Package: nprobust (via r-universe)

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Type Package

Title Nonparametric Robust Estimation and Inference Methods using
Local Polynomial Regression and Kernel Density Estimation

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Author Sebastian Calonico <sebastian.calonico@columbia.edu>, Matias D.
Cattaneo <cattaneo@princeton.edu>, Max H. Farrell

<max.farrell@chicagobooth.edu>

Maintainer Sebastian Calonico <sebastian.calonico@columbia.edu>

Description Tools for data-driven statistical analysis using local
polynomial regression and kernel density estimation methods as
described in Calonico, Cattaneo and Farrell (2018,
<doi:10.1080/01621459.2017.1285776>): lprobust() for local
polynomial point estimation and robust bias-corrected
inference, lpbwselect() for local polynomial bandwidth
selection, kdrobust() for kernel density point estimation and
robust bias-corrected inference, kdbwselect() for kernel
density bandwidth selection, and nprobust.plot() for plotting
results. The main methodological and numerical features of this
package are described in Calonico, Cattaneo and Farrell (2019,
<doi:10.18637/jss.v091.i08>).

Depends R (>= 3.1.1)

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Description

This package provides tools for data-driven statistical analysis using local polynomial regression (LPR) and kernel density estimation (KDE) methods as described in Calonico, Cattaneo and Farrell (2018): lprobust for local polynomial point estimation and robust bias-corrected inference, lpbwselect for local polynomial bandwidth selection, kdrobust for kernel density point estimation and robust bias-corrected inference, kdbwselect for kernel density bandwidth selection, and nprobust.plot for plotting results. The main methodological and numerical features of this package are described in Calonico, Cattaneo and Farrell (2019).

Details

Package:	nprobust
Type:	Package
Version:	0.4.0
Date:	2020-08-24
License:	GPL-2

Function for LPR estimation and inference: lprobust
Function for LPR bandwidth selection: lpbwselect
Function for KDE estimation and inference: kdrobust
Function for KDE bandwidth selection: kdbwselect
Function for graphical analysis: nprobust.plot

Author(s)

Sebastian Calonico, Columbia University, New York, NY. <sebastian.calonico@columbia.edu>.

Matias D. Cattaneo, Princeton University, Princeton, NJ. <cattaneo@princeton.edu>.

Max H. Farrell, University of Chicago, Chicago, IL. <max.farrell@chicagobooth.edu>.

References

Calonico, S., M. D. Cattaneo, and M. H. Farrell. 2018. On the Effect of Bias Estimation on Coverage Accuracy in Nonparametric Inference. Journal of the American Statistical Association, 113(522): 767-779. doi: 10.1080/01621459.2017.1285776.

Calonico, S., M. D. Cattaneo, and M. H. Farrell. 2019. nprobust: Nonparametric Kernel-Based Estimation and Robust Bias-Corrected Inference. Journal of Statistical Software, 91(8): 1-33. doi: 10.18637/jss.v091.i08.

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kdbwselect	*Bandwidth Selection Procedures for Kernel Density Estimation and Inference*

Description

kdbwselect implements bandwidth selectors for kernel density point estimators and inference procedures developed in Calonico, Cattaneo and Farrell (2018). See also Calonico, Cattaneo and Farrell (2020) for related optimality results. It also implements other bandwidth selectors available in the literature. See Wand and Jones (1995) for background references.

Companion commands are: kdrobust for kernel density point estimation and inference procedures.

A detailed introduction to this command is given in Calonico, Cattaneo and Farrell (2019). For more details, and related Stata and R packages useful for empirical analysis, visit https://nppackages.github.io/.

