SS154 Final - Analyzing South Africa's 2006 Same-Sex Marriage Legalization Impact on Foreign Direct Investments

```
# install.packages('vtable')

library(vtable)
```

```
## Loading required package: kableExtra
```

```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.0     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## v purrr     1.0.2
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter()     masks stats::filter()
## x dplyr::group_rows() masks kableExtra::group_rows()
## x dplyr::lag()        masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(dplyr)
library(mice)
```

```
##
## Attaching package: 'mice'
##
## The following object is masked from 'package:stats':
##
##     filter
##
## The following objects are masked from 'package:base':
##
##     cbind, rbind
```

```
library(Synth)
```

```
## ##
## ## Synth Package: Implements Synthetic Control Methods.
##
## ## See https://web.stanford.edu/~jhain/synthpage.html for additional information.
```

```
# import the data

data <- read.csv("https://docs.google.com/spreadsheets/d/e/2PACX-1vQPw6yEuH2geG6KCkYoD8VcBoMgP1xg9RADG1
colnames(data)
```

```
##  [1] "Country"
```

```
##  [2] "Year"
##  [3] "id"
##  [4] "GDP.per.capita..constant.2015.US.."
##  [5] "Foreign.direct.investment..net.inflows....of.GDP."
##  [6] "Foreign.direct.investment..net.outflows....of.GDP."
##  [7] "GDP.per.capita..current.US.."
##  [8] "Trade....of.GDP."
##  [9] "Political.Stability.and.Absence.of.Violence.Terrorism..Estimate"
## [10] "Government.expenditure.on.education..total....of.GDP."
## [11] "Individuals.using.the.Internet....of.population."
## [12] "Population..total"
## [13] "Taxes.on.international.trade....of.revenue."
## [14] "Taxes.on.international.trade..current.LCU."
## [15] "Real.interest.rate...."
## [16] "Foreign.direct.investment..net.inflows..BoP..current.US.."
## [17] "fdi_bop_per_capita"
```

```
head(data)
```

```
##   Country Year id GDP.per.capita..constant.2015.US..
## 1  Brazil 1990  1                          6086.078
## 2  Brazil 1991  1                          6043.433
## 3  Brazil 1992  1                          5911.687
## 4  Brazil 1993  1                          6103.377
## 5  Brazil 1994  1                          6358.679
## 6  Brazil 1995  1                          6524.519
##   Foreign.direct.investment..net.inflows....of.GDP.
## 1                                          0.2140916
## 2                                          0.2707826
## 3                                          0.5276628
## 4                                          0.2947738
## 5                                          0.5624007
## 6                                          0.6315860
##   Foreign.direct.investment..net.outflows....of.GDP.
## 1                                          0.14395442
## 2                                          0.24893342
## 3                                          0.03507511
## 4                                          0.11202316
## 5                                          0.18984685
## 6                                          0.17989608
##   GDP.per.capita..current.US.. Trade....of.GDP.
## 1                     3065.242         15.15560
## 2                     2656.497         16.59208
## 3                     2505.378         19.25337
## 4                     2766.346         19.59932
## 5                     3393.143         18.67476
## 6                     4704.960         16.98446
##   Political.Stability.and.Absence.of.Violence.Terrorism..Estimate
## 1                                                             NA
## 2                                                             NA
## 3                                                             NA
## 4                                                             NA
## 5                                                             NA
## 6                                                             NA
##   Government.expenditure.on.education..total....of.GDP.
```

```
## 1                                                    NA
## 2                                                    NA
## 3                                                    NA
## 4                                                    NA
## 5                                                    NA
## 6                                               4.56816
##   Individuals.using.the.Internet....of.population. Population..total
## 1                                       0.000000000         150706446
## 2                                       0.003288171         153336445
## 3                                       0.012946262         155900790
## 4                                       0.025498253         158440875
## 5                                       0.037672709         160980472
## 6                                       0.105138168         163515328
##   Taxes.on.international.trade....of.revenue.
## 1                                          NA
## 2                                          NA
## 3                                          NA
## 4                                          NA
## 5                                          NA
## 6                                          NA
##   Taxes.on.international.trade..current.LCU. Real.interest.rate....
## 1                                         NA                    NA
## 2                                         NA                    NA
## 3                                         NA                    NA
## 4                                         NA                    NA
## 5                                         NA                    NA
## 6                                         NA                    NA
##   Foreign.direct.investment..net.inflows..BoP..current.US.. fdi_bop_per_capita
## 1                                                       NA                 NA
## 2                                                       NA                 NA
## 3                                                       NA                 NA
## 4                                                       NA                 NA
## 5                                                       NA                 NA
## 6                                                 4.86e+09               29.7
```

```r
# renaming column names

data <-
  data %>%
    rename(
      country = Country,
      year = Year,
      fdi_in = Foreign.direct.investment..net.inflows....of.GDP.,
      fdi_out = Foreign.direct.investment..net.outflows....of.GDP.,
      gdp_cap_2015 = GDP.per.capita..constant.2015.US..,
      gdp_cap = GDP.per.capita..current.US..,
      trade_per_gdp = Trade....of.GDP.,
      real_interest = Real.interest.rate....,
      intnl_trade_tax = Taxes.on.international.trade....of.revenue.,
      intnl_trade_tax_lcu = Taxes.on.international.trade..current.LCU.,
      pol_stab_est = Political.Stability.and.Absence.of.Violence.Terrorism..Estimate,
      govt_educ = Government.expenditure.on.education..total....of.GDP.,
      internet = Individuals.using.the.Internet....of.population.,
      popn = Population..total
```

```
    )

head(data)
```

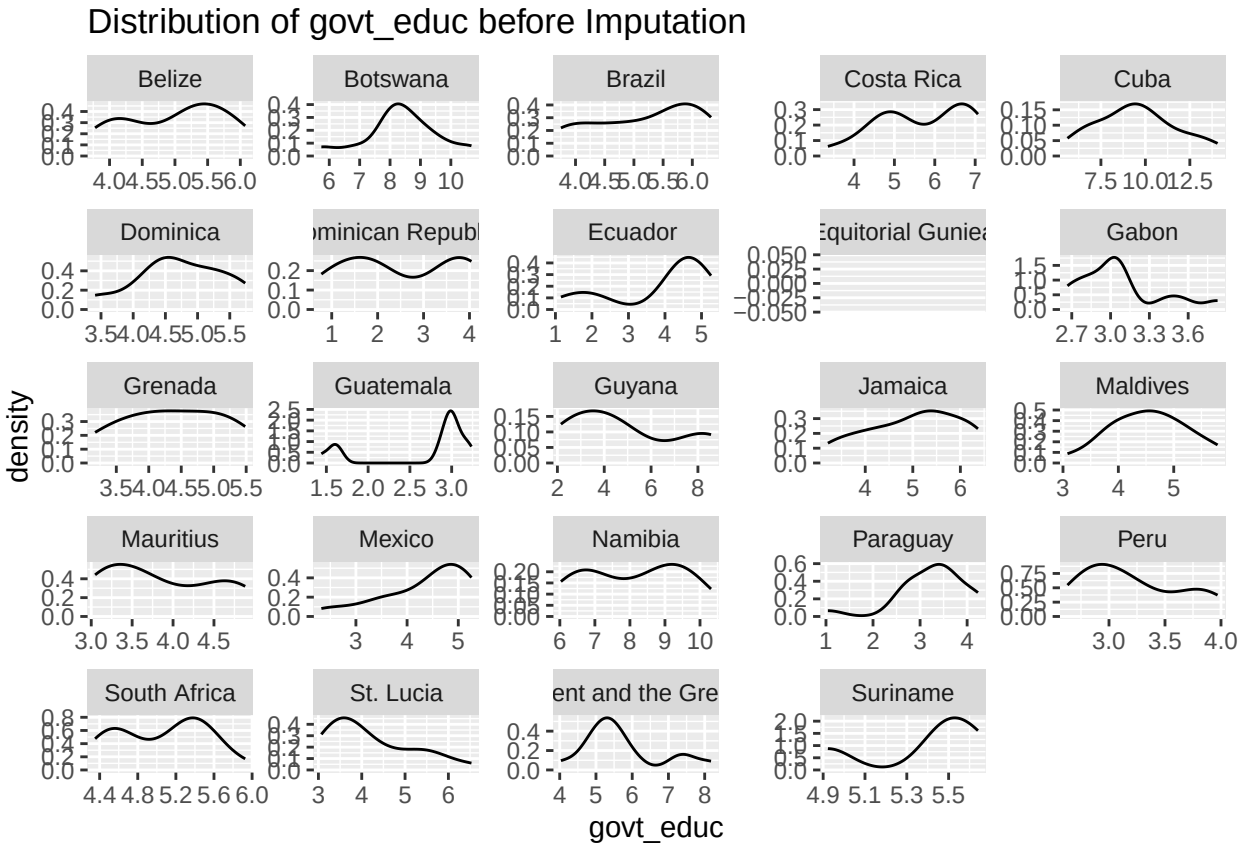
```
##   country year id gdp_cap_2015    fdi_in    fdi_out  gdp_cap trade_per_gdp
## 1  Brazil 1990  1     6086.078 0.2140916 0.14395442 3065.242      15.15560
## 2  Brazil 1991  1     6043.433 0.2707826 0.24893342 2656.497      16.59208
## 3  Brazil 1992  1     5911.687 0.5276628 0.03507511 2505.378      19.25337
## 4  Brazil 1993  1     6103.377 0.2947738 0.11202316 2766.346      19.59932
## 5  Brazil 1994  1     6358.679 0.5624007 0.18984685 3393.143      18.67476
## 6  Brazil 1995  1     6524.519 0.6315860 0.17989608 4704.960      16.98446
##   pol_stab_est govt_educ    internet      popn intnl_trade_tax
## 1           NA        NA 0.000000000 150706446              NA
## 2           NA        NA 0.003288171 153336445              NA
## 3           NA        NA 0.012946262 155900790              NA
## 4           NA        NA 0.025498253 158440875              NA
## 5           NA        NA 0.037672709 160980472              NA
## 6           NA   4.56816 0.105138168 163515328              NA
##   intnl_trade_tax_lcu real_interest
## 1                  NA            NA
## 2                  NA            NA
## 3                  NA            NA
## 4                  NA            NA
## 5                  NA            NA
## 6                  NA            NA
##   Foreign.direct.investment..net.inflows..BoP..current.US.. fdi_bop_per_capita
## 1                                                        NA                 NA
## 2                                                        NA                 NA
## 3                                                        NA                 NA
## 4                                                        NA                 NA
## 5                                                        NA                 NA
## 6                                                  4.86e+09               29.7
```

```
ggplot(data, aes(x = govt_educ)) +
  geom_density() +
  facet_wrap(~ country, scales = "free") +
  labs(title = "Distribution of govt_educ before Imputation")
```

```
## Warning: Removed 304 rows containing non-finite outside the scale range
## (`stat_density()`).
```

