Causal Inference with Time-Series Cross-Sectional Data

Shengqiao Lin (shengqiaolin@utexas.edu)

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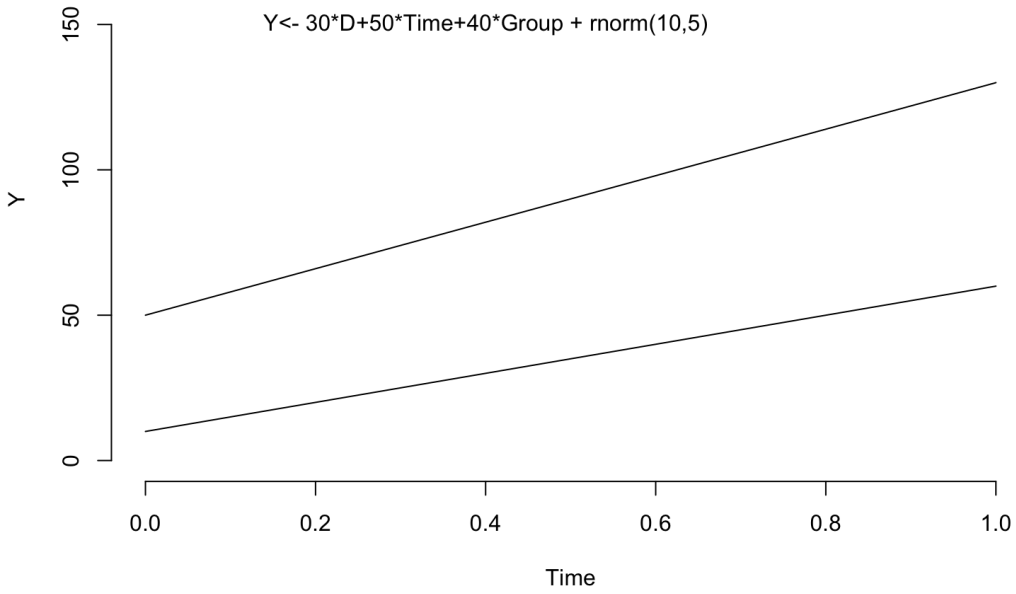
Goals for Today

- Methods:
  - *Difference-in-differences*
  - *Two-ways Fixed Effects/Staggered DID/Event study/Synthetic Control*
- Package Recommended:
  - *fixest (my favorite, super user-friendly)*
    - More than two-ways FE, clustered SE, logit
  - *plm*
    - lag, lead, diff
  - *did*
- Reference
  - *Yiqing Xu, Causal Inference with Time-Series Cross-Sectional Data: A Reflection*
  - *Liu, Wang and Xu, A Practical Guide to Counterfactual Estimators for Causal Inference with Time-Series Cross-Sectional Data, AJPS 2022*

Difference-in-differences

- DID: Difference 1 × Difference 2
  - *Treated Group × Before/After Treatment*
  - *Assumption:*
    - Common/Parallel Trend Assumption: Pre-treatment trend -> counterfactual post-treatment trend
    - No self-sorting behavior, especially treatment at an aggregated level
    - Treatment
- DID does not always use:
  - *time-series cross-sectional data -> could be repeated cross-sectional data (treated at age, location, industries)*
  - *time as one of the differences -> could be spatial, timing*
  - *two binary variables -> one could be countinous*

Simulated Data: Repeated Cross-sectional Data



Estimation

```
attach(Data)
summary(lm(Y~Group,data=Data))
```

```
##
## Call:
## lm(formula = Y ~ Group, data = Data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -54.052 -32.060   0.655  31.367  52.359
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   35.436      3.182   11.14   <2e-16 ***
## Group         54.372      4.691   11.59   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 33.06 on 198 degrees of freedom
## Multiple R-squared:  0.4042, Adjusted R-squared:  0.4012
## F-statistic: 134.3 on 1 and 198 DF,  p-value: < 2.2e-16
```

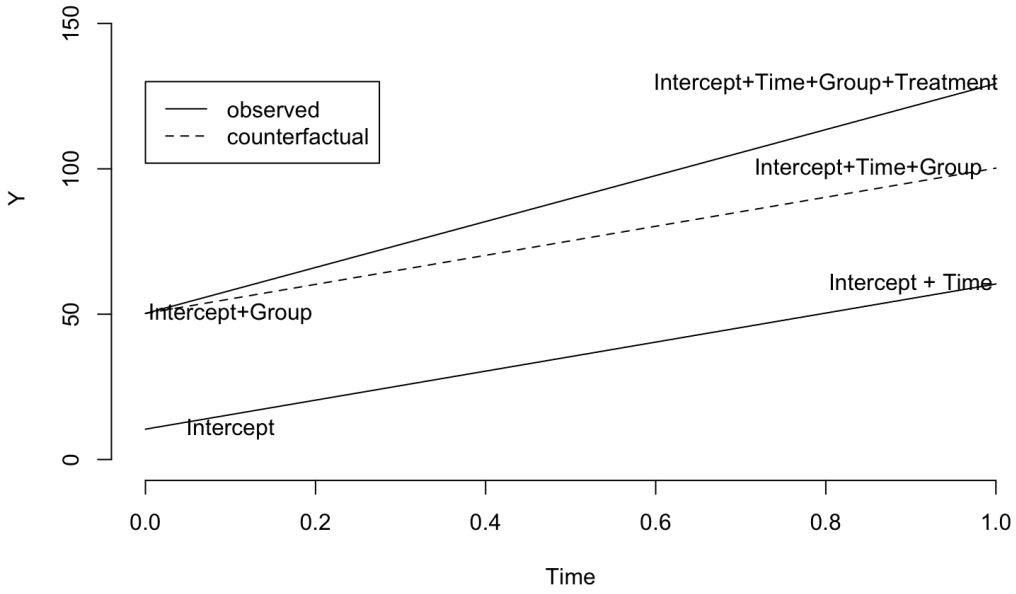
```
summary(lm(Y~Time,data=Data))
```

```
##
## Call:
## lm(formula = Y ~ Time, data = Data)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -41.50 -26.69 -11.74  27.31  50.03
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   28.756      2.864   10.04   <2e-16 ***
## Time          63.382      4.051   15.65   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 28.64 on 198 degrees of freedom
## Multiple R-squared:  0.5529, Adjusted R-squared:  0.5506
## F-statistic: 244.8 on 1 and 198 DF,  p-value: < 2.2e-16
```

```
summary(lm(Y~Group*Time,data=Data))
```