Usage

```
kdbwselect(x, eval = NULL, neval = NULL, kernel = "epa",
bwselect = "mse-dpi", bwcheck=21, imsegrid=30, subset = NULL)
```

Arguments

x	independent variable.
eval	vector of evaluation point(s). By default it uses 30 equally spaced points over to support of x.
neval	number of quantile-spaced evaluation points on support of x. Default is neval=30.
kernel	kernel function used to construct the kernel estimators. Options are epa for the epanechnikov kernel, and uni for the uniform kernel. Default is kernel = epa.
bwselect	bandwidth selection procedure to be used. Options are:
	mse-dpi second-generation DPI implementation of MSE-optimal bandwidth. Default option.
	imse-dpi second-generation DPI implementation of IMSE-optimal bandwidth (computed using grid of evaluation points selected).
	imse-rot ROT implementation of IMSE-optimal bandwidth (computed using grid of evaluation points selected).
	ce-dpi second generation DPI implementation of CE-optimal bandwidth.

ce-rot ROT implementation of CE-optimal bandwidth.

all reports all available bandwidth selection procedures.

Note: MSE = Mean Square Error; IMSE = Integrated Mean Squared Error; CE = Coverage Error; DPI = Direct Plug-in; ROT = Rule-of-Thumb. For details on implementation see Calonico, Cattaneo and Farrell (2019).

bwcheck   if a positive integer is provided, then the selected bandwidth is enlarged so that at least bwcheck effective observations are available at each evaluation point. Default is bwcheck = 15.

imsegrid   number of evaluations points used to compute the IMSE bandwidth selector. Default is imsegrid = 30.

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

Value

Estimate   A matrix containing eval (grid points), h and b (bandwidths).

opt   A list containing options passed to the function.

Author(s)

Sebastian Calonico, Columbia University, New York, NY. <sebastian.calonico@columbia.edu>.

Matias D. Cattaneo, Princeton University, Princeton, NJ. <cattaneo@princeton.edu>.

Max H. Farrell, University of Chicago, Chicago, IL. <max.farrell@chicagobooth.edu>.

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Calonico, S., M. D. Cattaneo, and M. H. Farrell. 2019. nprobust: Nonparametric Kernel-Based Estimation and Robust Bias-Corrected Inference. Journal of Statistical Software, 91(8). doi: 10.18637/jss.v091.i08.

Calonico, S., M. D. Cattaneo, and M. H. Farrell. 2020. Coverage Error Optimal Confidence Intervals for Local Polynomial Regression. Working Paper.

Fan, J., and Gijbels, I. 1996. Local polynomial modelling and its applications, London: Chapman and Hall.

Wand, M., and Jones, M. 1995. Kernel Smoothing, Florida: Chapman & Hall/CRC.

See Also

kdrobust

Examples

```
x   <- rnorm(500)
est <- kdbwselect(x)
summary(est)
```

---

kdrobust   *Kernel Density Methods with Robust Bias-Corrected Inference*

Description

[kdrobust](#) implements kernel density point estimators, with robust bias-corrected confidence intervals and inference procedures developed in Calonico, Cattaneo and Farrell (2018). See also Calonico, Cattaneo and Farrell (2020) for related optimality results. It also implements other estimation and inference procedures available in the literature. See Wand and Jones (1995) for background references.

Companion commands: [kdbwselect](#) for kernel density data-driven bandwidth selection, and [nprobust.plot](#) for plotting results.

A detailed introduction to this command is given in Calonico, Cattaneo and Farrell (2019). For more details, and related Stata and R packages useful for empirical analysis, visit https://nppackages.github.io/.

Usage

```
kdrobust(x, eval = NULL, neval = NULL, h = NULL, b = NULL, rho = 1,
kernel = "epa", bwselect = NULL, bwcheck = 21, imsegrid=30, level = 95, subset = NULL)
```

Arguments

x	independent variable.
eval	vector of evaluation point(s). By default it uses 30 equally spaced points over to support of x.
neval	number of quantile-spaced evaluation points on support of x. Default is neval=30.
h	main bandwidth used to construct the kernel density point estimator. Can be either scalar (same bandwidth for all evaluation points), or vector of same dimension as eval. If not specified, bandwidth h is computed by the companion command [kdbwselect](#).
b	bias bandwidth used to construct the bias-correction estimator. Can be either scalar (same bandwidth for all evaluation points), or vector of same dimension as eval. By default it is set equal to h. If rho is set to zero, b is computed by the companion command [kdbwselect](#).
rho	Sets b=h/rho. Default is rho = 1.
kernel	kernel function used to construct local polynomial estimators. Options are epa for the epanechnikov kernel, tri for the triangular kernel and uni for the uniform kernel. Default is kernel = epa.
bwselect	bandwidth selection procedure to be used via [lpbwselect](#). By default it computes h and sets b=h/rho (with rho=1 by default). It computes both h and b if rho is set equal to zero. Options are:
	mse-dpi second-generation DPI implementation of MSE-optimal bandwidth. Default option if only one evaluation point is chosen.

