. Default.
"hc3" for HC3 weights.

subset Optional rule specifying a subset of observations to be used.

rotnorm If TRUE, ROT selection is adjusted using normal densities.

... further arguments

object class lspkselect objects.

Value

ks A matrix may contain k.rot (IMSE-optimal number of knots for the main regression through ROT implementation), k.bias.rot (IMSE-optimal number of knots for bias correction through ROT implementation), k.dpi (IMSE-optimal number of knots for the main regression through DPI implementation), k.bias.dpi (IMSE-optimal number of knots for bias correction through DPI implementation)

opt A list containing options passed to the function.

Methods (by generic)

- print: print method for class "lspkselect".
- summary: summary method for class "lspkselect".

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References


See Also

lprobust, lprobust.plot, lsplincom
Examples

```r
x <- data.frame(runif(500), runif(500))
y <- sin(4*x[,1])+cos(x[,2])+rnorm(500)
est <- lspkselect(y, x)
summary(est)
```

---

**Description**

lsplincom implements user-specified linear combinations across different data sub-groups for regression functions estimation, and computes corresponding (pointwise and uniform) robust bias-corrected inference measures. Estimation and inference is implemented using the lspartition package. See Cattaneo and Farrell (2013) and Cattaneo, Farrell and Feng (2019a) for complete details.

A detailed introduction to this command is given in Cattaneo, Farrell and Feng (2019b).

For more details, and related Stata and R packages useful for empirical analysis, visit https://sites.google.com/site/nppackages/.

**Usage**

```r
lsplincom(y, x, G, R, eval = NULL, neval = NULL, level = 95,
band = FALSE, cb.method = NULL, cb.grid = NULL, cb.ngrid = 50,
B = 1000, subset = NULL, knot = NULL, ...)
```

```r
## S3 method for class 'lsplincom'
print(x, ...)
```

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

**Arguments**

- `y` Outcome variable.
- `x` Independent variable. A matrix or data frame.
- `G` Group indicator. It may take on multiple discrete values.
- `R` A numeric vector giving the linear combination of interest. Each element is the coefficient of the conditional mean estimator of one group, and they are ordered ascendingly along the value of `G`.
- `eval` Evaluation points. A matrix or data frame.
- `neval` Number of quantile-spaced evaluating points.
- `level` Confidence level used for confidence intervals; default is `level=95`.
- `band` If `TRUE`, the critical value for constructing confidence band is calculated. Default is `band=FALSE`.
cb.method
Method used to calculate the critical value for confidence bands. Options are "pl" for a simulation-based plug-in procedure, and "wb" for a wild bootstrap procedure. If band=TRUE with cb.method unspecified, default is cb.method="pl".

cb.grid
A matrix containing all grid points used to construct confidence bands. Each row corresponds to the coordinates of one grid point.

cb.ngrid
A numeric vector of the same length as ncol(x). Each element corresponds to the number of grid points for each dimension used to implement uniform inference. Default is uni.ngrid=50.

B
Number of simulated samples used to obtain the critical value for confidence bands. Default is B=1000.

subset
Optional rule specifying a subset of observations to be used.

knot
A list of numeric vectors giving the knot positions (including boundary knots) for each dimension which are used in the main regression. The length of the list is equal to ncol(x). If not specified, it uses the number of knots either specified by users or computed by the companion command lspkselect to generate the corresponding knots according to the rule specified by ktype. See help for lsprobust.

...Arguments to be passed to the function. See lsprobust.

object
class lsplincom objects.

Value

Estimate
A matrix containing eval (grid points), N (effective sample sizes), tau.cl (point estimates with a basis of order m), tau.bc (bias corrected point estimates with a basis of order m.bc), se.cl (standard error corresponding to tau.cl), and se.rb (robust standard error).

sup.cval
Critical value for constructing confidence bands.

opt
A list containing options passed to the function.

Methods (by generic)

• print: print method for class "lsplincom".
• summary: summary method for class "lsplincom"

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References


**lsprobust**

Partitioning-Based Least Squares Regression with Robust Inference.

**Description**

lsprobust implements partitioning-based least squares point estimators for the regression function and its derivatives. It also provides robust bias-corrected (pointwise and uniform) inference, including simulation-based confidence bands. Three series methods are supported: B-splines, compact supported wavelets, and piecewise polynomials. See Cattaneo and Farrell (2013) and Cattaneo, Farrell and Feng (2019a) for complete details.

Companion commands: `lspkselect` for data-driven IMSE-optimal selection of the number of knots on rectangular partitions; `lsprobust.plot` for plotting results; `lsplincom` for multiple sample estimation and inference.

A detailed introduction to this command is given in Cattaneo, Farrell and Feng (2019b).

For more details, and related Stata and R packages useful for empirical analysis, visit [https://sites.google.com/site/nppackages/](https://sites.google.com/site/nppackages/).