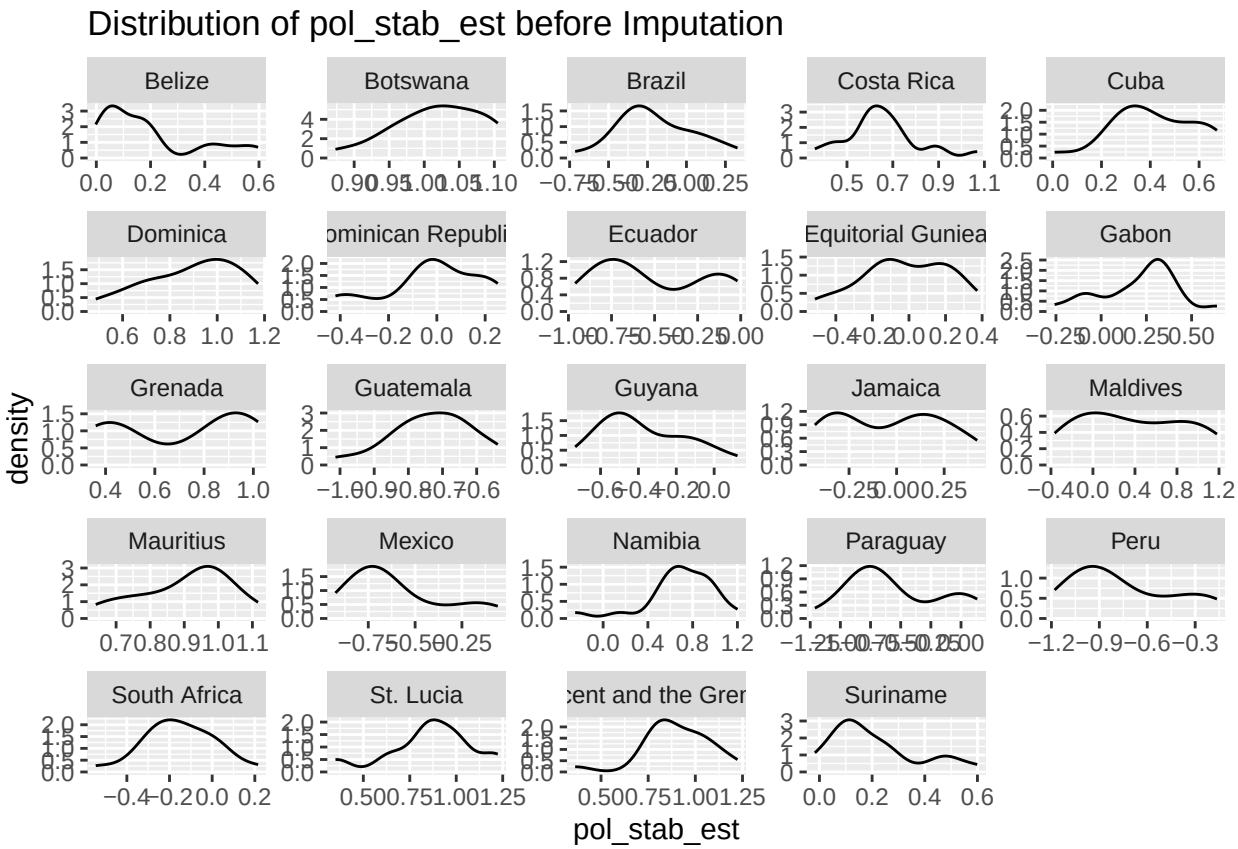
```
## Warning: Groups with fewer than two data points have been dropped.
```

```
## Warning in max(ids, na.rm = TRUE): no non-missing arguments to max; returning
## -Inf
```




```
ggplot(data, aes(x = pol_stab_est)) +
  geom_density() +
  facet_wrap(~ country, scales = "free") +
  labs(title = "Distribution of pol_stab_est before Imputation")
```

```
## Warning: Removed 216 rows containing non-finite outside the scale range
## (`stat_density()`).
```



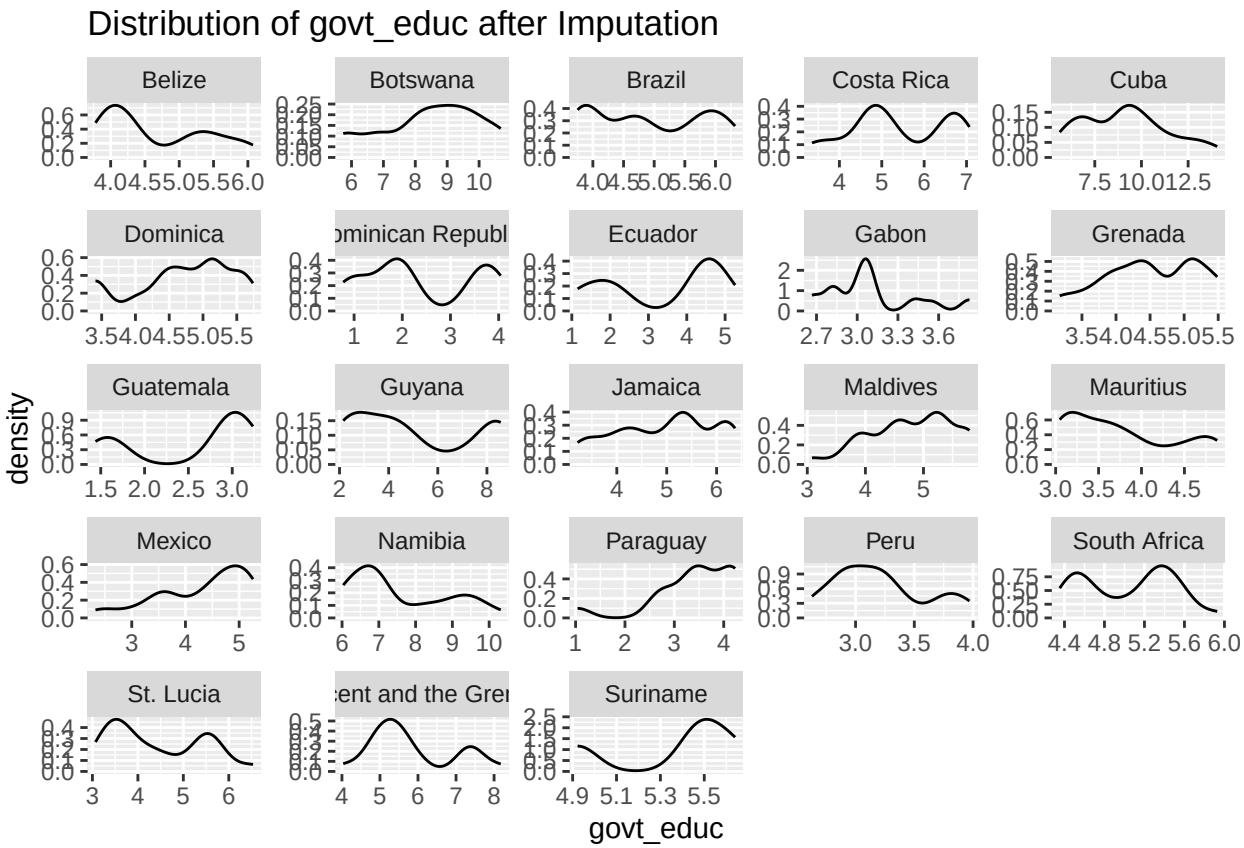

```
imputed_data <- data %>%
  filter(country != "Equitorial Guniea") %>%
  group_by(country) %>% # Group the data by country
  nest() %>% # Nest the data for each country
  mutate(imputed_govt_educ = map(data, ~ mice(data = .x[, c("year", "govt_educ")], m = 5, method = "pmm
  mutate(imputed_pol_stab = map(data, ~ mice(data = .x[, c("year", "pol_stab_est")], m = 5, method = "pr
  mutate(imputed_data = map2(imputed_govt_educ, imputed_pol_stab, ~bind_cols(complete(.x, action = "long
  unnest(cols = imputed_data) # Unnest the imputed_data column to bring the imputed values back into th
```

```
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
## New names:
```

```
## New names:
## New names:
## New names:
## New names:
## New names:
## * `.imp` -> `.imp...1`
## * `.id` -> `.id...2`
## * `year` -> `year...3`
## * `.imp` -> `.imp...5`
## * `.id` -> `.id...6`
## * `year` -> `year...7`
```

