Package ‘SpatialRDD’

August 8, 2023

Type Package

Title Conduct Multiple Types of Geographic Regression Discontinuity Designs

Version 0.1.0

Description Spatial versions of Regression Discontinuity Designs (RDDs) are becoming increasingly popular as tools for causal inference. However, conducting state-of-the-art analyses often involves tedious and time-consuming steps. This package offers comprehensive functionalities for executing all required spatial and econometric tasks in a streamlined manner. Moreover, it equips researchers with tools for performing essential placebo and balancing checks comprehensively. The fact that researchers do not have to rely on ‘APIs’ of external ‘GIS’ software ensures replicability and raises the standard for spatial RDDs.

Depends R (>= 3.5.0)

License GPL-3

Encoding UTF-8

LazyData true

Imports dplyr, sf, ggplot2, rdrobust, lmtest, sandwich, cowplot, magrittr, rlang, broom

RoxygenNote 7.2.3

Suggests knitr, tmap, rmarkdown, testthat, utils, kableExtra, lfe, stargazer

VignetteBuilder knitr

URL https://axlehner.github.io/SpatialRDD/

BugReports https://github.com/axlehner/SpatialRDD/issues

NeedsCompilation no

Author Alexander Lehner [aut, cre] (<https://orcid.org/0000-0001-5885-5966>)

Maintainer Alexander Lehner <lehner@uchicago.edu>

Repository CRAN

Date/Publication 2023-08-08 15:30:05 UTC
**assign_treated**

Let the package know which observations were treated

Description

Creates a vector with 0’s and 1’s to determine on which side of the cut-off each observation is. For this it is useful to have a polygon that fully describes the "treated area". If you do not have such a polygon there is a (preliminary and patchy) way implemented in the package via `points2line` and `cutoff2polygon` that lets you go from points to line to “treated polygon” in a very crude way.

Usage

`assign_treated(data, polygon, id = NA)`

Arguments

- **data** sf data frame containing point data (if you have polygons, convert first with `sf::st_centroid()`)
- **polygon** sf object with polygon geometry that fully describes the area(s) that contain the treated points
- **id** string that represents the name of the column in the data that represents the unique identifier for each observation

Value

A vector of type factor with 0’s and 1’s. Convert with `as.numeric()` if you want real numbers/integers.

Note

This is essentially a wrapper of `sf::st_intersection`. 

---

Index

| assign_treated | Let the package know which observations were treated |

- **R topics documented:**
  - assign_treated ........................................ 2
  - border_segment ........................................ 3
  - create_placebos ....................................... 4
  - cutoff2polygon ........................................ 5
  - cut_off ................................................... 6
  - discretise_border ....................................... 6
  - plotspatialrd ............................................ 7
  - points2line .............................................. 9
  - polygon_full ............................................ 9
  - polygon_treated ....................................... 10
  - printspatialrd .......................................... 10
  - shift_border ............................................ 11
  - spatialrd ............................................... 12
**Examples**

```r
points_samp.sf <- sf::st_sample(polygon_full, 100) # create points
# make it an sf object bc st_sample only created the geometry list-column (sfc):
points_samp.sf <- sf::st_sf(points_samp.sf)
# add a unique ID to each observation:
points_samp.sf$id <- 1:nrow(points_samp.sf)
points_samp.sf$treated <- assign_treated(points_samp.sf, polygon_treated, id = "id")
```

---

**border_segment**  
*Border Segment Creation for FE-estimation*

**Description**

Creates \( n \) segments of a line (the RD cut-off) and assigns the closest border segment for each observation in the sf data frame. Computationally these tasks are quite demanding when the sample size is big and thus might take a few seconds to complete.

**Usage**

`border_segment(data, cutoff, n = 10)`

**Arguments**

- `data` sf data frame containing point data
- `cutoff` the RDD border in the form of a line (preferred) or borderpoints
- `n` the number of segments to be produced

**Value**

a vector with factors, each category representing one segment

**Examples**

```r
points_samp.sf <- sf::st_sample(polygon_full, 100) # create points
# make it an sf object bc st_sample only created the geometry list-column (sfc):
points_samp.sf <- sf::st_sf(points_samp.sf)
points_samp.sf$segment10 <- border_segment(points_samp.sf, cutoff, 3)
```
**create_placebos**

*Multiple placebo checks unified in just one list or coefplot*

**Description**

Unifies `shift_border`, `cutoff2polygon`, `assign_treated` in one function to carry out a myriad of placebo checks at once. The output is either a data.frame (with or without geometry of the respective placeboline) or a coefplot. Requires operations data.frame that contains all desired operations (columns `shift.x`, `shift.y`, `scale`, `angle`, `orientation.1`, `orientation.2`, `endpoint.1`, `endpoint.2`), if you don’t need a certain operation just use default values (e.g. 0 for angle and 1 for scale), but the column has to be there.