                     `imse-dpi` second-generation DPI implementation of IMSE-optimal bandwidth (computed using a grid of evaluation points). Default option if more than one evaluation point is chosen.

                     `imse-rot` ROT implementation of IMSE-optimal bandwidth (computed using a grid of evaluation points).

                     `ce-dpi` second generation DPI implementation of CE-optimal bandwidth.

                     `ce-rot` ROT implementation of CE-optimal bandwidth.

                     `all` reports all available bandwidth selection procedures.

                     Note: MSE = Mean Square Error; IMSE = Integrated Mean Squared Error; CE = Coverage Error; DPI = Direct Plug-in; ROT = Rule-of-Thumb. For details on implementation see Calonico, Cattaneo and Farrell (2019).

`bwcheck`   if a positive integer is provided, then the selected bandwidth is enlarged so that at least bwcheck effective observations are available at each evaluation point. Default is bwcheck = 21.

`imsegrid`   number of evaluations points used to compute the IMSE bandwidth selector. Default is `imsegrid = 30`.

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

`subset`   optional rule specifying a subset of observations to be used.

Value

`Estimate`   A matrix containing `eval` (grid points), `h`, `b` (bandwidths), `N` (effective sample sizes), `tau.us` (point estimates with p-th order kernel function), `tau.bc` (bias corrected point estimates, `se.us` (standard error corresponding to `tau.us`), and `se.rb` (robust standard error).

`opt`   A list containing options passed to the function.

Author(s)

Sebastian Calonico, Columbia University, New York, NY. <sebastian.calonico@columbia.edu>.

Matias D. Cattaneo, Princeton University, Princeton, NJ. <cattaneo@princeton.edu>.

Max H. Farrell, University of Chicago, Chicago, IL. <max.farrell@chicagobooth.edu>.

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Fan, J., and Gijbels, I. 1996. Local polynomial modelling and its applications, London: Chapman and Hall.

Wand, M., and Jones, M. 1995. Kernel Smoothing, Florida: Chapman & Hall/CRC.

See Also

[kdbwselect](#)

Examples

```
x   <- rnorm(500)
est <- kdrobust(x)
summary(est)
```

---

lpbwselect	*Bandwidth Selection Procedures for Local Polynomial Regression Es-timation and Inference*

Description

[lpbwselect](#) implements bandwidth selectors for local polynomial regression point estimators and inference procedures developed in Calonico, Cattaneo and Farrell (2018). See also Calonico, Cattaneo and Farrell (2020) for related optimality results. It also implements other bandwidth selectors available in the literature. See Wand and Jones (1995) and Fan and Gijbels (1996) for background references.

Companion commands: [lprobust](#) for local polynomial point estimation and inference procedures.

A detailed introduction to this command is given in Calonico, Cattaneo and Farrell (2019). For more details, and related Stata and R packages useful for empirical analysis, visit https://nppackages.github.io/.