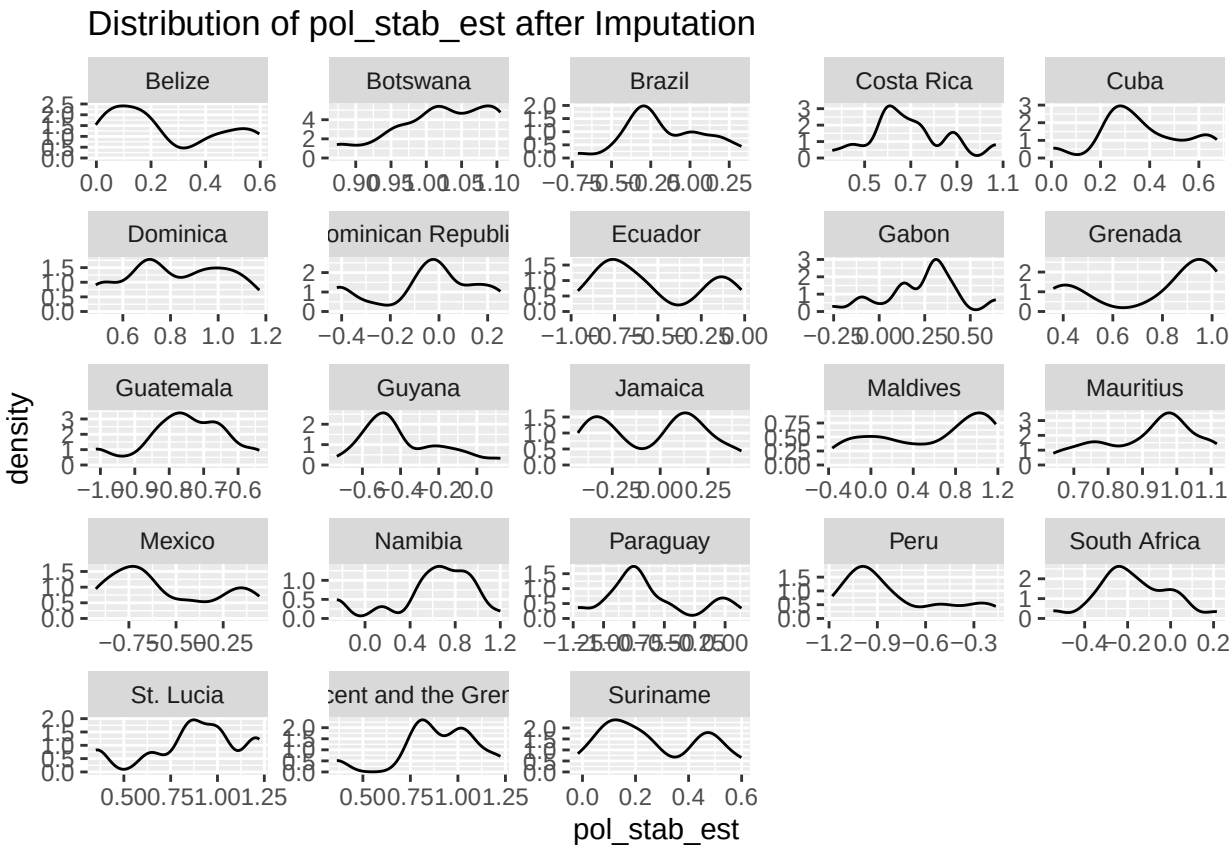
```
ggplot(imputed_data, aes(x = govt_educ)) +
  geom_density() +
  facet_wrap(~ country, scales = "free") +
  labs(title = "Distribution of govt_educ after Imputation")
```

```
## Warning: Removed 275 rows containing non-finite outside the scale range
## (`stat_density()`).
```




```
ggplot(imputed_data, aes(x = pol_stab_est)) +
  geom_density() +
  facet_wrap(~ country, scales = "free") +
  labs(title = "Distribution of pol_stab_est after Imputation")
```

```
## Warning: Removed 207 rows containing non-finite outside the scale range
## (`stat_density()`).
```




```
# Perform missing data imputation for govt_educ and pol_stab_est using mice (synthetic control)
imputed_data <- data %>%
  filter(country != "Equitorial Guniea") %>%
  group_by(country) %>%
  nest() %>%
  mutate(imputed_govt_educ = map(data, ~ mice(data = .x[, c("year", "govt_educ")], m = 5, method = "norm
  mutate(imputed_pol_stab = map(data, ~ mice(data = .x[, c("year", "pol_stab_est")], m = 5, method = "no
  mutate(imputed_data = map2(imputed_govt_educ, imputed_pol_stab, ~ left_join(complete(.x, action = "lo
  unnest(cols = imputed_data)
```

```
## Warning: There were 23 warnings in `mutate()`.
## The first warning was:
## i In argument: `imputed_data = map2(...)`.
## i In group 1: `country = "Belize"`.
## Caused by warning in `left_join()`:
## ! Detected an unexpected many-to-many relationship between `x` and `y`.
## i Row 1 of `x` matches multiple rows in `y`.
## i Row 1 of `y` matches multiple rows in `x`.
## i If a many-to-many relationship is expected, set `relationship =
##   "many-to-many"` to silence this warning.
## i Run `dplyr::last_dplyr_warnings()` to see the 22 remaining warnings.
```

```
# Calculate the average of imputed values for each year within each country
imputed_data_avg <- imputed_data %>%
  group_by(country, year) %>%
  summarise(govt_educ = mean(govt_educ, na.rm = TRUE),
            pol_stab_est = mean(pol_stab_est, na.rm = TRUE))
```