**Usage**

```r
create_placebos(
  data,
  cutoff,
  formula,
  operations,
  bw_dist,
  coefplot = FALSE,
  geometry = FALSE
)
```

**Arguments**

- `data`: sf data.frame that contains all units of observation
- `cutoff`: initial RD cutoff as an sj object
- `formula`: provide the formula you want to use for OLS, omit the treatetment dummy (if you want a univariate regression just on "treated", then provide `y ~ 1` as formula)
- `operations`: container that has all the information in it on how to change the border for each placeboregression
- `bw_dist`: what is the distance for the bandwidth (in CRS units, thus ideally metres)
- `coefplot`: provide coefplot instead of a data.frame
- `geometry`: set to TRUE if you want to plot all the lines of the used placebo borders

**Value**

either a coefplot or data.frame containing results of placebo regressions

**Examples**

```r
points_samp.sf <- sf::st_sample(polygon_full, 100) # create points
# make it an sf object bc st_sample only created the geometry list-column (sfc):
points_samp.sf <- sf::st_sf(points_samp.sf)
# add a unique ID to each observation:
```
points_samp.sf$id <- 1:nrow(points_samp.sf)
points_samp.sf$treated <- assign_treated(points_samp.sf, polygon_treated, id = "id")
operations.df <- data.frame(operation = c("shift"),
shift.x = c(0),
shift.y = c(0),
scale = 1,
angle = 0,
orientation.1 = c("west"),
orientation.2 = c("west"),
endpoint.1 = c(.8),
endpoint.2 = c(.2))
c Create_placebos(data = points_samp.sf, cutoff = cut_off,
formula = id ~ 1, operations = operations.df, bw_dist = 3000)

---

cutoff2polygon  Create (treated) polygon from line

Description

Creates an approximation of a "treated/untreated polygon" to assign the status again to each observation after the border has been shifted. The function extends both ends of the provided cutoff to the edge of the (imaginary) bounding box of the provided data (this ensures all observations will be included). Key is that you provide a 2-tuple that indicates in which side of the bounding box each end should go (1st element is the one with lower x-coordinate, i.e. leftern most). Always check the output manually by plotting the polygon (e.g. with `tm_shape(your.polygon) + tm_polygons()`). If the output polygon looks odd, a first check should be to just switch the elements from the orientation vector around! See vignette(shifting_borders) for details and illustrative examples.

Usage

cutoff2polygon(data, cutoff, orientation = NA, endpoints = c(0, 0))

Arguments

data study dataset to determine the bounding box (so that all observations are covered by the new polygons) in sf format

cutoff sf object of the (placebo) cut-off

orientation in which side of the bounding box does each of the extensions of the cutoff go into? First element refers to endpoint of border with smaller x-coordinate ("westernmost") (takes two of "north", "east", "south", "west" in a vector, e.g. c("west", "north"))

endpoints at what position on the edge should each polygon end? (vector with two numbers between 0 and 1, where 0.5 e.g. means right in the middle of the respective edge)

Value

a polygon as an sf object
Examples

```r
points_samp.sf <- sf::st_sample(polygon_full, 100) # create points
# make it an sf object bc st_sample only created the geometry list-column (sfc):
points_samp.sf <- sf::st_sf(points_samp.sf)
# add a unique ID to each observation:
points_samp.sf$id <- 1:nrow(points_samp.sf)
cutoff2polygon(data = points_samp.sf, cutoff = cut_off,
orientation = c("west", "west"), endpoints = c(.8, .2))
```

cut_off

Dataset with boundaries and polygons for the SpatialRDD vignette.