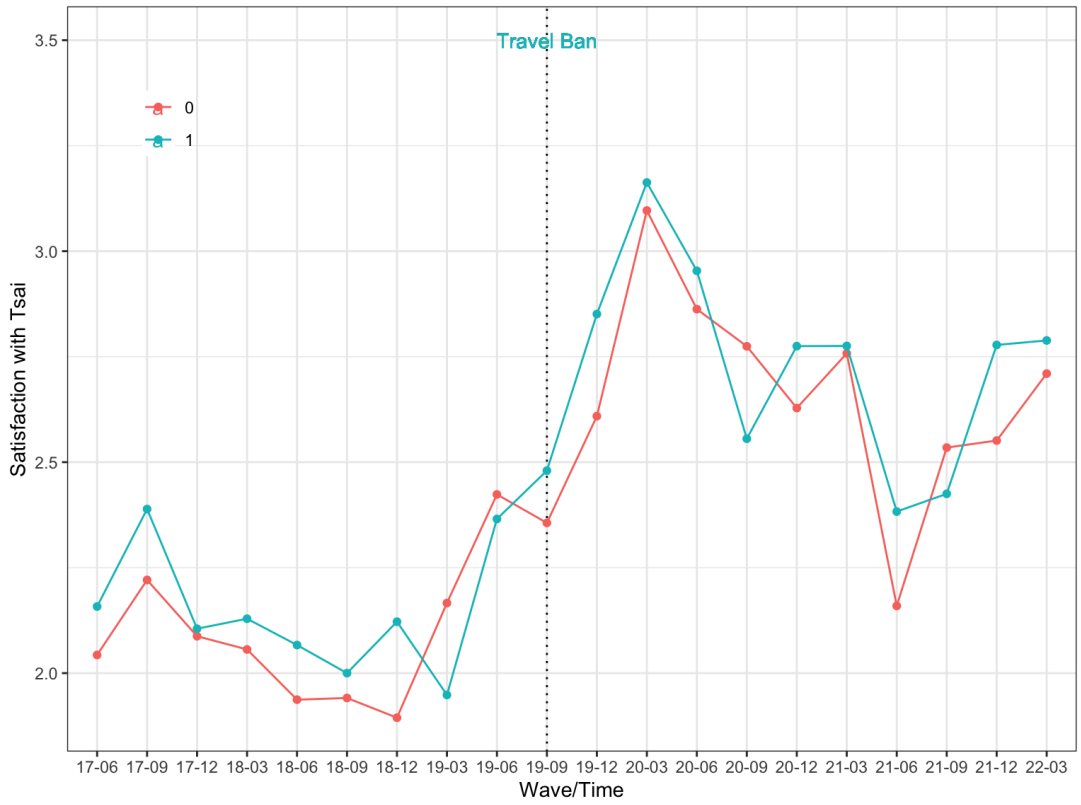
```
##
## Call:
## lm(formula = Y ~ Group * Time, data = Data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -14.4988  -3.1516  -0.4755   3.3986  13.1783
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  10.4427     0.6912   15.11   <2e-16 ***
```

```
## Group        39.8114     1.0191   39.07   <2e-16 ***
## Time         49.9863     0.9775   51.14   <2e-16 ***
## Group:Time   29.1207     1.4412   20.21   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.079 on 196 degrees of freedom
## Multiple R-squared:  0.9861, Adjusted R-squared:  0.9859
## F-statistic:  4629 on 3 and 196 DF,  p-value: < 2.2e-16
```



Example

- Research question: how do sanctions affect public opinion, especially people in sanctioned industries?
- Argument: backlash effect, sanctions increase political support of targeted group for the incumbent
- Context: Beijing's tourism ban on Taiwan
- Research Design: Tourism * Travel Ban




```
library(fixest)

mdid<- feols(SatisfyTsai~Tourism*TravelBan+AGE+EDU+Female+Minnan+TaiwanID|JobSelf+Time+City,cluster=~JobSelf,data=Data)
etable(mdid)
```

```
##                                  mdid
## Dependent Var.:             SatisfyTsai
##
## Tourism1                 -0.0153 (0.0571)
## AGE.L                    -0.0013 (0.0243)
## AGE.Q                     0.0527* (0.0205)
## AGE.C                   0.0497*** (0.0116)
## AGE^4                     0.0208. (0.0120)
```