Table 1: Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 75	Max
gdp_cap	720	5037	2985	187	2806	6693	19850
trade_per_gdp	529	76	37	15	48	95	275
pol_stab_est	690	0.2	0.66	-1.5	-0.28	0.79	1.7
govt_educ	690	4.9	2.1	0.31	3.3	5.7	14
internet	713	19	22	0	0.31	34	81
fdi_bop_per_capita	715	354	1601	-794	0	224	23900

```
## `summarise()` has grouped output by 'country'. You can override using the
## `.groups` argument.
```

```
# Merge the averaged imputed data back into the filtered dataset
merged_data <- data %>%
  select(-govt_educ, -pol_stab_est) %>%  # Remove the original govt_educ and pol_stab_est variables
  left_join(imputed_data_avg, by = c("country", "year"))

# View the updated dataset
head(merged_data)
```

```
##   country year id gdp_cap_2015    fdi_in    fdi_out  gdp_cap trade_per_gdp
## 1  Brazil 1990  1     6086.078 0.2140916 0.14395442 3065.242      15.15560
## 2  Brazil 1991  1     6043.433 0.2707826 0.24893342 2656.497      16.59208
## 3  Brazil 1992  1     5911.687 0.5276628 0.03507511 2505.378      19.25337
## 4  Brazil 1993  1     6103.377 0.2947738 0.11202316 2766.346      19.59932
## 5  Brazil 1994  1     6358.679 0.5624007 0.18984685 3393.143      18.67476
## 6  Brazil 1995  1     6524.519 0.6315860 0.17989608 4704.960      16.98446
##      internet      popn intnl_trade_tax intnl_trade_tax_lcu real_interest
## 1 0.000000000 150706446              NA                  NA            NA
## 2 0.003288171 153336445              NA                  NA            NA
## 3 0.012946262 155900790              NA                  NA            NA
## 4 0.025498253 158440875              NA                  NA            NA
## 5 0.037672709 160980472              NA                  NA            NA
## 6 0.105138168 163515328              NA                  NA            NA
##   Foreign.direct.investment..net.inflows..BoP..current.US.. fdi_bop_per_capita
## 1                                                       NA                  NA
## 2                                                       NA                  NA
## 3                                                       NA                  NA
## 4                                                       NA                  NA
## 5                                                       NA                  NA
## 6                                                 4.86e+09                29.7
##   govt_educ pol_stab_est
## 1  2.857108  0.344843774
## 2  3.012677 -0.007502549
## 3  3.432674  0.314661194
## 4  3.500593  0.313099208
## 5  3.686193  0.054930021
## 6  4.568160  0.212099695
```

```
#descriptive stats table

st(merged_data, vars = c("gdp_cap", "trade_per_gdp", "pol_stab_est", "govt_educ", "internet", "fdi_bop_
```

```r
# dataprep for synthetic control

dataprep_out <- dataprep(
  foo = merged_data,
  predictors = c("gdp_cap", "trade_per_gdp", "pol_stab_est", "govt_educ", "internet"),
  # predictors.op = "mean",
  time.predictors.prior = 1995:2005,
  dependent = "fdi_bop_per_capita",
  unit.variable = "id",
  unit.names.variable = "country",
  time.variable = "year",
  treatment.identifier = 24,
  controls.identifier = c(2:5, 7:8, 10, 12:14, 16:20), # c(1:4, 7, 12, 14, 16:20),
  time.optimize.ssr = 1995:2005, # pretreatment for dependent
  time.plot = 1995:2019
)
```

```r
synth_out <- synth(data.prep.obj = dataprep_out)
```

```
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 2448.899
##
## solution.v:
##  0.0007954393 0.1208847 0.5294094 7.805e-07 0.3489097
##
## solution.w:
##  0.01641852 0.00595456 0.005184547 0.3304196 0.01750175 0.02019968 0.01049561 0.01719477 0.007194166
```

```r
synth.tables <- synth.tab(
  dataprep.res = dataprep_out,
  synth.res = synth_out)
print(synth.tables)
```

```
## $tab.pred
##                Treated Synthetic Sample Mean
## gdp_cap       3815.434  3797.848    3176.999
## trade_per_gdp   45.266    45.294      83.102
## pol_stab_est    -0.230    -0.230       0.018
## govt_educ        4.715     5.244       4.474
## internet         4.682     4.682       3.875
##
## $tab.v
##               v.weights
## gdp_cap       0.001
```

```
## trade_per_gdp 0.121
## pol_stab_est  0.529
## govt_educ     0
## internet      0.349
##
## $tab.w
##    w.weights          unit.names unit.numbers
## 2      0.016              Belize            2
## 3      0.006            Botswana            3
## 4      0.005          Costa Rica            4
## 5      0.330                Cuba            5
## 7      0.018 Dominican Republic            7
## 8      0.020             Ecuador            8
## 10     0.010               Gabon           10
## 12     0.017           Guatemala           12
## 13     0.007              Guyana           13
## 14     0.015             Jamaica           14
## 16     0.013           Mauritius           16
## 17     0.279              Mexico           17
## 18     0.010             Namibia           18
## 19     0.012            Paraguay           19
## 20     0.240                Peru           20
##
## $tab.loss
##            Loss W   Loss V
## [1,] 2.257762e-07 2448.899
```

```
top_weights <- head(synth.tables$tab.w[order(synth.tables$tab.w$w, decreasing = TRUE), ], 5)

# Extract the top 5 weights
cat("\nRobustness test weights - taking out Cuba from Donor Pool:\n")
```

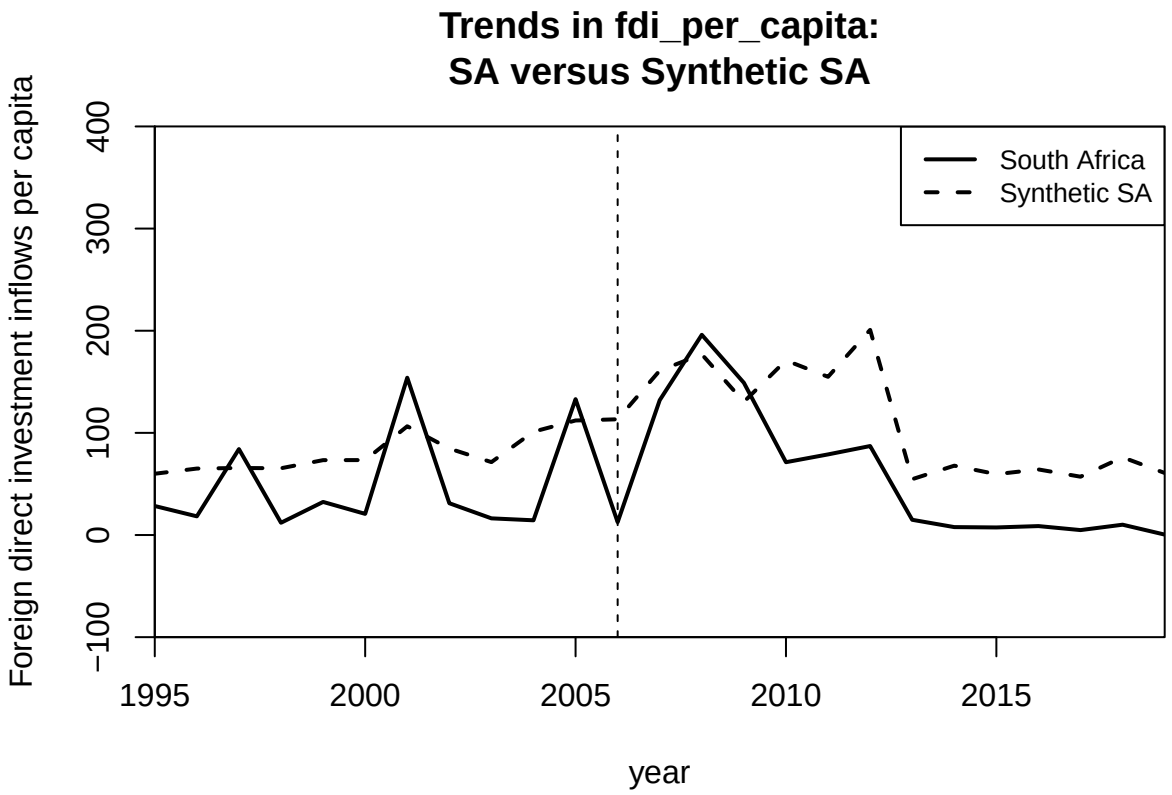
```
##
## Robustness test weights - taking out Cuba from Donor Pool:
```

```
print(top_weights)
```

```
##    w.weights          unit.names unit.numbers
## 5      0.330                Cuba            5
## 17     0.279              Mexico           17
## 20     0.240                Peru           20
## 8      0.020             Ecuador            8
## 7      0.018 Dominican Republic            7
```

