Package 'did2s'

September 27, 2021

Title Two-Stage Difference-in-Differences Following Gardner (2021)

Version 0.4.0

Description Estimates Two-way Fixed Effects difference-in-differences/event-study models using the approach proposed by Gardner (2021). To avoid the problems caused by OLS estimation of the Two-way Fixed Effects model, this function first estimates the fixed effects and covariates using untreated observations and then in a second stage, estimates the treatment effects.

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Encoding UTF-8

LazyData true

RoxygenNote 7.1.1

Depends R (>= 2.10), fixest (>= 0.9.0)

Imports dplyr, magrittr, ggplot2, glue, stats, stringr, rlang, tibble, tidyr, rsample, purrr, cli, Matrix, Rcpp, did, broom, methods, staggered, didimputation, gt

URL http://kylebutts.com/did2s/

Suggests rmarkdown, knitr, haven, testthat (>= 3.0.0)

VignetteBuilder knitr

LinkingTo RcppArmadillo, Rcpp

Config/testthat/edition 3

NeedsCompilation yes

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Repository CRAN

Date/Publication 2021-09-27 08:50:07 UTC

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`castle` *Data from Cheng and Hoekstra (2013)*

Description

State-wide panel data from 2000-2010 that has information on castle-doctrine, the so-called "stand-your-ground" laws that were implemented by 20 states.

Usage

```
castle
```

Format

A data frame with 550 rows and 5 variables:

sid state id, unit of observation

year time in panel data

l_homicide log of the number of homicides per capita

effyear year that castle doctrine is passed

post 0/1 variable for when castle doctrine is active

time_til time relative to castle doctrine being passed into law

---

`df_het` *Simulated data with two treatment groups and heterogenous effects Generated using the following call:* `did2s::gen_data(panel = c(1990, 2020), g1 = 2000, g2 = 2010, g3 = 0, te1 = 2, te2 = 1, te3 = 0, te_m1 = 0.05, te_m2 = 0.15, te_m3 = 0)`

Description

Simulated data with two treatment groups and heterogenous effects

Generated using the following call: `did2s::gen_data(panel = c(1990,2020),g1 = 2000,g2 = 2010,g3 = 0,te1 = 2,te2 = 1,te3 = 0,te_m1 = 0.05,te_m2 = 0.15,te_m3 = 0)`

Usage

```
df_het
```

Format

A data frame with 31000 rows and 15 variables:

unit individual in panel data

year time in panel data

g the year that treatment starts

dep_var outcome variable

treat T/F variable for when treatment is on

rel_year year relative to treatment start. Inf = never treated.

rel_year_binned year relative to treatment start, but <=-6 and >=6 are binned.

unit_fe Unit FE

year_fe Year FE

error Random error component

te Static treatment effect = te

te_dynamic Dynamic treatmet effect = te_m

state State that unit is in

group String name for group

`df_hom` *Simulated data with two treatment groups and homogenous effects Generated using the following call:* `did2s::gen_data(panel = c(1990, 2020), g1 = 2000, g2 = 2010, g3 = 0, te1 = 2, te2 = 2, te3 = 0, te_m1 = 0, te_m2 = 0, te_m3 = 0)`

Description

Simulated data with two treatment groups and homogenous effects

Generated using the following call: `did2s::gen_data(panel = c(1990,2020),g1 = 2000,g2 = 2010,g3 = 0,te1 = 2,te2 = 2,te3 = 0,te_m1 = 0,te_m2 = 0,te_m3 = 0)`

Usage

```
df_hom
```

Format

A data frame with 31000 rows and 15 variables:

unit individual in panel data

year time in panel data

g the year that treatment starts

dep_var outcome variable

treat T/F variable for when treatment is on

rel_year year relative to treatment start. Inf = never treated.

rel_year_binned year relative to treatment start, but <=-6 and >=6 are binned.

unit_fe Unit FE

year_fe Year FE

error Random error component

te Static treatment effect = te

te_dynamic Dynamic treatmet effect = te_m

group String name for group

state State that unit is in

weight Weight from runif()

`did2s` *Calculate two-stage difference-in-differences following Gardner (2021)*

Description

Calculate two-stage difference-in-differences following Gardner (2021)

Usage

```
did2s(
  data,
  yname,
  first_stage,
  second_stage,
  treatment,
  cluster_var,
  weights = NULL,
  bootstrap = FALSE,
  n_bootstraps = 250,
  return_bootstrap = FALSE,
  verbose = TRUE
)
```