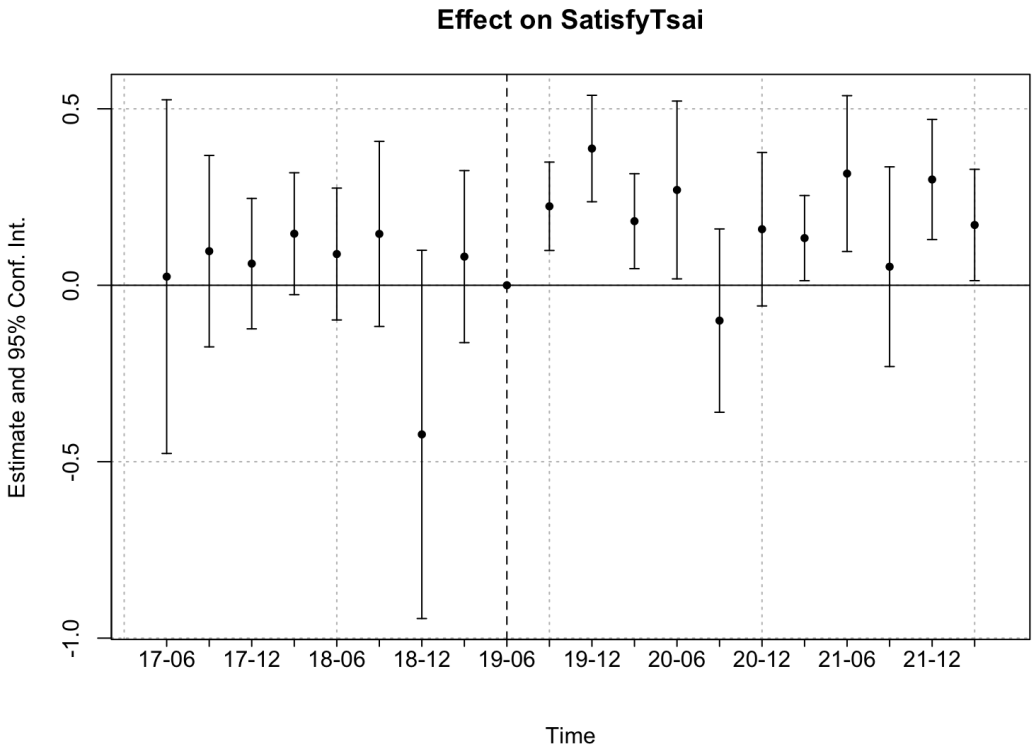
```
## EDU.L                  -0.2178*** (0.0308)
## EDU.Q                   0.0857*** (0.0166)
## EDU.C                     0.0315. (0.0167)
## EDU^4                    -0.0194 (0.0123)
## Female1                 -0.0619** (0.0228)
## Minnan1                  0.2394*** (0.0192)
## TaiwanID1                0.8284*** (0.0627)
## Tourism1 x TravelBan1     0.1276** (0.0442)
## Fixed-Effects:          ------------------
## JobSelf                                Yes
## Time                                   Yes
## City                                   Yes
## ______________________ ________________
## S.E.: Clustered                by: JobSelf
## Observations                        20,150
## R2                                 0.31610
## Within R2                          0.21975
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
mdid_plot = feols(SatisfyTsai ~ i(Time, as.numeric(Tourism), ref = c('19-
        06'))+Tourism+AGE+EDU+Female+Minnan+TaiwanID|JobSelf+Time+City,cluster=~JobSelf,data=Data)
etable(mdid_plot)
```

```
##                                        mdid_plot
## Dependent Var.:                       SatisfyTsai
##
## as.numeric(Tourism) x Time = 17-06     0.0244 (0.2557)
## as.numeric(Tourism) x Time = 17-09     0.0966 (0.1384)
## as.numeric(Tourism) x Time = 17-12     0.0613 (0.0943)
## as.numeric(Tourism) x Time = 18-03     0.1461 (0.0881)
## as.numeric(Tourism) x Time = 18-06     0.0885 (0.0953)
## as.numeric(Tourism) x Time = 18-09     0.1455 (0.1338)
## as.numeric(Tourism) x Time = 18-12    -0.4227 (0.2662)
## as.numeric(Tourism) x Time = 19-03     0.0811 (0.1244)
## as.numeric(Tourism) x Time = 19-09   0.2237** (0.0639)
## as.numeric(Tourism) x Time = 19-12  0.3874*** (0.0770)
## as.numeric(Tourism) x Time = 20-03    0.1816* (0.0687)
## as.numeric(Tourism) x Time = 20-06    0.2700* (0.1286)
## as.numeric(Tourism) x Time = 20-09    -0.1002 (0.1325)
## as.numeric(Tourism) x Time = 20-12     0.1588 (0.1110)
## as.numeric(Tourism) x Time = 21-03    0.1336* (0.0616)
## as.numeric(Tourism) x Time = 21-06   0.3165** (0.1126)
## as.numeric(Tourism) x Time = 21-09     0.0525 (0.1444)
## as.numeric(Tourism) x Time = 21-12   0.2997** (0.0868)
## as.numeric(Tourism) x Time = 22-03    0.1708* (0.0805)
## Tourism1                             -0.0870 (0.0627)
## AGE.L                                -0.0014 (0.0243)
## AGE.Q                                 0.0529* (0.0205)
## AGE.C                               0.0494*** (0.0116)
## AGE^4                                 0.0209. (0.0120)
## EDU.L                               -0.2190*** (0.0308)
## EDU.Q                                0.0863*** (0.0167)
## EDU.C                                 0.0309. (0.0168)
## EDU^4                                -0.0197 (0.0123)
## Female1                              -0.0621* (0.0230)
## Minnan1                              0.2390*** (0.0194)
## TaiwanID1                            0.8284*** (0.0629)
## Fixed-Effects:                       ------------------
## JobSelf                                             Yes
## Time                                                Yes
## City                                                Yes
## ____________________________________ ________________
## S.E.: Clustered                                by: JobSelf
```

```
## Observations                                      20,150
## R2                                               0.31646
## Within R2                                        0.22016
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
iplot(mdid_plot,ci_level = 0.95)
```



Panel Data

- Panel Data + Treatment at the same time + Not Exit -> TWFE (fixest), fect
  - *Very small treated group/hard to justify control group -> Synthetic Control (gsynth)*
- Panel Data + Treatment at multiple time + Not Exit ->
  - *TWFE (still acceptable)*
  - *Other DID packages (to deal with treatment effect heterogeneity)*