**Usage**

```r
lsprobust(y, x, eval = NULL, neval = NULL, method = "bs", m = NULL, m.bc = NULL, deriv = NULL, smooth = NULL, bsmooth = NULL, ktype = "uni", knot = NULL, nknot = NULL, same = TRUE, bknot = NULL, bnknot = NULL, J = NULL, bc = "bc3", proj = TRUE, kselect = "imse-dpi", vce = "hc2", level = 95, uni.method = NULL, uni.grid = NULL, uni.ngrid = 50, uni.out = FALSE, band = FALSE, B = 1000, subset = NULL, rotnorm = TRUE)
```

```r
## S3 method for class 'lsprobust'
print(x, ...)
```

```r
## S3 method for class 'lsprobust'
summary(object, ...)
```
## Arguments

**y**  
Outcome variable.

**x**  
Independent variable. A matrix or data frame.

**eval**  
Evaluation points. A matrix or data frame.

**neval**  
Number of quantile-spaced evaluating points.

**method**  
Type of basis used for expansion. Options are "bs" for B-splines, "wav" for compactly supported wavelets (Cohen, Daubechies and Vial, 1993), and "pp" for piecewise polynomials. Default is method="bs".

**m**  
Order of basis used in the main regression. Default is m=2. For B-splines, if smooth is specified but m is unspecified, default is m=smooth+2.

**m.bc**  
Order of basis used to estimate leading bias. Default is m.bc=m+1. For B-splines, if bsmooth is specified but m.bc is unspecified, default is m.bc=bsmooth+2.

**deriv**  
Derivative order of the regression function to be estimated. A vector object of the same length as ncol(x). Default is deriv=c(0,...,0).

**smooth**  
Smoothness of B-splines for point estimation. When smooth=s, B-splines have s-order continuous derivatives. Default is smooth=m-2.

**bsmooth**  
Smoothness of B-splines for bias correction. Default is bsmooth=m.bc-2.

**ktype**  
Knot placement. Options are "uni" for evenly-spaced knots over the support of x and "qua" for quantile-spaced knots. Default is ktype="uni".

**knot**  
A list of numeric vectors giving the knot positions (including boundary knots) for each dimension which are used in the main regression. The length of the list is equal to ncol(x). If not specified, it uses the number of knots either specified by users or computed by the companion command lspkselect to generate the corresponding knots according to the rule specified by ktype.

**nknot**  
A numeric vector of the same length as ncol(x). Each element corresponds to the number of inner partitioning knots for each dimension used in the main regression. If not specified, nknot is computed by the companion command lspkselect.

**same**  
If TRUE, the same knots are used for bias correction as that for the main regression. Default is same=TRUE.

**bknot**  
A list of numeric vectors giving knot positions used for bias correction. If not specified and same=FALSE, it uses the number of knots either specified by users or computed by the companion command lspkselect to generate knots according to the rule specified by ktype.

**bnknot**  
A numeric vector of the same length as ncol(x). Each element corresponds to the number of inner partitioning knots for each dimension used for bias correction. If not specified, bnknot is computed by the companion command lspkselect.

**J**  
A numeric vector containing resolution levels of father wavelets for each dimension.

**bc**  
Bias correction method. Options are "bc1" for higher-order-basis bias correction, "bc2" for least squares bias correction, and "bc3" for plug-in bias correction. Default are "bc3" for splines and piecewise polynomials and "bc2" for wavelets.
proj
If TRUE, projection of leading approximation error onto the lower-order approximation space is included for bias correction (splines and piecewise polynomials only). Default is proj=TRUE.

kselect
Method for selecting the number of inner knots used by lspkselect. Options are "imse-rot" for ROT implementation of IMSE-optimal number of knots and "imse-dpi" for second generation of DPI implementation of IMSE-optimal number of knots. Default is kselect="imse-dpi".

vce
Procedure to compute the heteroskedasticity-consistent (HCk) variance-covariance matrix estimator with plug-in residuals. Options are
- "hc0" for unweighted residuals (HC0).
- "hc1" for HC1 weights.
- "hc2" for HC2 weights. Default.
- "hc3" for HC3 weights.

level
Confidence level used for confidence intervals; default is level=95.

uni.method
Method used to implement uniform inference. Options are "pl" for a simulation-based plug-in procedure, "wb" for a wild bootstrap procedure. If unspecified, neither procedure is implemented. Default is uni.method=NULL.

uni.grid
A matrix containing all grid points used to implement uniform inference. Each row corresponds to the coordinates of one grid point.

uni.ngrid
A numeric vector of the same length as ncol(x). Each element corresponds to the number of grid points for each dimension used to implement uniform inference. Default is uni.ngrid=50.

uni.out
If TRUE, the quantities used to implement uniform inference is outputted. Default is uni.out=FALSE.

band
If TRUE, the critical value for constructing confidence band is calculated. Default is band=FALSE. If band=TRUE with uni.method unspecified, default is uni.method="pl".

B
Number of simulated samples used to obtain the critical value for confidence bands. Default is B=1000.

subset
Optional rule specifying a subset of observations to be used.

rotnorm
If TRUE, ROT selection is adjusted using normal densities.