Usage

```
lpbwselect(y, x, eval = NULL, neval = NULL, p = NULL, deriv = NULL,
kernel = "epa", bwselect = "mse-dpi", bwcheck = 21, bwregul = 1,
imsegrid = 30, vce = "nn", cluster = NULL,
nnmatch = 3, interior = FALSE, subset = NULL)
```

Arguments

y	dependent variable.
x	independent variable.
eval	vector of evaluation point(s). By default it uses 30 equally spaced points over to support of x.
neval	number of quantile-spaced evaluation points on support of x. Default is neval=30.
p	polynomial order used to construct point estimator; default is p = 1 (local linear regression).
deriv	derivative order of the regression function to be estimated. Default is deriv=0 (regression function).

kernel	kernel function used to construct local polynomial estimators. Options are epa for the epanechnikov kernel, tri for the triangular kernel, uni for the uniform kernel and gau for the gaussian kernel. Default is kernel = epa.
bwselect	bandwidth selection procedure to be used. Options are:
	mse-dpi second-generation DPI implementation of MSE-optimal bandwidth. Default option.
	mse-rot ROT implementation of MSE-optimal bandwidth.
	imse-dpi second-generation DPI implementation of IMSE-optimal bandwidth (computed using grid of evaluation points selected).
	imse-rot ROT implementation of IMSE-optimal bandwidth (computed using grid of evaluation points selected).
	ce-dpi second generation DPI implementation of CE-optimal bandwidth.
	ce-rot ROT implementation of CE-optimal bandwidth.
	all reports all available bandwidth selection procedures.
	Note: MSE = Mean Square Error; IMSE = Integrated Mean Squared Error; CE = Coverage Error; DPI = Direct Plug-in; ROT = Rule-of-Thumb. For details on implementation see Calonico, Cattaneo and Farrell (2019).
bwcheck	if a positive integer is provided, then the selected bandwidth is enlarged so that at least bwcheck effective observations are available at each evaluation point. Default is bwcheck = 21.
bwregul	specifies scaling factor for the regularization term added to the denominator of bandwidth selectors. Setting bwregul = 0 removes the regularization term from the bandwidth selectors. Default is bwregul = 1.
imsegrid	number of evaluations points used to compute the IMSE bandwidth selector. Default is imsegrid = 30.
vce	procedure used to compute the variance-covariance matrix estimator. Options are:
	nn heteroskedasticity-robust nearest neighbor variance estimator with nnmatch the (minimum) number of neighbors to be used. Default choice.
	hc0 heteroskedasticity-robust plug-in residuals variance estimator without weights.
	hc1 heteroskedasticity-robust plug-in residuals variance estimator with hc1 weights.
	hc2 heteroskedasticity-robust plug-in residuals variance estimator with hc2 weights.
	hc3 heteroskedasticity-robust plug-in residuals variance estimator with hc3 weights.
cluster	indicates the cluster ID variable used for cluster-robust variance estimation with degrees-of-freedom weights. By default it is combined with vce=nn for cluster-robust nearest neighbor variance estimation. Another option is plug-in residuals combined with vce=hc1.
nnmatch	to be combined with for vce=nn for heteroskedasticity-robust nearest neighbor variance estimator with nnmatch indicating the minimum number of neighbors to be used. Default is nnmatch=3
.	
interior	if TRUE, all evaluation points are assumed to be interior points. This option affects only data-driven bandwidth selection via [lpbwselect](). Default is interior = FALSE.
subset	optional rule specifying a subset of observations to be used.

Value

Estimate   A matrix containing `grid` (grid points), `h` and `b` (bandwidths), `N` (sample size)

opt   A list containing options passed to the function.

Author(s)

Sebastian Calonico, Columbia University, New York, NY. `<sebastian.calonico@columbia.edu>`.

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Max H. Farrell, University of Chicago, Chicago, IL. `<max.farrell@chicagobooth.edu>`.

References

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Fan, J., and Gijbels, I. 1996. Local polynomial modelling and its applications, London: Chapman and Hall.

Wand, M., and Jones, M. 1995. Kernel Smoothing, Florida: Chapman & Hall/CRC.

See Also

lprobust

Examples

```
x   <- runif(500)
y   <- sin(4*x) + rnorm(500)
est <- lpbwselect(y,x)
summary(est)
```

---

lprobust   *Local Polynomial Methods with Robust Bias-Corrected Inference*

Description

    [lprobust](#) implements local polynomial regression point estimators, with robust bias-corrected confidence intervals and inference procedures developed in Calonico, Cattaneo and Farrell (2018). See also Calonico, Cattaneo and Farrell (2020) for related optimality results. It also implements other estimation and inference procedures available in the literature. See Wand and Jones (1995) and Fan and Gijbels (1996) for background references.