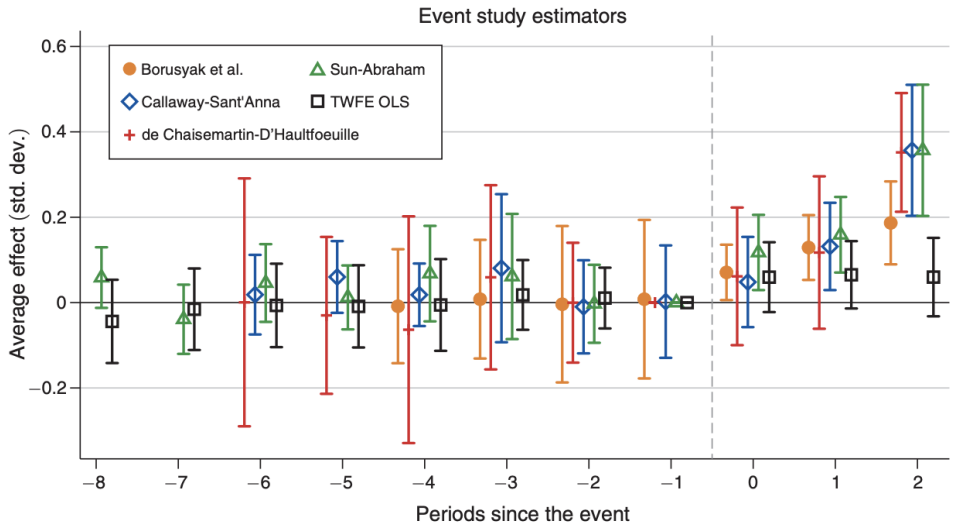


FIGURE 2. EFFECTS OF FACEBOOK ON THE INDEX OF POOR MENTAL HEALTH BASED ON DISTANCE TO/FROM FACEBOOK

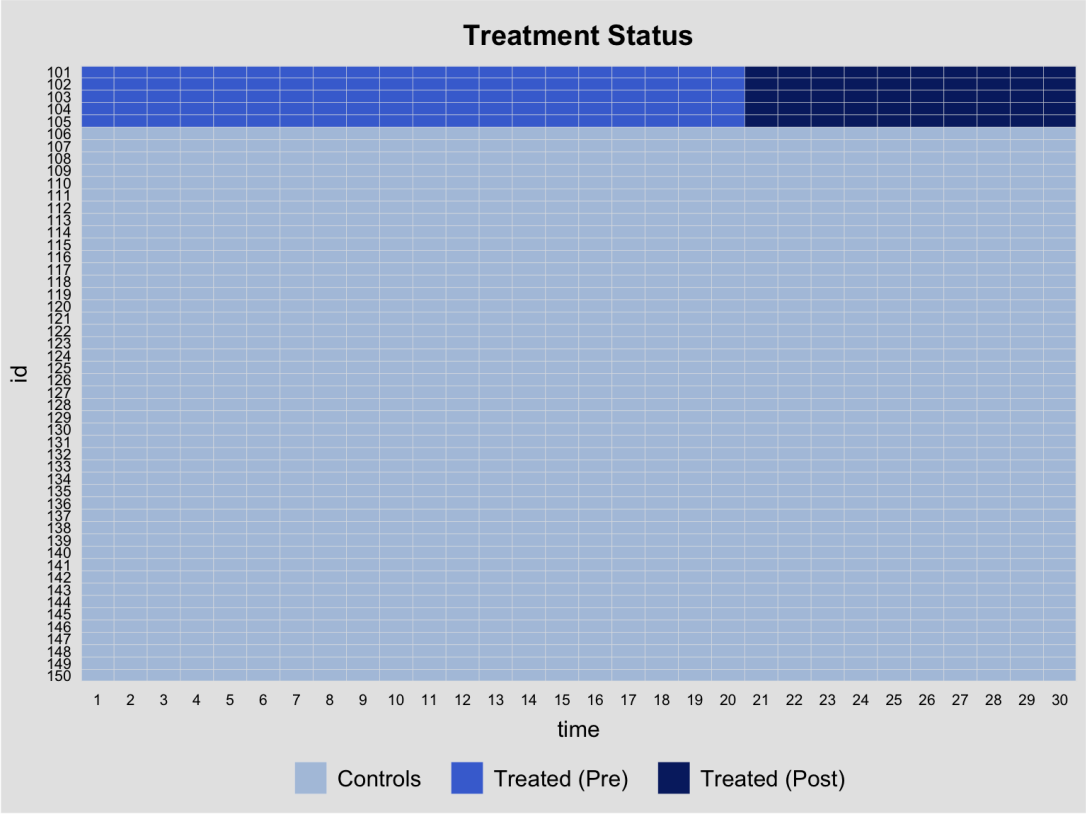
INTRODUCTION

(Source: Braghieri, Luca, Ro'ee Levy, and Alexey Makarin. 2022. "Social Media and Mental Health." American Economic Review, 112 (11): 3660-93.DOI: 10.1257/aer.20211218)

- Panel Data + Treatment at multiple time + Exit -> TWFE, fect
  - *Usually we don't call this DID*
- Panel Data + Continuous Treatment * Time -> TWFE

Examples: Treated at the Sample Time

```
library(gsynth)
library(plm)
library(panelView)
data(gsynth)
panelview(Y ~ D, data = simdata,  index = c("id","time"), pre.post = TRUE)
```




```
#TWFE
twfe1<- feols(Y~D+X1+X2|id+time,data=simdata)
etable(twfe1)
```

```
##                             twfe1
## Dependent Var.:                 Y
##
## D               5.098*** (0.3863)
## X1              1.470*** (0.0447)
## X2              3.511*** (0.0415)
## Fixed-Effects:  -----------------
## id                            Yes
## time                          Yes
## _______________ _________________
## S.E.: Clustered             by: id
## Observations                1,500
## R2                        0.93768
## Within R2                 0.91568
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#PLM
pdata<- pdata.frame(simdata,index = c('id','time'))
plm1<- plm(Y~D+X1+X2,effect = "twoways",model='within',data=pdata)
summary(plm1)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = Y ~ D + X1 + X2, data = pdata, effect = "twoways",
##     model = "within")
##
## Balanced Panel: n = 50, T = 30, N = 1500
##
## Residuals:
##       Min.    1st Qu.     Median    3rd Qu.       Max.
## -7.5909535 -0.9561893  0.0063562  0.9791419  8.1881619
##
## Coefficients:
##    Estimate Std. Error t-value  Pr(>|t|)
## D  5.098313   0.276589  18.433 < 2.2e-16 ***
## X1 1.469726   0.035839  41.009 < 2.2e-16 ***
## X2 3.511163   0.034906 100.589 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    38170
## Residual Sum of Squares: 3218.3
## R-Squared:      0.91568
## Adj. R-Squared: 0.91087
## F-statistic: 5133.27 on 3 and 1418 DF, p-value: < 2.22e-16
```

```r
plm2<- plm(lag(Y)~D+X1+X2,effect = "twoways",model='within',data=pdata)
summary(plm2)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = lag(Y) ~ D + X1 + X2, data = pdata, effect = "twoways",
##     model = "within")
##
## Balanced Panel: n = 50, T = 29, N = 1450
##
## Residuals:
##      Min.   1st Qu.    Median   3rd Qu.      Max.
## -17.65278  -3.32205  -0.15693   3.20254  19.84775
##
## Coefficients:
##     Estimate Std. Error t-value Pr(>|t|)
## D   1.401058   0.961171  1.4577  0.14516
## X1 -0.022742   0.125532 -0.1812  0.85626
## X2 -0.211156   0.122819 -1.7193  0.08579 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    37042
## Residual Sum of Squares: 36881
## R-Squared:      0.00435
## Adj. R-Squared: -0.053833
## F-statistic: 1.99374 on 3 and 1369 DF, p-value: 0.11306
```

```
plm3<- plm(lead(Y)~D+X1+X2,effect = "twoways",model='within',data=pdata)
summary(plm3)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = lead(Y) ~ D + X1 + X2, data = pdata, effect = "twoways",
##     model = "within")
##
## Balanced Panel: n = 50, T = 29, N = 1450
##
## Residuals:
##       Min.    1st Qu.     Median    3rd Qu.       Max.
## -17.334003  -3.171253  -0.069724   3.272421  19.419832
##
## Coefficients:
##     Estimate Std. Error t-value Pr(>|t|)
## D   2.558278   0.988992  2.5868 0.009791 **
## X1 -0.130162   0.125415 -1.0378 0.299524
## X2 -0.025923   0.121868 -0.2127 0.831582
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    37192
## Residual Sum of Squares: 36955
## R-Squared:      0.0063878
## Adj. R-Squared: -0.051676
## F-statistic: 2.93371 on 3 and 1369 DF, p-value: 0.03242
```

```
plm4<- plm(diff(Y)~D+X1+X2,effect = "twoways",model='within',data=pdata)
summary(plm4)
```