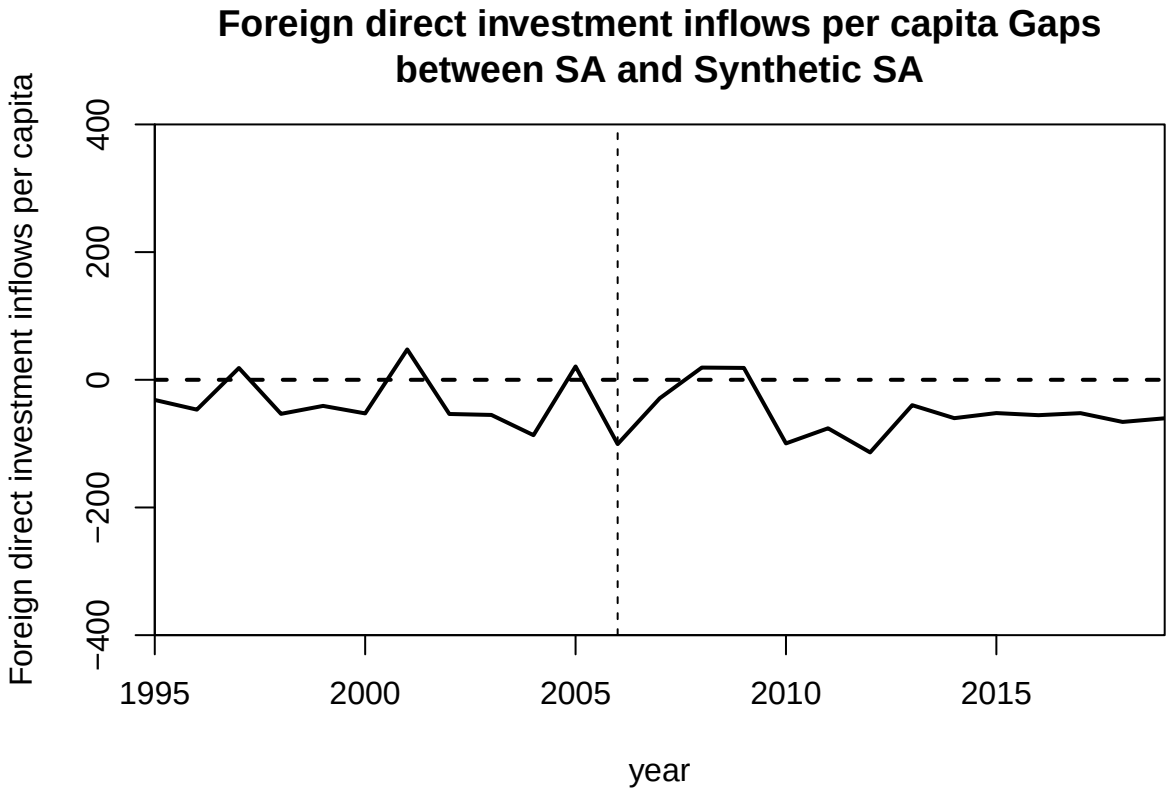
```
# paths plot
path.plot(synth_out, dataprep_out,
          Ylab = c("Foreign direct investment inflows per capita"),
          Xlab = c("year"),
          Legend = c("South Africa", "Synthetic SA"),
          Main = "Trends in fdi_per_capita:\nSA versus Synthetic SA",
          Ylim = c(-100, 400)
)

abline(v = 2006, lty = 2)
```




```
# gaps plot
gaps.plot(synth.res    = synth_out,
          dataprep.res = dataprep_out,
          Ylab = c("Foreign direct investment inflows per capita"),
          Xlab         = c("year"),
          Main         = "Foreign direct investment inflows per capita Gaps\nbetween SA and Synthetic S
          Ylim = c(-400, 400)
)

abline(v = 2006, lty = 2)
```




```
# Treatment Effects from Gaps
gaps<- dataprep_out$Y1plot-(
        dataprep_out$Y0plot%*%synth_out$solution.w
        ) ; gaps
```

```
##              24
## 1995  -31.59382
## 1996  -46.74574
## 1997   18.46729
## 1998  -53.35476
## 1999  -40.89733
## 2000  -52.65242
## 2001   47.54637
## 2002  -53.55205
## 2003  -55.05410
## 2004  -86.75245
## 2005   20.89254
## 2006 -100.69469
## 2007  -28.96954
## 2008   19.12616
## 2009   18.59559
## 2010  -99.64083
## 2011  -75.97929
## 2012 -113.74225
## 2013  -39.76489
## 2014  -60.11923
## 2015  -52.15069
## 2016  -55.43398
## 2017  -52.27162
```

```
## 2018  -66.00093
## 2019  -60.33302
```

Robustness Checks

```
# install.packages("remotes")
# remotes::install_github("bcastanho/SCtools")
library(SCtools)
```

In-space Placebo tests

```
## Loading required package: future
```

```
placebos <- generate.placebos(dataprep_out, synth_out, Sigf.ipop = 5)
```

```
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 21083.08
##
## solution.v:
##  0.1379261 0.001349831 0.5456375 0.02317939 0.2919072
##
## solution.w:
##  0.01272003 0.1662284 8.5926e-06 0.007432914 0.008613743 0.3021805 0.0103668 0.01458496 0.01756509 0
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 8857.767
##
## solution.v:
##  0.01687796 0.1131923 0.01202475 0.004202498 0.8537025
##
## solution.w:
##  0.0003118098 0.0002432953 0.00188681 1.85385e-05 8.2381e-06 0.2062467 4.0027e-06 0.0001106666 4.1045
##
```

```
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 8021.158
##
## solution.v:
##  4e-10 0.5818519 5.7e-09 0.2960028 0.1221452
##
## solution.w:
##  2.1e-09 3.8206e-06 0.0001403703 0 1e-10 5e-10 1e-10 1.3e-09 6.1e-09 0.494132 0.5057238 1.35e-08 6e-
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 2930.691
##
## solution.v:
##  2.47e-08 0.1436044 0.01106524 7.3e-09 0.8453303
##
## solution.w:
##  5.86e-08 1.36e-07 1.248e-07 3.84e-08 0.8837426 5.5e-09 1.14e-08 1.8e-09 2.01e-08 2.68e-08 1.71825e-
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 1556.187
##
```

```
## solution.v:
##  0.1512742 0.467467 0.04033938 2.89e-08 0.3409194
##
## solution.w:
##  0.03362408 0.04643646 0.09451097 0.0814824 0.06855493 0.03166498 0.1072659 0.06613143 0.04153417 0.0
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 605.2585
##
## solution.v:
##  0.5760672 0.3973799 0.02616863 0.0003428146 4.14283e-05
##
## solution.w:
##  0.00210084 0.003842388 6.0489e-06 0.06378552 0.1479542 0.003900305 0.2945273 0.003400642 0.00391026
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 22394.31
##
## solution.v:
##  0.1546586 0.09924032 0.08586995 0.1937076 0.4665236
##
## solution.w:
##  0.1937159 0.3138974 2.2e-09 1.5e-09 3.87e-08 0.4923748 1.59e-08 1.09e-08 9.1e-09 1.4e-08 1.33e-08 1
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
```