    Companion commands: [lpbwselect](#) for local polynomial data-driven bandwidth selection, and [nprobust.plot](#) for plotting results.

    A detailed introduction to this command is given in Calonico, Cattaneo and Farrell (2019). For more details, and related Stata and R packages useful for empirical analysis, visit https://nppackages.github.io/.

Usage

```
lprobust(y, x, eval = NULL, neval = NULL, p = NULL, deriv = NULL,
h = NULL, b = NULL, rho = 1, kernel = "epa", bwselect = NULL,
bwcheck = 21, bwregul = 1, imsegrid = 30, vce = "nn", covgrid = FALSE,
cluster = NULL, nnmatch = 3, level = 95, interior = FALSE, subset = NULL)
```

Arguments

y	dependent variable.
x	independent variable.
eval	vector of evaluation point(s). By default it uses 30 equally spaced points over to support of x.
neval	number of quantile-spaced evaluation points on support of x. Default is neval=30.
p	polynomial order used to construct point estimator; default is p = 1 (local linear regression).
deriv	derivative order of the regression function to be estimated. Default is deriv=0 (regression function).
h	main bandwidth used to construct local polynomial point estimator. Can be either scalar (same bandwidth for all evaluation points), or vector of same dimension as eval. If not specified, bandwidth h is computed by the companion command [lpbwselect](#).
b	bias bandwidth used to construct the bias-correction estimator. Can be either scalar (same bandwidth for all evaluation points), or vector of same dimension as eval. By default it is set equal to h. If rho is set to zero, b is computed by the companion command [lpbwselect](#).
rho	Sets b=h/rho. Default is rho = 1.
kernel	kernel function used to construct local polynomial estimators. Options are epa for the epanechnikov kernel, tri for the triangular kernel, uni for the uniform kernel and gau for the gaussian kernel. Default is kernel = epa.
bwselect	bandwidth selection procedure to be used via [lpbwselect](#). By default it computes h and sets b=h/rho (with rho=1 by default). It computes both h and b if rho is set equal to zero. Options are:

mse-dpi second-generation DPI implementation of MSE-optimal bandwidth. Default option if only one evaluation point is chosen.

mse-rot ROT implementation of MSE-optimal bandwidth.

imse-dpi second-generation DPI implementation of IMSE-optimal bandwidth (computed using a grid of evaluation points). Default option if more than one evaluation point is chosen.

imse-rot ROT implementation of IMSE-optimal bandwidth (computed using a grid of evaluation points).

ce-dpi second generation DPI implementation of CE-optimal bandwidth.

ce-rot ROT implementation of CE-optimal bandwidth.

all reports all available bandwidth selection procedures.

Note: MSE = Mean Square Error; IMSE = Integrated Mean Squared Error; CE = Coverage Error; DPI = Direct Plug-in; ROT = Rule-of-Thumb. For details on implementation see Calonico, Cattaneo and Farrell (2019).

bwcheck   if a positive integer is provided, then the selected bandwidth is enlarged so that at least bwcheck effective observations are available at each evaluation point. Default is bwcheck = 21.

bwregul   specifies scaling factor for the regularization term added to the denominator of bandwidth selectors. Setting bwregul = 0 removes the regularization term from the bandwidth selectors. Default is bwregul = 1.

imsegrid   number of evaluations points used to compute the IMSE bandwidth selector. Default is imsegrid = 30.

vce   procedure used to compute the variance-covariance matrix estimator. Options are:

nn heteroskedasticity-robust nearest neighbor variance estimator with nnmatch the (minimum) number of neighbors to be used. Default choice.

hc0 heteroskedasticity-robust plug-in residuals variance estimator without weights.

hc1 heteroskedasticity-robust plug-in residuals variance estimator with hc1 weights.

hc2 heteroskedasticity-robust plug-in residuals variance estimator with hc2 weights.