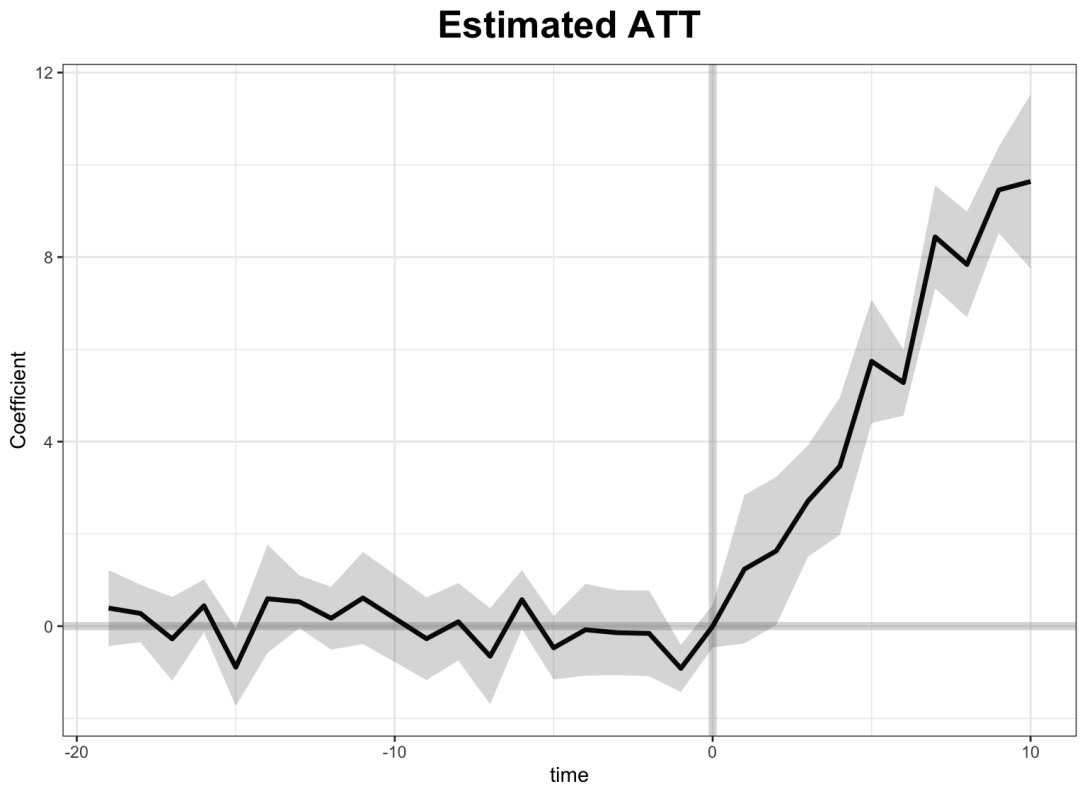
```
## Twoways effects Within Model
##
## Call:
## plm(formula = diff(Y) ~ D + X1 + X2, data = pdata, effect = "twoways",
##     model = "within")
##
## Balanced Panel: n = 50, T = 29, N = 1450
##
## Residuals:
##       Min.    1st Qu.     Median    3rd Qu.       Max.
## -18.847583  -3.394837  -0.046142   3.328497  17.250125
##
## Coefficients:
##    Estimate Std. Error t-value  Pr(>|t|)
## D   3.71342    0.97814  3.7964 0.0001532 ***
## X1  1.49760    0.12775 11.7230 < 2.2e-16 ***
## X2  3.74110    0.12499 29.9321 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    75657
## Residual Sum of Squares: 38195
## R-Squared:      0.49516
## Adj. R-Squared: 0.46566
## F-statistic: 447.584 on 3 and 1369 DF, p-value: < 2.22e-16
```

```
#Synthetic Control
syn1 <- gsynth(Y ~ D + X1 + X2, data = simdata,
```

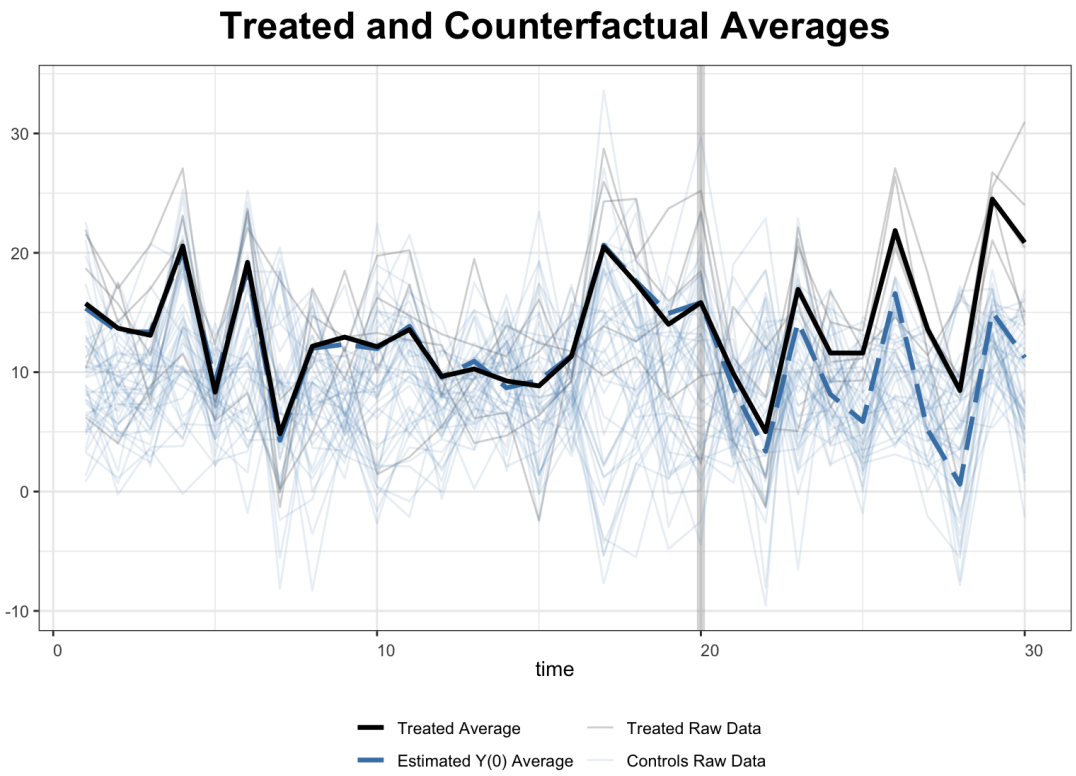
```
                index = c("id","time"), force = "two-way",
                se = TRUE, nboots = 1000)
```

```
## Parallel computing ...
## Cross-validating ...
##   r = 0; sigma2 = 1.84865; IC = 1.02023; PC = 1.74458; MSPE = 2.37280
##   r = 1; sigma2 = 1.51541; IC = 1.20588; PC = 1.99818; MSPE = 1.71743
##   r = 2; sigma2 = 0.99737; IC = 1.16130; PC = 1.69046; MSPE = 1.14540*
##   r = 3; sigma2 = 0.94664; IC = 1.47216; PC = 1.96215; MSPE = 1.15032
##   r = 4; sigma2 = 0.89411; IC = 1.76745; PC = 2.19241; MSPE = 1.21397
##   r = 5; sigma2 = 0.85060; IC = 2.05928; PC = 2.40964; MSPE = 1.23876
##
##   r* = 2
##
##
Bootstrapping ...
##
```

```
plot(syn1)
```