Arguments

data	The dataframe containing all the variables
yname	Outcome variable
first_stage	Fixed effects and other covariates you want to residualize with in first stage. Formula following fixest::feols. Fixed effects specified after "|".
second_stage	Second stage, these should be the treatment indicator(s) (e.g. treatment variable or event-study leads/lags). Formula following fixest::feols. Use i() for factor variables, see fixest::i.
treatment	A variable that = 1 if treated, = 0 otherwise
cluster_var	What variable to cluster standard errors. This can be IDs or a higher aggregate level (state for example)
weights	Optional. Variable name for regression weights.
bootstrap	Optional. Should standard errors be calculated using bootstrap? Default is FALSE.
n_bootstraps	Optional. How many bootstraps to run. Default is 250.
return_bootstrap	Optional. Logical. Will return each bootstrap second-stage estimate to allow for manual use, e.g. percentile standard errors and empirical confidence intervals.
verbose	Optional. Logical. Should information about the two-stage procedure be printed back to the user? Default is TRUE.

Value

fixest object with adjusted standard errors (either by formula or by bootstrap). All the methods from fixest package will work, including fixest::esttable and fixest::coefplot

Examples

Load example dataset which has two treatment groups and homogeneous treatment effects

```
# Load Example Dataset
data("df_hom")
```

Static TWFE:

You can run a static TWFE fixed effect model for a simple treatment indicator

```
static <- did2s(df_hom,
    yname = "dep_var", treatment = "treat", cluster_var = "state",
    first_stage = ~ 0 | unit + year,
    second_stage = ~ i(treat, ref=FALSE))
#> Running Two-stage Difference-in-Differences
#> • first stage formula `~ 0 | unit + year`
#> • second stage formula `~ i(treat, ref = FALSE)`
#> • The indicator variable that denotes when treatment is on is `treat`
#> • Standard errors will be clustered by `state`
```

```
fixest::esttable(static)
#>                             static
#> Dependent Var.:           dep_var
#>
#> treat = TRUE    2.025*** (0.0307)
#> _______________ _________________
#> S.E. type                  Custom
#> Observations               31,000
#> R2                        0.31846
#> Adj. R2                   0.31846
```

Event Study:

Or you can use relative-treatment indicators to estimate an event study estimate

```
es <- did2s(df_hom,
    yname = "dep_var", treatment = "treat", cluster_var = "state",
    first_stage = ~ 0 | unit + year,
    second_stage = ~ i(rel_year, ref=c(-1, Inf)))
#> Running Two-stage Difference-in-Differences
#> • first stage formula `~ 0 | unit + year`
#> • second stage formula `~ i(rel_year, ref = c(-1, Inf))`
#> • The indicator variable that denotes when treatment is on is `treat`
#> • Standard errors will be clustered by `state`

fixest::esttable(es)
#>                                es
#> Dependent Var.:           dep_var
#>
#> rel_year = -20   -0.0335 (0.0697)
#> rel_year = -19    0.0581 (0.0588)
#> rel_year = -18    0.0348 (0.0578)
#> rel_year = -17    0.0236 (0.0670)
#> rel_year = -16    0.0115 (0.0542)
#> rel_year = -15   -0.0148 (0.0769)
#> rel_year = -14   0.1150. (0.0613)
#> rel_year = -13   -0.0108 (0.0720)
#> rel_year = -12   -0.0727 (0.0635)
#> rel_year = -11    0.0666 (0.0559)
#> rel_year = -10    0.0396 (0.0382)
#> rel_year = -9    -0.0109 (0.0379)
#> rel_year = -8     0.0105 (0.0388)
#> rel_year = -7    -0.0001 (0.0445)
#> rel_year = -6   -0.0829* (0.0388)
#> rel_year = -5     0.0189 (0.0429)
#> rel_year = -4    -0.0664 (0.0437)
#> rel_year = -3    -0.0144 (0.0302)
#> rel_year = -2     0.0223 (0.0442)
#> rel_year = 0    2.117*** (0.0622)
#> rel_year = 1    1.857*** (0.0720)
```

```
#> rel_year = 2    1.986*** (0.0665)
#> rel_year = 3    2.005*** (0.0708)
#> rel_year = 4    1.950*** (0.0748)
#> rel_year = 5    2.038*** (0.0797)
#> rel_year = 6    2.032*** (0.0732)
#> rel_year = 7    2.025*** (0.0858)
#> rel_year = 8    1.976*** (0.0621)
#> rel_year = 9    2.121*** (0.0619)
#> rel_year = 10   2.088*** (0.0913)
#> rel_year = 11   1.943*** (0.1148)
#> rel_year = 12   1.941*** (0.1131)
#> rel_year = 13   1.965*** (0.1076)
#> rel_year = 14   2.023*** (0.0972)
#> rel_year = 15   2.235*** (0.1174)
#> rel_year = 16   2.178*** (0.1282)
#> rel_year = 17   1.936*** (0.1044)
#> rel_year = 18   2.135*** (0.1115)
#> rel_year = 19   2.112*** (0.1038)
#> rel_year = 20   1.925*** (0.1071)
#> _______________ _________________
#> S.E. type                  Custom
#> Observations               31,000
#> R2                        0.31957
#> Adj. R2                   0.31872
```

```
# plot rel_year coefficients and standard errors
fixest::coefplot(es, keep = "rel_year::(.*)")
```