Description

sf multilinestring representing a spatial RD cut-off

Usage

```r
data(cut_off)
```

Format

A spatial data.frame of class sf

Source

Lehner, Alexander (2023) Culture, Institutions, and the Roots of Gender Inequality: 450 Years of Portuguese Colonialism in India

discretise_border

Split the RD cut-off into borderpoints

Description

Takes in a border in the form of a polyline (or borderpoints) and converts it into point data. These points are later used to run separate non-parametric RD estimations which eventually allows to visualise potential heterogeneous treatment effects alongside the cut-off.
Usage

    discretise_border(
        cutoff,  
        n = 10,  
        random = FALSE,  
        range = FALSE,  
        ymax = NA,  
        ymin = NA,  
        xmax = NA,  
        xmin = NA
    )

Arguments

cutoff             sf object of the RD cut-off in the form of a line (not preferred, but also boundarypoints are possible)
n                 the number of borderpoints to be created
random            whether they are randomly chosen (not desirable in most cases)
range             default = FALSE, if there is a specific range (N-S or E-W) for which the points are to be drawn (useful in order to exclude sparse borderpoints with little/no observations around because the non-parametric RD estimation will fail)
ymax              if range = TRUE: y coordinates
ymin              if range = TRUE: y coordinates
xmax              if range = TRUE: x coordinates
xmin              if range = TRUE: x coordinates

Value

    an sf object with selected (and evenly spaced) borderpoints

Examples

    borderpoints <- discretise_border(cutoff = cut_off, n = 10)


---

plotspatialrd

Plot SpatialRD output

---

Description

    Produces plot of GRDDseries and optionally of a map that visualises every point estimate in space.

Usage

    plotspatialrd(SpatialRDoutput, map = FALSE)
### Arguments

- **SpatialRDoutput**
  - spatial object that is produced by an estimation with `spatialrd`.

- **map**
  - TRUE/FALSE depending on whether mapplot is desired (make sure to set `spatial.object = TRUE` in the `spatialrd` function).

### Value

- plots produced with ggplot2

### Examples

```r
points_samp.sf <- sf::st_sample(polygon_full, 1000) # create points
# make it an sf object bc st_sample only created the geometry list-column (sfc):
points_samp.sf <- sf::st_sf(points_samp.sf)
# add a unique ID to each observation:
points_samp.sf$id <- 1:nrow(points_samp.sf)
# assign treatment:
points_samp.sf$treated <- assign_treated(points_samp.sf, polygon_treated, id = "id")
# first we define a variable for the number of "treated" and control
NTr <- length(points_samp.sf$id[points_samp.sf$treated == 1])
NCo <- length(points_samp.sf$id[points_samp.sf$treated == 0])
# the treated areas get a 10 percentage point higher literacy rate
points_samp.sf$education[points_samp.sf$treated == 1] <- 0.7
points_samp.sf$education[points_samp.sf$treated == 0] <- 0.6
# and we add some noise, otherwise we would obtain regression coefficients with no standard errors
points_samp.sf$education[points_samp.sf$treated == 1] <- rnorm(NTr, mean = 0, sd = .1) +
  points_samp.sf$education[points_samp.sf$treated == 1]
points_samp.sf$education[points_samp.sf$treated == 0] <- rnorm(NCo, mean = 0, sd = .1) +
  points_samp.sf$education[points_samp.sf$treated == 0]
# create distance to cutoff
points_samp.sf$dist2cutoff <- as.numeric(sf::st_distance(points_samp.sf, cut_off))
# give the non-treated one's a negative score
points_samp.sf$distrunning[points_samp.sf$treated == 0] <- -1 *
  points_samp.sf$distrunning[points_samp.sf$treated == 0]
# create borderpoints
borderpoints.sf <- discretise_border(cutoff = cut_off, n = 10)
borderpoints.sf$id <- 1:nrow(borderpoints.sf)
# finally, carry out estimation alongside the boundary:
results <- spatialrd(y = "education", data = points_samp.sf, cutoff.points = borderpoints.sf,
  treated = "treated", minobs = 20, spatial.object = FALSE)

plotspatialrd(results)
```
points2line

Convert borderpoints to a line

Description
Small function that connects dots and makes them one line which can later be used as a cutoff for the RD.

Usage
points2line(borderpoints, crs)

Arguments
borderpoints  a set of points on a boundary
crs  set the coordinate reference system (CRS)

Value
a line as an sf object

Examples
points_samp.sf <- sf::st_sample(polygon_full, 2) # create points
# make it an sf object bc st_sample only created the geometry list-column (sfc):
points_samp.sf <- sf::st_sf(points_samp.sf)
points2line(points_samp.sf, crs = sf::st_crs(points_samp.sf))

polygon_full
Dataset with boundaries and polygons for the SpatialRDD vignette.

Description
sf multipolygon

Usage
data(polygon_full)

Format
A spatial data.frame of class sf

Source
Lehner, Alexander (2023) Culture, Institutions, and the Roots of Gender Inequality: 450 Years of Portuguese Colonialism in India
**polygon_treated**  
Dataset with boundaries and polygons for the SpatialRDD vignette.