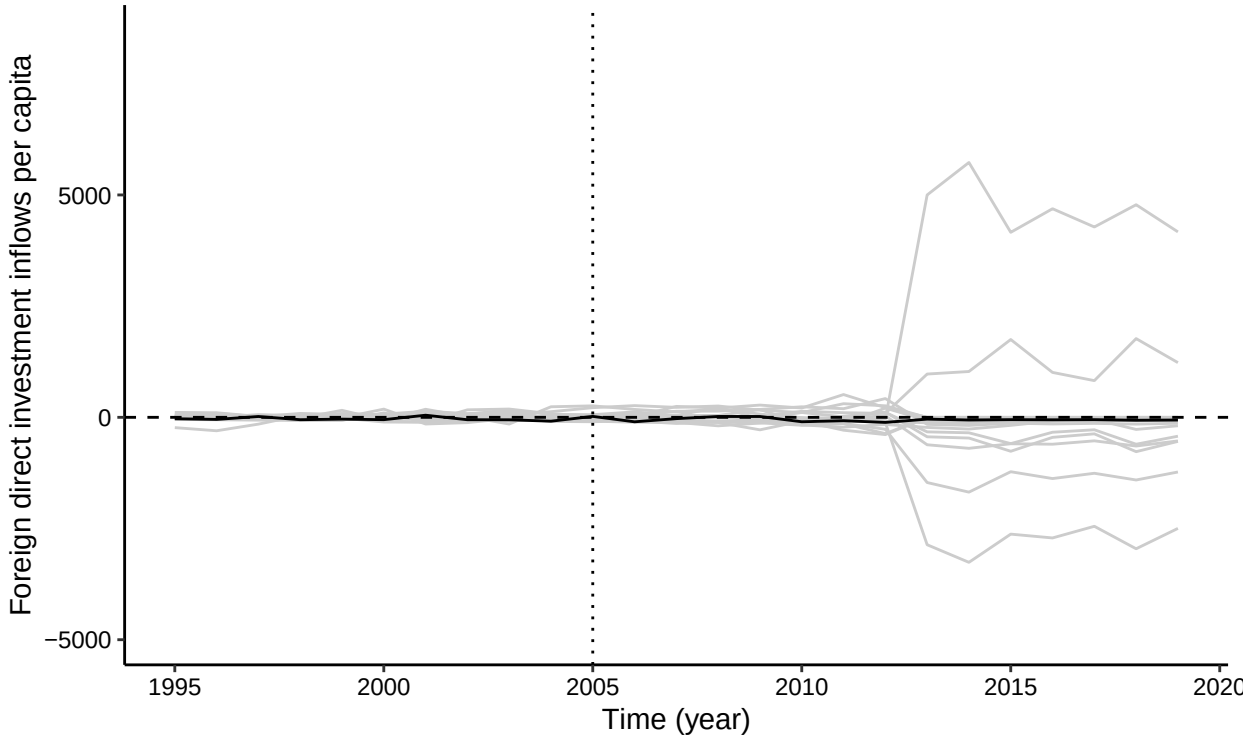
```
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 3370.051
##
## solution.v:
##  0.5013578 0.0003128123 0.4772426 0.01962149 0.00146533
##
## solution.w:
##  2e-08 1.64e-08 3.39e-08 1.43e-08 3.508e-07 2.7046e-06 2.33e-08 5.1e-09 2.35e-08 3.46e-08 4.8e-09 4.9
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 644.1798
##
## solution.v:
##  0.255291 0.1602648 0.1645518 0.184098 0.2357943
##
## solution.w:
##  6.3e-09 0.04929471 1.32e-08 5e-10 3.2e-09 6e-10 2.4e-09 0 1.89e-08 9.43e-08 1.3e-09 0.4490357 0.501
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 5648.466
##
## solution.v:
##  0.002244409 0.379159 0.008291287 0.5931836 0.01712172
##
## solution.w:
##  0.05061363 0.02919531 0.1343992 0.03071587 0.06397899 0.05139883 0.04416258 0.05307418 0.1689668 0.0
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
```

```
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 4568.05
##
## solution.v:
##  4.68e-08 0.5502713 0.005704177 0.4440245 6.3e-09
##
## solution.w:
##  5.26662e-05 1.66609e-05 4.39346e-05 1.09794e-05 0.472018 2.28506e-05 0.183043 2.05776e-05 0.3446516
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 5554.548
##
## solution.v:
##  0.0007936399 1.0981e-06 0.001907755 0.7128054 0.2844921
##
## solution.w:
##  0.4343238 0.004243963 0.280997 0.02446824 0.0008936169 0.0001786536 0.0004287662 0.0002177069 0.001
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 2719.347
##
## solution.v:
##  0.6197193 0.002311019 0.08643633 0.2909228 0.0006106084
```

```
##
## solution.w:
##  3.78534e-05 0.2172639 0.263903 2.149e-07 0.01946617 0.0004785324 5.69621e-05 0.005150644 0.42467 4.4
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 1285.134
##
## solution.v:
##  0.000197648 0.04933212 0.2689966 0.66689 0.01458362
##
## solution.w:
##  7.522e-07 2.4008e-06 5.239e-07 1.74637e-05 2.894e-07 2.0935e-06 1.0004e-06 0.5226855 0.2580118 1.42
##
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 1422.7
##
## solution.v:
##  0.05927164 0.5043216 0.198307 0.1779857 0.06011404
##
## solution.w:
##  1.5422e-06 1.1871e-06 4.8475e-06 0.02615989 1.7978e-06 0.7918963 6.702e-07 0.03226622 6.512e-07 3.3
## New names:
## * `w.weight` -> `w.weight...1`
## * `w.weight` -> `w.weight...2`
## * `w.weight` -> `w.weight...3`
## * `w.weight` -> `w.weight...4`
## * `w.weight` -> `w.weight...5`
## * `w.weight` -> `w.weight...6`
## * `w.weight` -> `w.weight...7`
## * `w.weight` -> `w.weight...8`
## * `w.weight` -> `w.weight...9`
```

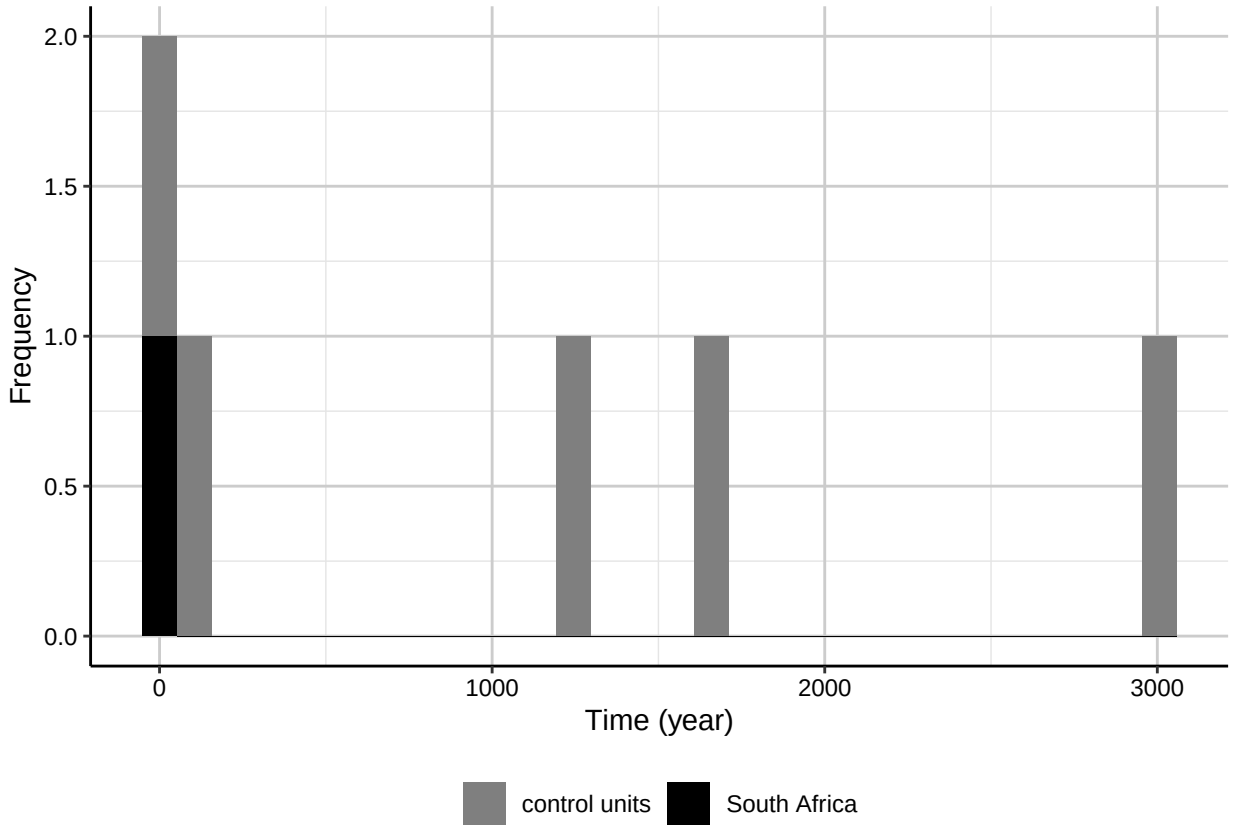
```
## * `w.weight` -> `w.weight...10`
## * `w.weight` -> `w.weight...11`
## * `w.weight` -> `w.weight...12`
## * `w.weight` -> `w.weight...13`
## * `w.weight` -> `w.weight...14`
## * `w.weight` -> `w.weight...15`
```

```
plot_placebos(placebos, xlab = "Time (year)", ylab = "Foreign direct investment inflows per capita")
```




```
mspe.plot(placebos, discard.extreme = TRUE, mspe.limit = 1, plot.hist = TRUE, xlab = "Time (year)", ylab
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
# ROBUSTNESS TEST -> taking out highest weighted country (Cuba 5) from synthetic control donor pool
dataprep_out2 <- dataprep(
  foo = merged_data,
  predictors = c("gdp_cap", "trade_per_gdp", "pol_stab_est", "govt_educ", "internet"),
  # predictors.op = "mean",
  time.predictors.prior = 1995:2005,
  dependent = "fdi_bop_per_capita",
  unit.variable = "id",
  unit.names.variable = "country",
  time.variable = "year",
  treatment.identifier = 24,
  controls.identifier = c(2:4, 7:8, 10, 12:14, 16:20), # c(1:4, 7, 12, 14, 16:20),
  time.optimize.ssr = 1995:2005, # pretreatment for dependent
  time.plot = 1995:2019
)
```

```
# Run Synth
synth_out2 <- synth(data.prep.obj = dataprep_out2)
```