Example from Cheng and Hoekstra (2013):

Here's an example using data from Cheng and Hoekstra (2013)

```
# Castle Data
castle <- haven::read_dta("https://github.com/scunning1975/mixtape/raw/master/castle.dta")

did2s(
data = castle,
yname = "l_homicide",
first_stage = ~ 0 | sid + year,
second_stage = ~ i(post, ref=0),
treatment = "post",
cluster_var = "state", weights = "popwt"
)
#> Running Two-stage Difference-in-Differences
#> • first stage formula `~ 0 | sid + year`
#> • second stage formula `~ i(post, ref = 0)`
#> • The indicator variable that denotes when treatment is on is `post`
#> • Standard errors will be clustered by `state`
#> OLS estimation, Dep. Var.: l_homicide
#> Observations: 550
#> Standard-errors: Custom
```

```
#>         Estimate Std. Error t value Pr(>|t|)
#> post::1 0.075142    0.03538  2.1239 0.034127 *
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#> RMSE: 263.4   Adj. R2: 0.052465
```

`event_study` *Estimate event-study coefficients using TWFE and 5 proposed improvements.*

Description

Uses the estimation procedures recommended from Borusyak, Jaravel, Spiess (2021); Callaway and Sant'Anna (2020); Gardner (2021); Roth and Sant'Anna (2021); Sun and Abraham (2020)

Usage

```
event_study(
  data,
  yname,
  idname,
  gname,
  tname,
  xformla = NULL,
  horizon = NULL,
  weights = NULL
)

plot_event_study(out, seperate = TRUE, horizon = NULL)
```

Arguments

`data`	The dataframe containing all the variables
`yname`	Variable name for outcome variable
`idname`	Variable name for unique unit id
`gname`	Variable name for unit-specific date of initial treatment (never-treated should be zero or NA)
`tname`	Variable name for calendar period
`xformla`	A formula for the covariates to include in the model. It should be of the form `~ X1 + X2`. Default is NULL.
`horizon`	Numeric. Vector of length 2. First element is min and second element is max of event_time to plot
`weights`	Variable name for estimation weights. This is used in estimating Y(0) and also augments treatment effect weights
`out`	Output from `event_study()`
`seperate`	Logical. Should the estimators be on seperate plots? Default is TRUE.

Value

event_study returns a data.frame of point estimates for each estimator

plot_event_study returns a ggplot object that can be fully customized

Examples

```
out = event_study(
  data = did2s::df_het, yname = "dep_var", idname = "unit",
  tname = "year", gname = "g"
)
plot_event_study(out)
```

---

gen_data *Generate TWFE data*

Description

Generate TWFE data

Usage

```
gen_data(
  g1 = 2000,
  g2 = 2010,
  g3 = 0,
  panel = c(1990, 2020),
  te1 = 2,
  te2 = 2,
  te3 = 2,
  te_m1 = 0,
  te_m2 = 0,
  te_m3 = 0
)
```

Arguments

g1	treatment date for group 1. For no treatment, set g = 0.
g2	treatment date for group 2. For no treatment, set g = 0.
g3	treatment date for group 3. For no treatment, set g = 0.
panel	numeric vector of size 2, start and end years for panel
te1	treatment effect for group 1. Will ignore for that group if g = 0.
te2	treatment effect for group 1. Will ignore for that group if g = 0.
te3	treatment effect for group 1. Will ignore for that group if g = 0.

te_m1	treatment effect slope per year
te_m2	treatment effect slope per year
te_m3	treatment effect slope per year

Value

Dataframe of generated data

Examples

```
# Homogeneous treatment effect
df_hom <- gen_data(panel = c(1990, 2020),
    g1 = 2000, g2 = 2010, g3 = 0,
    te1 = 2, te2 = 2, te3 = 0,
    te_m1 = 0, te_m2 = 0, te_m3 = 0)
# Heterogeneous treatment effect
df_het <- gen_data(panel = c(1990, 2020),
    g1 = 2000, g2 = 2010, g3 = 0,
    te1 = 2, te2 = 1, te3 = 0,
    te_m1 = 0.05, te_m2 = 0.15, te_m3 = 0)
```

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