**Description**

sf multipolygon

**Usage**

data(polygon_treated)

**Format**

A spatial data.frame of class sf

**Source**

Lehner, Alexander (2023) Culture, Institutions, and the Roots of Gender Inequality: 450 Years of Portuguese Colonialism in India

---

**printspatialrd**  
Print spatialrd output

**Description**

Preliminary function, styling with e.g. kable and kableExtra has to be done by the user individually. You could also just use the package of your choice to print out columns of the output from spatialrd.

**Usage**

printspatialrd(SpatialRDoutput)

**Arguments**

SpatialRDoutput

output file from the spatialrd function

**Value**

A table with results from the spatialrd function
Examples

points_samp.sf <- sf::st_sample(polygon_full, 1000) # create points
# make it an sf object bc st_sample only created the geometry list-column (sfc):
points_samp.sf <- sf::st_sf(points_samp.sf)
# add a unique ID to each observation:
points_samp.sf$id <- 1:nrow(points_samp.sf)
# assign treatment:
points_samp.sf$treated <- assign_treated(points_samp.sf, polygon_treated, id = "id")
# first we define a variable for the number of "treated" and control
NTr <- length(points_samp.sf$id[points_samp.sf$treated == 1])
NCo <- length(points_samp.sf$id[points_samp.sf$treated == 0])
# the treated areas get a 10 percentage point higher literacy rate
points_samp.sf$education[points_samp.sf$treated == 1] <- 0.7
points_samp.sf$education[points_samp.sf$treated == 0] <- 0.6
# and we add some noise, otherwise we would obtain regression coeffictions with no standard errors
points_samp.sf$education[points_samp.sf$treated == 1] <- rnorm(NTr, mean = 0, sd = .1) +
    points_samp.sf$education[points_samp.sf$treated == 1]
points_samp.sf$education[points_samp.sf$treated == 0] <- rnorm(NCo, mean = 0, sd = .1) +
    points_samp.sf$education[points_samp.sf$treated == 0]
# create distance to cutoff
points_samp.sf$dist2cutoff <- as.numeric(sf::st_distance(points_samp.sf, cut_off))

points_samp.sf$distrunning <- points_samp.sf$dist2cutoff
# give the non-treated one’s a negative score
points_samp.sf$distrunning[points_samp.sf$treated == 0] <- -1 *
    points_samp.sf$distrunning[points_samp.sf$treated == 0]

# create borderpoints
borderpoints.sf <- discretise_border(cutoff = cut_off, n = 10)
borderpoints.sf$id <- 1:nrow(borderpoints.sf)
# finally, carry out estimation alongside the boundary:
results <- spatialrd(y = "education", data = points_samp.sf, cutoff.points = borderpoints.sf,
    treated = "treated", minobs = 20, spatial.object = FALSE)
printspatialrd(results)

shift_border  Shift, shrink/grow, and rotate borders around

Description

This functions takes in a border and can either shift, shrink, or rotate it. All of them can be done
together as well. This usually takes a bit of trial and error, so make sure to plot the result each time.
For a detailed walk through check out the according vignette: vignette(shiftingBorders).
shift_border(
  border,
  operation = c("shift", "scale", "rotate"),
  shift = c(0, 0),
  scale = 1,
  angle = 0
)

Arguments

border                   sf object with line geometry
operation                "shift", "rotate", "scale" - or a combination of them
shift                    if operation = "shift", shift distance in CRS units (if UTM it is metres) for x
                          and y coordinates as c(dist_x, dist_y)
scale                    if operation = "scale", provide shrinkage/growth factor: e.g. .9 to shrink by
                          10perc. and 1.1 to increase by 10perc.
angle                    if operation = "rotate", provide angle in degrees

Value

a new border in the form of an sf object

Examples

shift_border(border = cut_off, operation = c("shift", "scale"),
             shift = c(-5000, -3000), scale = .85)

shift_border(border = cut_off, operation = "rotate", angle = 10)

spatialrd               non-parametric Spatial RD / GRD

Description

This function loops over all boundary points and locally estimates a non-parametric RD (using local
linear regression) using the rdrobust function from the rdrobust package from Calonico, Catta-
neo, Titunik (2014). It takes in the discretized cutoff point file (the RDcutoff, a linestring chopped
into parts by the discretise_border function) and the sf object (which essentially is just a con-
ventional data.frame with a geometry() column) containing all the observations (treated and unt-
treated). The treated indicator variable has to be assigned before (potentially with assign_treated)
and be part of the sf object as a column.
Usage

```r
spatialrd(
  y, data, cutoff.points, treated, minobs = 50, bwfix_m = NA, sample = FALSE, samplesize = NA, sparse.exclusion = FALSE, store.CIs = FALSE, spatial.object = TRUE, ...
)
```