... further arguments

object
class lsprobust objects.

Value

Estimate
A matrix containing eval (grid points), N (effective sample sizes), tau.cl (point estimates with a basis of order m), tau.bc (bias corrected point estimates with a basis of order m.bc), se.cl (standard error corresponding to tau.cl), and se.rb (robust standard error).

k.num
A matrix containing the number of inner partitioning knots used in the main regression and bias correction for each covariate.

knot
A list of knots for point estimation.
bknott  A list of knots for bias correction.
sup.cval  Critical value for constructing confidence band.
uni.output  A list containing quantities used to implement uniform inference.
opt  A list containing options passed to the function.

Methods (by generic)

- print: print method for class "lsprobust"
- summary: summary method for class "lsprobust"

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References

See Also
lspkselect, lsprobust.plot, lsplincom

Examples

```r
x <- data.frame(runif(500), runif(500))
y <- sin(4*x[,1])+cos(x[,2])+rnorm(500)
est <- lsprobust(y, x)
summary(est)
```

Description

`lsprobust.plot` plots estimated regression functions and confidence regions using the `lspartition` package. See Cattaneo and Farrell (2013) and Cattaneo, Farrell and Feng (2019a) for complete details.

Companion command: `lsprobust` for partitioning-based least squares regression estimation and inference; `lsprobust.plot` for plotting results; `lsplincom` for multiple sample estimation and inference.

A detailed introduction to this command is given in Cattaneo, Farrell and Feng (2019b).

For more details, and related Stata and R packages useful for empirical analysis, visit https://sites.google.com/site/nppackages/.

Usage

```r
lsprobust.plot(..., alpha = NULL, type = NULL, CS = "ci", CStype = NULL, title = "", xlabel = "", ylabel = "", lty = NULL, lwd = NULL, lcol = NULL, pty = NULL, pwd = NULL, pcol = NULL, CSshade = NULL, CScol = NULL, legendTitle = NULL, legendGroups = NULL)
```

Arguments

- `...` Objects returned by `lsprobust`.
- `alpha` Numeric scalar between 0 and 1, the significance level for plotting confidence regions. If more than one is provided, they will be applied to data series according.
- `type` String, one of "line" (default), "points", "binsscatter", "none" or "both", how the point estimates are plotted. If more than one is provided, they will be applied to data series accordingly.
- `CS` String, type of confidence sets. Options are "ci" for pointwise confidence intervals, "cb" for uniform confidence bands, and "all" for both.
- `CStype` String, one of "region" (shaded region, default), "line" (dashed lines), "ebar" (error bars), "all" (all of the previous) or "none" (no confidence region), how the confidence region should be plotted. If more than one is provided, they will be applied to data series accordingly. If CS = "all", pointwise confidence intervals are forced to be represented by error bars, and uniform bands are represented by both lines and regions.
- `title` String, title of the plot.
- `xlabel` Strings, labels for x-axis.
- `ylabel` Strings, labels for y-axis.
lsprobust.plot

1ty  Line type for point estimates, only effective if type is "line" or "both". 1 for solid line, 2 for dashed line, 3 for dotted line. For other options, see the instructions for ggplot2 or par. If more than one is provided, they will be applied to data series accordingly.

1wd  Line width for point estimates, only effective if type is "line" or "both". Should be strictly positive. For other options, see the instructions for ggplot2 or par. If more than one is provided, they will be applied to data series accordingly.

1col Line color for point estimates, only effective if type is "line" or "both". 1 for black, 2 for red, 3 for green, 4 for blue. For other options, see the instructions for ggplot2 or par. If more than one is provided, they will be applied to data series accordingly.

pty  Scatter plot type for point estimates, only effective if type is "points" or "both". For options, see the instructions for ggplot2 or par. If more than one is provided, they will be applied to data series accordingly.

pwd  Scatter plot size for point estimates, only effective if type is "points" or "both". Should be strictly positive. If more than one is provided, they will be applied to data series accordingly.

pcol Scatter plot color for point estimates, only effective if type is "points" or "both". 1 for black, 2 for red, 3 for green, 4 for blue. For other options, see the instructions for ggplot2 or par. If more than one is provided, they will be applied to data series accordingly.

CSshade Numeric, opaqueness of the confidence region, should be between 0 (transparent) and 1. Default is 0.2. If more than one is provided, they will be applied to data series accordingly.

CScol Color for confidence region. 1 for black, 2 for red, 3 for green, 4 for blue. For other options, see the instructions for ggplot2 or par. If more than one is provided, they will be applied to data series accordingly.

legendTitle String, title of legend.

legendGroups String vector, group names used in legend.

Details

Companion command: lsprobust for partition-based least-squares regression estimation.

Value

A standard ggplot2 object is returned, hence can be used for further customization.

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References


See Also

lsprobust, lspkselect, lsplincom, ggplot2.

Examples

```r
x <- runif(500)
y <- sin(4*x)+rnorm(500)
est <- lsprobust(y, x)
lsprobust.plot(est)
```
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