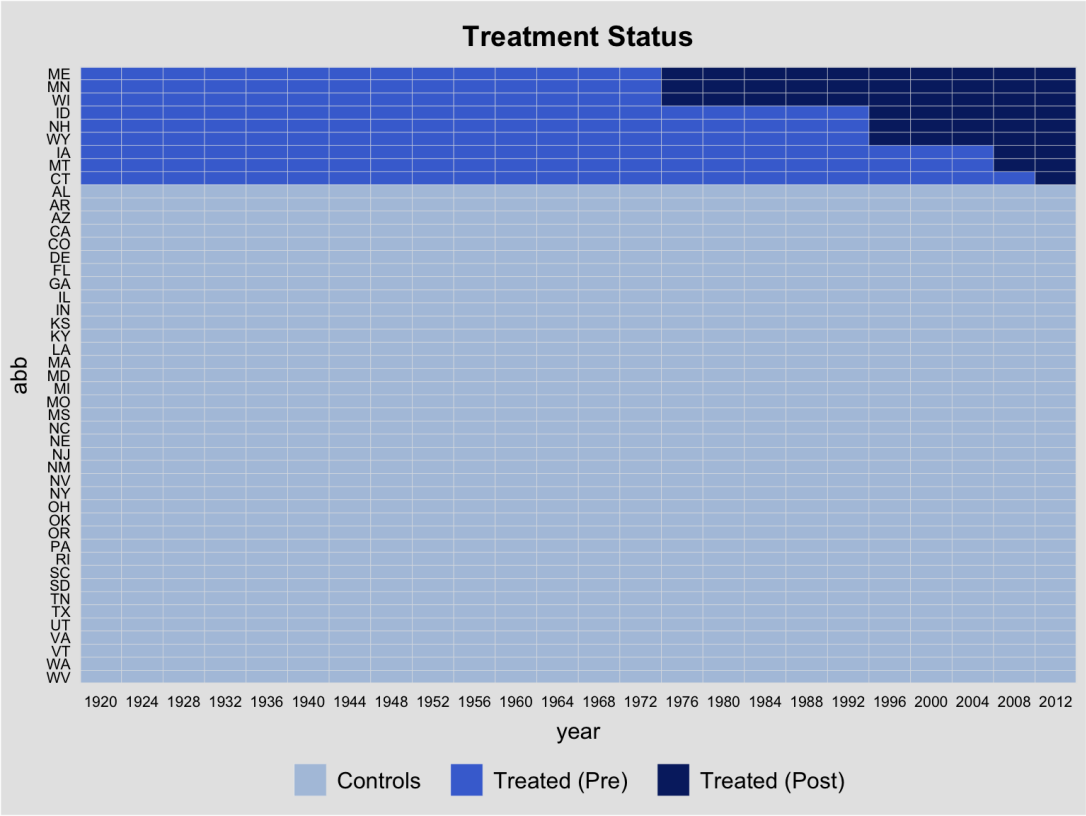



```
plot(syn1,type='counterfactual',raw = "all")
```


Treated and Counterfactual Averages
30
20
10
0
-10
0
10
20
30
time
Treated Average
Estimated Y(0) Average
Treated Raw Data
Controls Raw Data