Arguments

- `y`: The name of the dependent variable in the points frame in the form of a string
- `data`: sf data.frame with points that describe the observations
- `cutoff.points`: sf object of borderpoints (provided by user or obtained with `discretise_border`)
- `treated`: column that contains the treated dummy (as string)
- `minobs`: the minimum amount of observations in each estimation for the point estimate to be included (default is 50)
- `bwfix_m`: fixed bandwidth in meters (in case you want to impose one yourself)
- `sample`: draw a random sample of points (default is FALSE)
- `samplesize`: if random, how many points
- `sparse.exclusion`: in case we want to try to exclude sparse border points before the estimation (should reduce warnings)
- `store.CIs`: set TRUE of confidence intervals should be stored
- `spatial.object`: return a spatial object (default is TRUE, needed if you want to plot the point estimates on a map)?
- `...`: in addition you can use all options in `rdrobust`

Details

This function nests `rdrobust`. All its options (aside from running variable `x` and cutoff `c`) are available here as well (e.g. bw selection, cluster level, kernel, weights). Check the documentation in the `rdrobust` package for details. (bandwidth selection default in `rdrobust` is `bwselect = 'mserd'`)

To visualise the output, use `plotspatialrd` for a graphical representation. You can use `printspatialrd` (or an R package of your choice) for a table output.

Value

a data.frame or spatial data.frame (sf object) in case `spatial.object = TRUE` (default)
References


Examples

```r
points_samp.sf <- sf::st_sample(polygon_full, 1000) # create points
# make it an sf object bc st_sample only created the geometry list-column (sfc):
points_samp.sf <- sf::st_sf(points_samp.sf)
# add a unique ID to each observation:
points_samp.sf$id <- 1:nrow(points_samp.sf)
# assign treatment:
points_samp.sf$treated <- assign_treated(points_samp.sf, polygon_treated, id = "id")
# first we define a variable for the number of "treated" and control
NTr <- length(points_samp.sf$id[points_samp.sf$treated == 1])
NCo <- length(points_samp.sf$id[points_samp.sf$treated == 0])
# the treated areas get a 10 percentage point higher literacy rate
points_samp.sf$education[points_samp.sf$treated == 1] <- 0.7
points_samp.sf$education[points_samp.sf$treated == 0] <- 0.6
# and we add some noise, otherwise we would obtain regression coeffictions with no standard errors
points_samp.sf$education[points_samp.sf$treated == 1] <- rnorm(NTr, mean = 0, sd = .1) +
  points_samp.sf$education[points_samp.sf$treated == 1]
points_samp.sf$education[points_samp.sf$treated == 0] <- rnorm(NCo, mean = 0, sd = .1) +
  points_samp.sf$education[points_samp.sf$treated == 0]

# create distance to cutoff
points_samp.sf$dist2cutoff <- as.numeric(sf::st_distance(points_samp.sf, cut_off))
points_samp.sf$distrunning <- points_samp.sf$dist2cutoff
# give the non-treated one's a negative score
points_samp.sf$distrunning[points_samp.sf$treated == 0] <- -1 *
  points_samp.sf$distrunning[points_samp.sf$treated == 0]

# create borderpoints
borderpoints.sf <- discretise_border(cutoff = cut_off, n = 10)
borderpoints.sf$id <- 1:nrow(borderpoints.sf)

# finally, carry out estimation alongside the boundary:
results <- spatialrd(y = "education", data = points_samp.sf, cutoff.points = borderpoints.sf,
  treated = "treated", minobs = 20, spatial.object = FALSE)
```
Index

* datasets
  cut_off, 6
  polygon_full, 9
  polygon_treated, 10

assign_treated, 2, 4, 12

border_segment, 3

create_placebos, 4
cut_off, 6
cutoff2polygon, 2, 4, 5

discretise_border, 6, 12, 13

plotspatialrd, 7, 13
points2line, 2, 9
polygon_full, 9
polygon_treated, 10
printspatialrd, 10, 13

rdrobust, 13

shift_border, 4, 11
spatialrd, 8, 10, 12