Remove highest weight country

```
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
```

```
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 3412.635
##
## solution.v:
##  6.23756e-05 0.7048776 0.0005266627 0.0005036989 0.2940297
##
## solution.w:
##  0.0001023298 0.06968575 6.07595e-05 0.000155608 0.297274 0.0001313628 0.0003541634 2.3947e-05 0.000
```

```
synth.tables <- synth.tab(
  dataprep.res  = dataprep_out2,
  synth.res     = synth_out2)
top_weights <- head(synth.tables$tab.w[order(synth.tables$tab.w$w, decreasing = TRUE), ], 5)

# Extract the top 5 weights
cat("\nRobustness test weights - taking out Cuba from Donor Pool:\n")
```

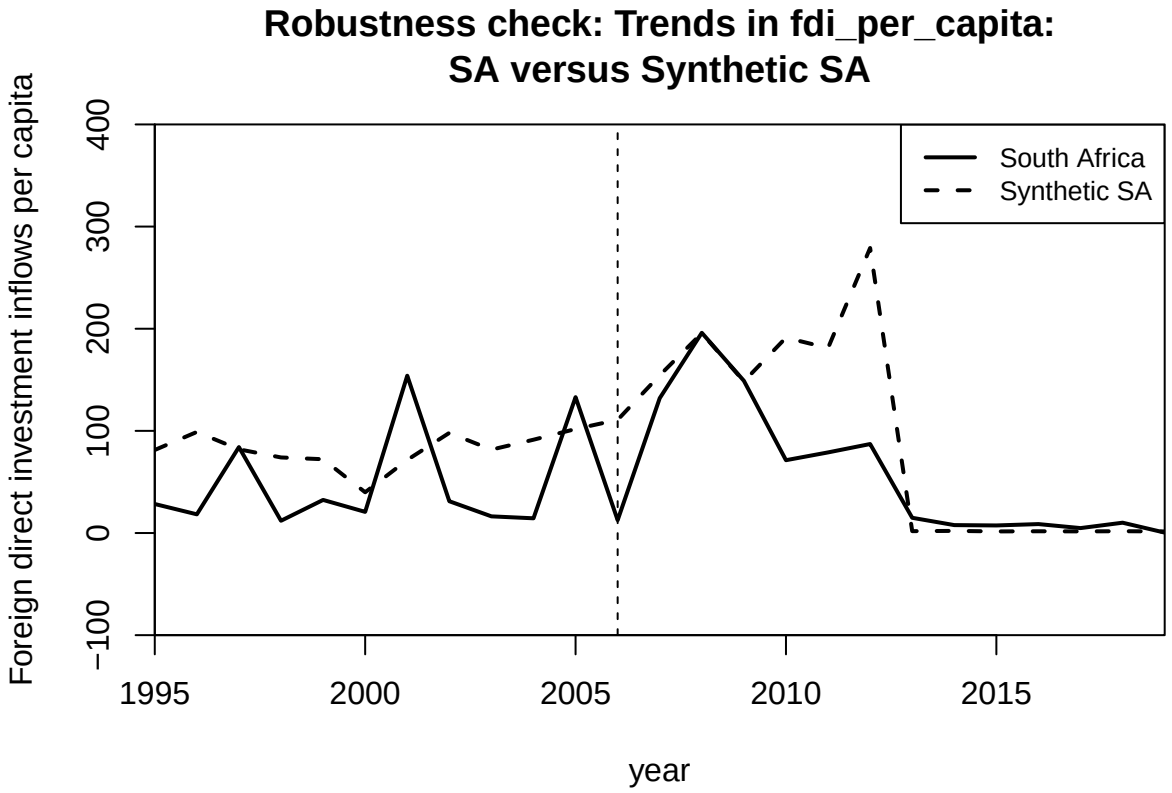
```
##
## Robustness test weights - taking out Cuba from Donor Pool:
```

```
print(top_weights)
```

```
##    w.weights unit.names unit.numbers
## 20     0.512       Peru           20
## 8      0.297    Ecuador            8
## 17     0.119     Mexico           17
## 3      0.070   Botswana            3
## 2      0.000     Belize            2
```

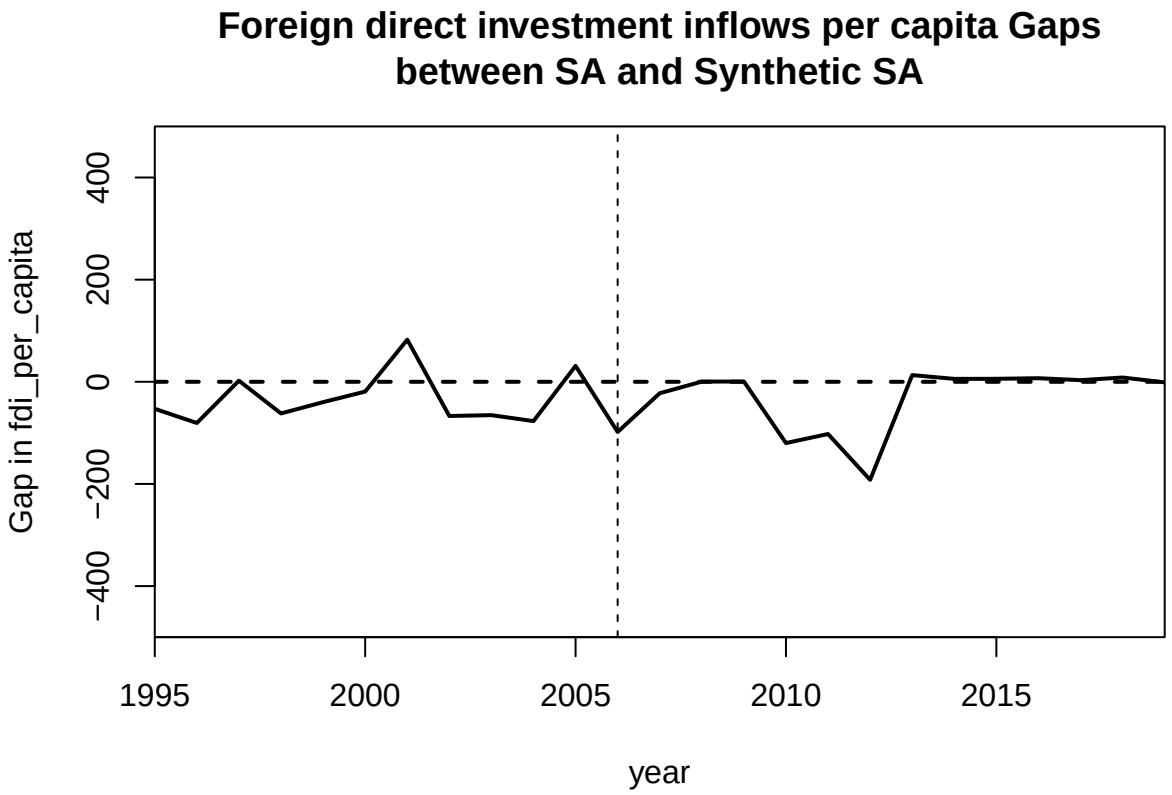
```
# path plot
path.plot(synth_out2, dataprep_out2,
          Ylab = c("Foreign direct investment inflows per capita"),
          Xlab = c("year"),
          Legend = c("South Africa", "Synthetic SA"),
          Main = "Robustness check: Trends in fdi_per_capita:\nSA versus Synthetic SA",
          Ylim = c(-100, 400)
)

abline(v = 2006, lty = 2)
```




```
# gaps plot
gaps.plot(synth.res    = synth_out2,
          dataprep.res = dataprep_out2,
          Ylab         = c("Gap in fdi_per_capita"),
          Xlab         = c("year"),
          Main         = "Foreign direct investment inflows per capita Gaps\nbetween SA and Synthetic S
          Ylim = c(-500, 500)
)

abline(v = 2006, lty = 2)
```




```
# IN-TIME PLACEBO TEST: Choosing a fake treatment year (pre-treatment) 2001

dataprep_out3 <- dataprep(
  foo = merged_data,
  predictors = c("gdp_cap", "trade_per_gdp", "pol_stab_est", "govt_educ", "internet"),
  # predictors.op = "mean",
  time.predictors.prior = 1995:2000,
  dependent = "fdi_bop_per_capita",
  unit.variable = "id",
  unit.names.variable = "country",
  time.variable = "year",
  treatment.identifier = 24,
  controls.identifier = c(2:4, 7:8, 10, 12:14, 16:20),
  time.optimize.ssr = 1995:2000, # pretreatment for dependent
  time.plot = 1995:2006
)
```

```
# Run Synth
synth_out3 <- synth(data.prep.obj = dataprep_out3)
```