hc3 heteroskedasticity-robust plug-in residuals variance estimator with hc3 weights.

covgrid   if TRUE, it computes two covariance matrices (cov.us and cov.rb) for classical and robust covariances across point estimators over the grid of evaluation points.

cluster   indicates the cluster ID variable used for cluster-robust variance estimation with degrees-of-freedom weights. By default it is combined with vce=nn for cluster-robust nearest neighbor variance estimation. Another option is plug-in residuals combined with vce=hc1.

nnmatch   to be combined with for vce=nn for heteroskedasticity-robust nearest neighbor variance estimator with nnmatch indicating the minimum number of neighbors to be used. Default is nnmatch=3

.

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

interior   if TRUE, all evaluation points are assumed to be interior points. This option affects only data-driven bandwidth selection via [lpbwselect](). Default is interior = FALSE.

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

Value

Estimate	A matrix containing eval (grid points), h, b (bandwidths), N (effective sample sizes), m.us (point estimates with p-th order local polynomial), tau.bc (bias corrected point estimates with (p+1)-th order local polynomial, se.us (standard error corresponding to tau.us), and se.rb (robust standard error).
opt	A list containing options passed to the function.

Author(s)

Sebastian Calonico, Columbia University, New York, NY. <sebastian.calonico@columbia.edu>.

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References

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Calonico, S., M. D. Cattaneo, and M. H. Farrell. 2019. nprobust: Nonparametric Kernel-Based Estimation and Robust Bias-Corrected Inference. Journal of Statistical Software, 91(8): 1-33. doi: 10.18637/jss.v091.i08.

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Wand, M., and Jones, M. 1995. Kernel Smoothing, Florida: Chapman & Hall/CRC.

See Also

lpbwselect

Examples

```
x   <- runif(500)
y   <- sin(4*x) + rnorm(500)
est <- lprobust(y,x)
summary(est)
```

nprobust.plot	*Graphical Presentation of Results from* nprobust *Package.*

Description

nprobust.plot plots estimated density and regression function using the nprobust package. A detailed introduction to this command is given in Calonico, Cattaneo and Farrell (2019).

Companion commands: [lprobust](#) for local polynomial point estimation and inference procedures, and [kdrobust](#) for kernel density point estimation and inference procedures.

For more details, and related Stata and R packages useful for empirical analysis, visit https://nppackages.github.io/.

Usage

```
nprobust.plot(..., alpha = NULL, type = NULL, CItype = NULL,
  title = "", xlabel = "", ylabel = "", lty = NULL, lwd = NULL,
  lcol = NULL, pty = NULL, pwd = NULL, pcol = NULL, CIshade = NULL,
  CIcol = NULL, legendTitle = NULL, legendGroups = NULL)
```

Arguments

...	Objects returned by [kdrobust](#) or [lprobust](#).
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 accordingly.
type	String, one of "line" (default), "points" or "both", how the point estimates are plotted. If more than one is provided, they will be applied to data series accordingly.
CItype	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.
title, xlabel, ylabel	
	Strings, title of the plot and labels for x- and y-axis.
lty	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.
lwd	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.
lcol	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.

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

CIcol   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: [lprobust](#) for local polynomial-based regression functions and derivatives
estimation.

Value

A standard [ggplot2](#) object is returned, hence can be used for further customization.

Author(s)

Sebastian Calonico, Columbia University, New York, NY. <sebastian.calonico@columbia.edu>.

Matias D. Cattaneo, Princeton University, Princeton, NJ. <cattaneo@princeton.edu>.

Max H. Farrell, University of Chicago, Chicago, IL. <max.farrell@chicagobooth.edu>.

References

Calonico, S., M. D. Cattaneo, and M. H. Farrell. 2019. nprobust: Nonparametric Kernel-Based
Estimation and Robust Bias-Corrected Inference. Journal of Statistical Software, 91(8): 1-33.
doi: 10.18637/jss.v091.i08.

See Also

[lprobust](#), [kdrobust](#), [ggplot2](#)

Examples

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

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