Examples: Treated at the Multiple Period

```
library(fect)
panelview(turnout ~ policy_edr, data = turnout,
          index = c("abb","year"), pre.post = TRUE,
          by.timing = TRUE)
```




```
twfe<- feols(turnout~policy_edr + policy_mail_in + policy_motor|abb+year,data=turnout)
etable(twfe)
```

```
##                            twfe
## Dependent Var.:         turnout
##
## policy_edr        0.7776 (3.178)
## policy_mail_in   -0.9443 (1.756)
## policy_motor     -0.2057 (1.395)
## Fixed-Effects:   ---------------
## abb                          Yes
## year                         Yes
## _________________ _______________
## S.E.: Clustered          by: abb
## Observations               1,128
## R2                       0.67752
## Within R2                0.00111
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#PLM
turnout$year_n<- as.numeric(as.ordered(turnout$year))
pdata<- pdata.frame(turnout,index=c('abb','year_n'))

plm1<-  plm(turnout~policy_edr + policy_mail_in + policy_motor,effect = "twoways",model='within',data=pdata)
summary(plm1)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = turnout ~ policy_edr + policy_mail_in + policy_motor,
##     data = pdata, effect = "twoways", model = "within")
##
## Balanced Panel: n = 47, T = 24, N = 1128
##
## Residuals:
##     Min.  1st Qu.   Median  3rd Qu.     Max.
## -24.1205  -4.4345  -0.2496   4.7807  24.4261
##
## Coefficients:
##                Estimate Std. Error t-value Pr(>|t|)
## policy_edr      0.77757    1.54688  0.5027   0.6153
## policy_mail_in -0.94430    1.10808 -0.8522   0.3943
## policy_motor   -0.20571    1.48122 -0.1389   0.8896
##
## Total Sum of Squares:    71046
## Residual Sum of Squares: 70967
## R-Squared:      0.0011148
## Adj. R-Squared: -0.067056
## F-statistic: 0.392461 on 3 and 1055 DF, p-value: 0.75846
```

```r
plm2<-  plm(lag(turnout)~policy_edr + policy_mail_in + policy_motor,effect = "twoways",model='within',data=pdata)
summary(plm2)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = lag(turnout) ~ policy_edr + policy_mail_in + policy_motor,
##     data = pdata, effect = "twoways", model = "within")
##
## Balanced Panel: n = 47, T = 23, N = 1081
##
## Residuals:
##      Min.   1st Qu.    Median   3rd Qu.      Max.
## -23.11438  -4.45346  -0.32108   4.70358  25.13543
##
## Coefficients:
##                Estimate Std. Error t-value Pr(>|t|)
## policy_edr      0.30019    1.54061  0.1949   0.8455
## policy_mail_in -0.58161    1.10343 -0.5271   0.5982
## policy_motor   -0.45979    1.46694 -0.3134   0.7540
##
## Total Sum of Squares:    66037
## Residual Sum of Squares: 66000
## R-Squared:      0.00055664
## Adj. R-Squared: -0.069771
## F-statistic: 0.187321 on 3 and 1009 DF, p-value: 0.90505
```

```r
plm3<-  plm(lead(turnout)~policy_edr + policy_mail_in + policy_motor,effect = "twoways",model='within',data=pdata)
summary(plm3)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = lead(turnout) ~ policy_edr + policy_mail_in + policy_motor,
##     data = pdata, effect = "twoways", model = "within")
##
## Balanced Panel: n = 47, T = 23, N = 1081
##
## Residuals:
##      Min.   1st Qu.    Median   3rd Qu.      Max.
## -24.69907  -4.13482  -0.28463   4.67709  22.09843
##
## Coefficients:
##                 Estimate Std. Error t-value Pr(>|t|)
## policy_edr      1.032913   1.649732  0.6261   0.5314
## policy_mail_in -1.402187   1.104945 -1.2690   0.2047
## policy_motor   -0.030967   1.486380 -0.0208   0.9834
##
## Total Sum of Squares:    65836
## Residual Sum of Squares: 65698
## R-Squared:      0.0020993
## Adj. R-Squared: -0.06812
## F-statistic: 0.707553 on 3 and 1009 DF, p-value: 0.54758
```

```
plm4<-  plm(diff(turnout)~policy_edr + policy_mail_in + policy_motor,effect = "twoways",model='within',data=pdata)
summary(plm4)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = diff(turnout) ~ policy_edr + policy_mail_in + policy_motor,
##     data = pdata, effect = "twoways", model = "within")
##
## Balanced Panel: n = 47, T = 23, N = 1081
##
## Residuals:
##       Min.    1st Qu.     Median    3rd Qu.       Max.
## -26.146442  -1.928416  -0.098985   1.934434  20.119553
##
## Coefficients:
##                 Estimate Std. Error t-value Pr(>|t|)
## policy_edr      0.148692   0.685627  0.2169   0.8284
## policy_mail_in -0.027064   0.491069 -0.0551   0.9561
## policy_motor    0.269099   0.652844  0.4122   0.6803
##
## Total Sum of Squares:    13074
## Residual Sum of Squares: 13072
## R-Squared:      0.0001841
## Adj. R-Squared: -0.07017
## F-statistic: 0.0619316 on 3 and 1009 DF, p-value: 0.97984
```

```
#Synthetic Control
syn2 <- gsynth(turnout ~ policy_edr + policy_mail_in + policy_motor,
               data = turnout, index = c("abb","year"),
               se = TRUE, inference = "parametric",
               r = (0:5), CV = FALSE, force = "two-way",
               nboots = 1000, seed = 02139)
```

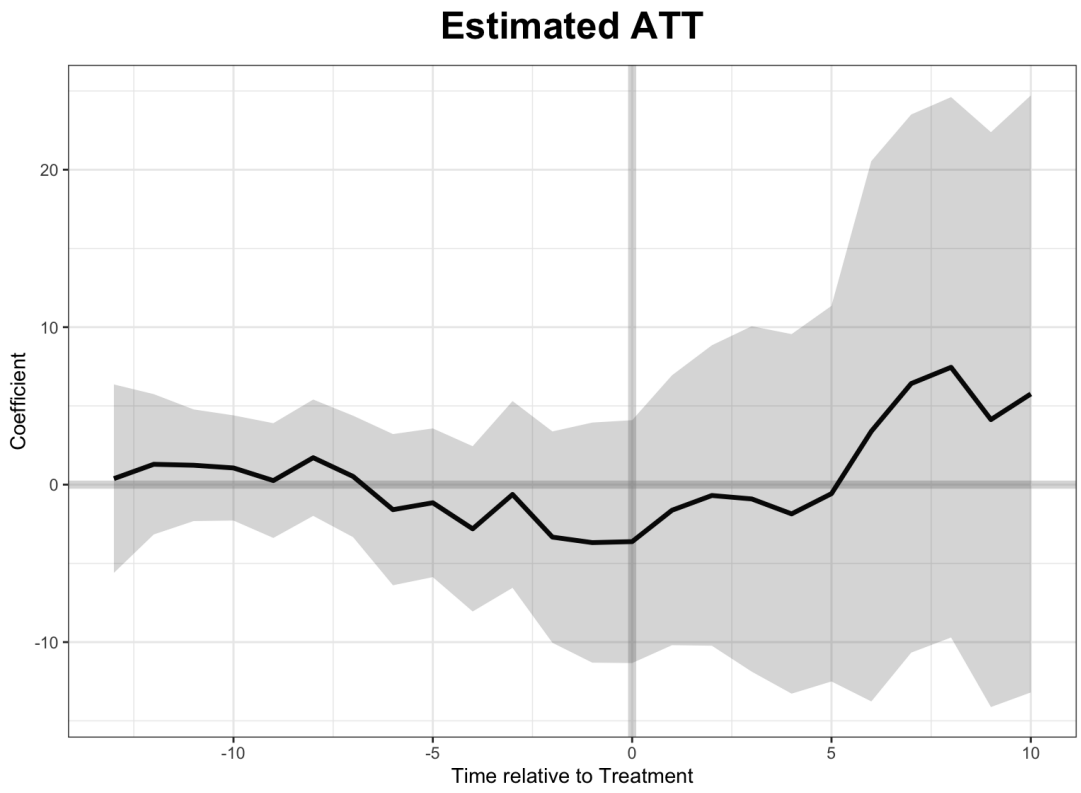
```
## Parallel computing ...
##
Simulating errors ...
```

```
Bootstrapping ...
##
```