In-time Placebo tests

```
##
## X1, X0, Z1, Z0 all come directly from dataprep object.
##
##
## ****************
```

```
##  searching for synthetic control unit
##
##
## ****************
## ****************
## ****************
##
## MSPE (LOSS V): 2384.897
##
## solution.v:
##  3.56882e-05 0.02845532 0.2093683 0.7621325 8.1462e-06
##
## solution.w:
##  0.0001658042 0.3368163 0.000354362 0.0001141835 0.0002188454 0.0001000569 0.000136092 0 2.69441e-05
```

```
synth.tables <- synth.tab(
  dataprep.res  = dataprep_out3,
  synth.res     = synth_out3)
top_weights <- head(synth.tables$tab.w[order(synth.tables$tab.w$w, decreasing = TRUE), ], 5)

# Extract the top 5 weights
cat("\nRobustness test weights - taking out Cuba from Donor Pool:\n")
```

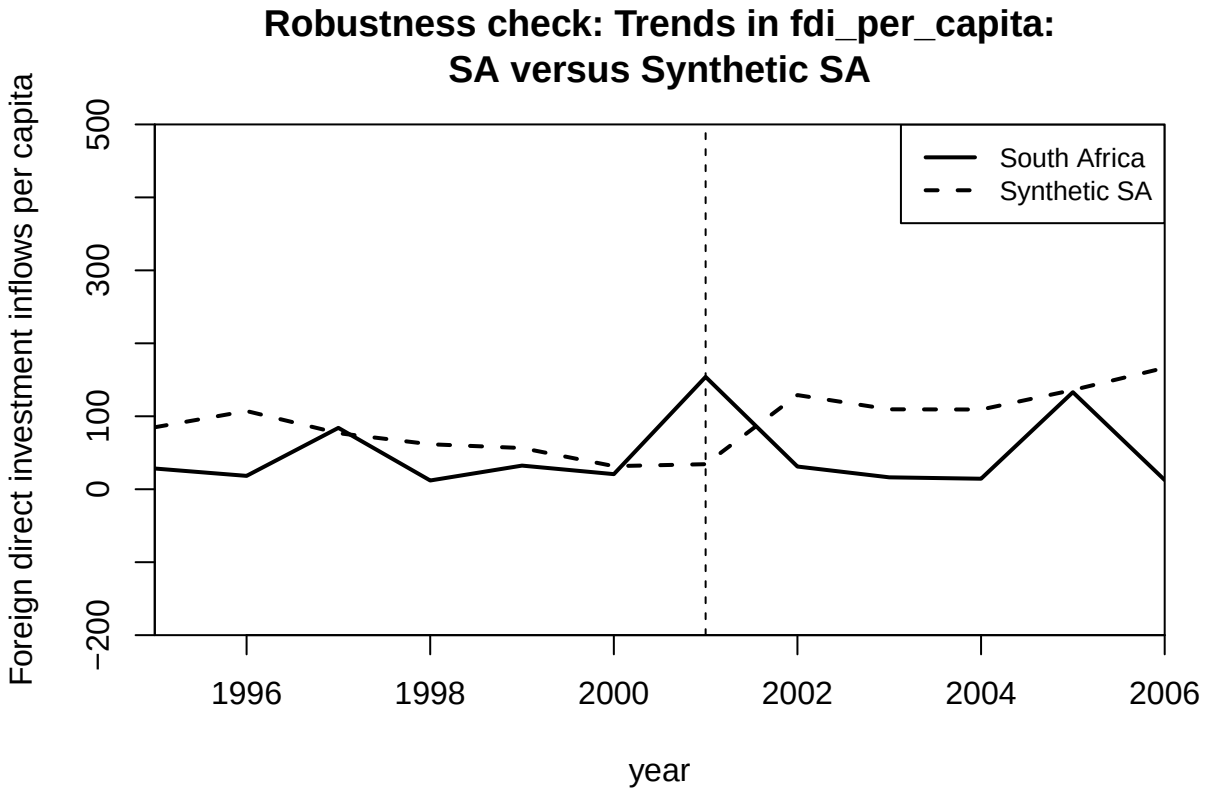
```
##
## Robustness test weights - taking out Cuba from Donor Pool:
```

```
print(top_weights)
```

```
##    w.weights unit.names unit.numbers
## 20     0.660       Peru           20
## 3      0.337   Botswana            3
## 17     0.002     Mexico           17
## 2      0.000     Belize            2
## 4      0.000 Costa Rica            4
```

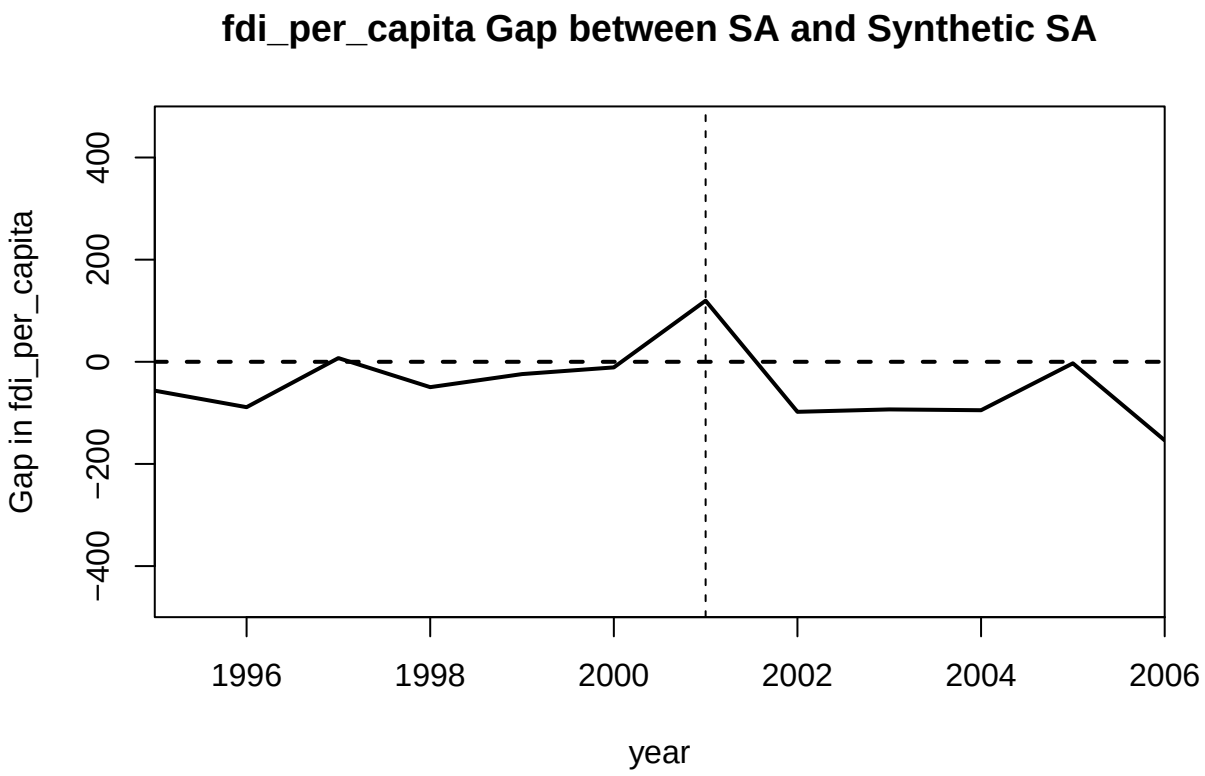
```
# path plot
path.plot(synth_out3, dataprep_out3,
          Ylab = c("Foreign direct investment inflows per capita"),
          Xlab = c("year"),
          Legend = c("South Africa", "Synthetic SA"),
          Main = "Robustness check: Trends in fdi_per_capita:\nSA versus Synthetic SA",
          Ylim = c(-200, 500)
)

abline(v = 2001, lty = 2)
```




```
# gaps plot
gaps.plot(synth.res    = synth_out3,
          dataprep.res = dataprep_out3,
          Ylab         = c("Gap in fdi_per_capita"),
          Xlab         = c("year"),
          Main         = "fdi_per_capita Gap between SA and Synthetic SA",
          Ylim = c(-500, 500)
)

abline(v = 2001, lty = 2)
```


fdi_per_capita Gap between SA and Synthetic SA
Gap in fdi_per_capita
−400
−200
0
200
400
1996
1998
2000
2002
2004
2006
year