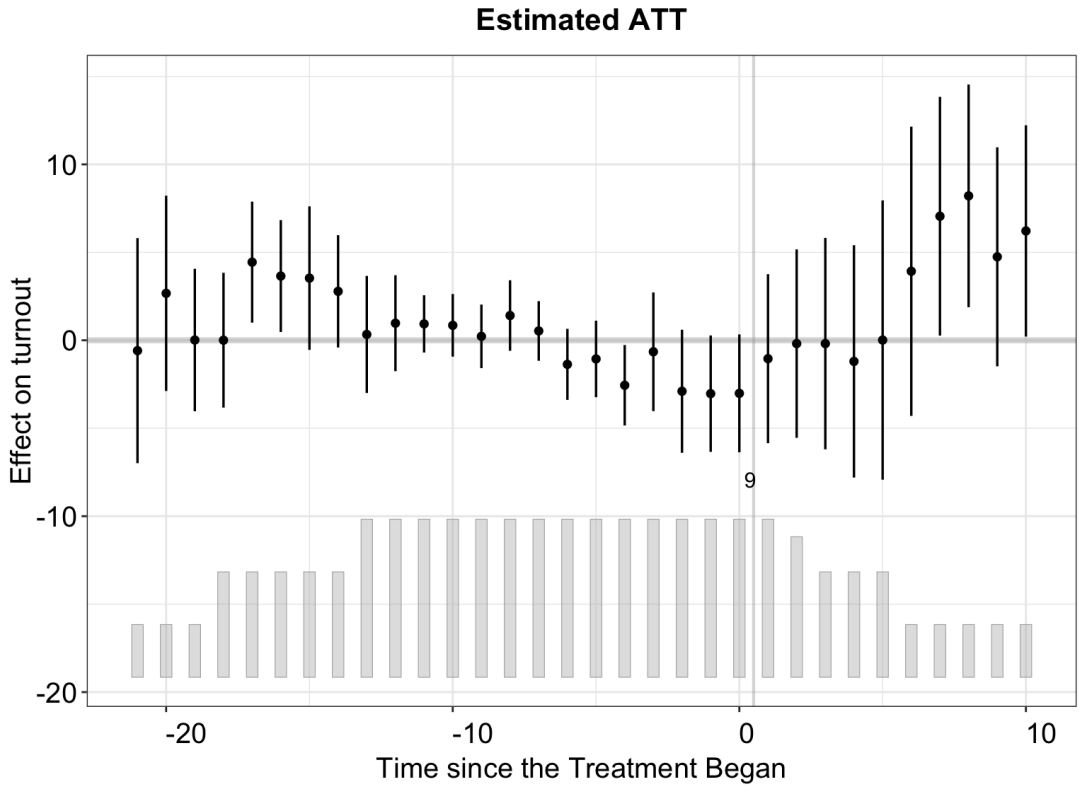
```
syn2
```

```
## Call:
## gsynth.formula(formula = turnout ~ policy_edr + policy_mail_in +
##     policy_motor, data = turnout, index = c("abb", "year"), force = "two-way",
##     r = (0:5), CV = FALSE, se = TRUE, nboots = 1000, inference = "parametric",
##     seed = 2139)
##
## Average Treatment Effect on the Treated:
##         Estimate  S.E. CI.lower CI.upper p.value
## ATT.avg   0.8259 5.777    -10.5    12.15  0.8863
##
##    ~ by Period (including Pre-treatment Periods):
##         ATT  S.E. CI.lower CI.upper p.value n.Treated
## -13  0.3809 3.052   -5.601    6.363  0.9007         0
## -12  1.2925 2.272   -3.161    5.746  0.5695         0
## -11  1.2318 1.808   -2.312    4.776  0.4957         0
## -10  1.0602 1.703   -2.278    4.399  0.5336         0
## -9   0.2587 1.858   -3.383    3.900  0.8893         0
## -8   1.7109 1.884   -1.981    5.403  0.3638         0
## -7   0.5221 1.967   -3.333    4.377  0.7907         0
## -6  -1.5891 2.448   -6.388    3.210  0.5163         0
## -5  -1.1514 2.408   -5.871    3.569  0.6326         0
## -4  -2.8074 2.676   -8.053    2.438  0.2942         0
## -3  -0.6234 3.024   -6.551    5.304  0.8367         0
## -2  -3.3316 3.423  -10.040    3.377  0.3304         0
## -1  -3.6807 3.889  -11.302    3.941  0.3439         0
## 0   -3.6181 3.934  -11.328    4.092  0.3577         0
## 1   -1.6252 4.372  -10.194    6.944  0.7101         9
## 2   -0.6894 4.867  -10.228    8.849  0.8874         8
## 3   -0.9072 5.596  -11.875   10.060  0.8712         6
## 4   -1.8565 5.824  -13.272    9.559  0.7499         6
## 5   -0.5720 6.084  -12.497   11.353  0.9251         6
## 6    3.3898 8.753  -13.765   20.545  0.6985         3
## 7    6.4193 8.717  -10.666   23.505  0.4615         3
## 8    7.4514 8.753   -9.705   24.607  0.3946         3
## 9    4.1303 9.312  -14.121   22.382  0.6574         3
## 10   5.7601 9.671  -13.194   24.714  0.5514         3
##
## Coefficients for the Covariates:
##                   beta  S.E. CI.lower CI.upper p.value
## policy_mail_in -2.647 2.759   -8.054    2.760  0.3374
## policy_motor   -1.677 2.918   -7.395    4.041  0.5655
```

```
plot(syn2)
```




```
#Fect
fect1 <- fect(turnout ~ policy_edr + policy_mail_in + policy_motor,
              index = c("abb","year"), force = "two-way",data=turnout,
              CV = TRUE, r = c(0, 5), se = TRUE, parallel = FALSE)
plot(fect1)
```



Other Difference-in-Differences Design

- Lueders, APSR, 2021, *Electoral Responsiveness in Closed Autocracies: Evidence from Petitions in the former German Democratic Republic*
  - *Responsiveness to petion ~ Election Year * Before Election*
- Nunn and Qian, QJE, 2011 *The Potato's Contribution to Population and Urbanization: Evidence From A Historical Experiment*
  - *Population ~ Land suitability for potato (continuous) * Potato was adopted*
- Korovkin, Vasily, and Alexey Makarin, AER, 2023. *Conflict and Intergroup Trade: Evidence from the 2014 Russia-Ukraine Crisis*
  - *Trade ~ War * Russian Ethnicity*