Diff: simplifying the causal inference analysis with difference-in-differences

Juan M. Villa

PhD Student – University of Manchester

18th London Stata Users Group Meeting
September 12th, 2012

Content

1. Considerations on causal inference.

2. What is diff?

3. Difference in differences
   a) Single diff-in-diff
   b) Diff-in-diff with covariates
   c) Kernel propensity score diff-in-diff
   d) Quantile diff-in-diff

4. Balancing test

Causal inference

Researchers have been interested in the attribution of certain effect to an intervention (medical, public policy, etc.). Causal inference are threatened by the selection bias.

• Experimental designs are the golden rule but costly and not always available. Targeting methods do not necessarily fit the evaluation requirements.

• Quasi-experiments are the second best at mitigating the selection bias; the combination of methods yield better-quality results.

Causal inference

Common quasi-experiments methods:

- Propensity score matching
  - o Causal inference conditional on observables.
  - o Requires baseline covariates.
- IV
  - o Requires a credible instrument. Assumptions on the LATE estimator.
- Regression discontinuity
  - o Suitable when selection is based on an assignment score and a clear cut-off point.
- Interrupted time series
  - o Applied especially in macroeconomics and some medical trials.

What is diff?

Diff-in-diff is a quasi-experimental method
> • Relies on the panel structure of the data (usually two periods: based line and follow up).
>
> • Control for unobservable and time invariant characteristics. Control for observable characteristics if available.
>
> • Combinable with PSM if possible.

What is diff?

Stata's **diff** command simplifies this analysis.
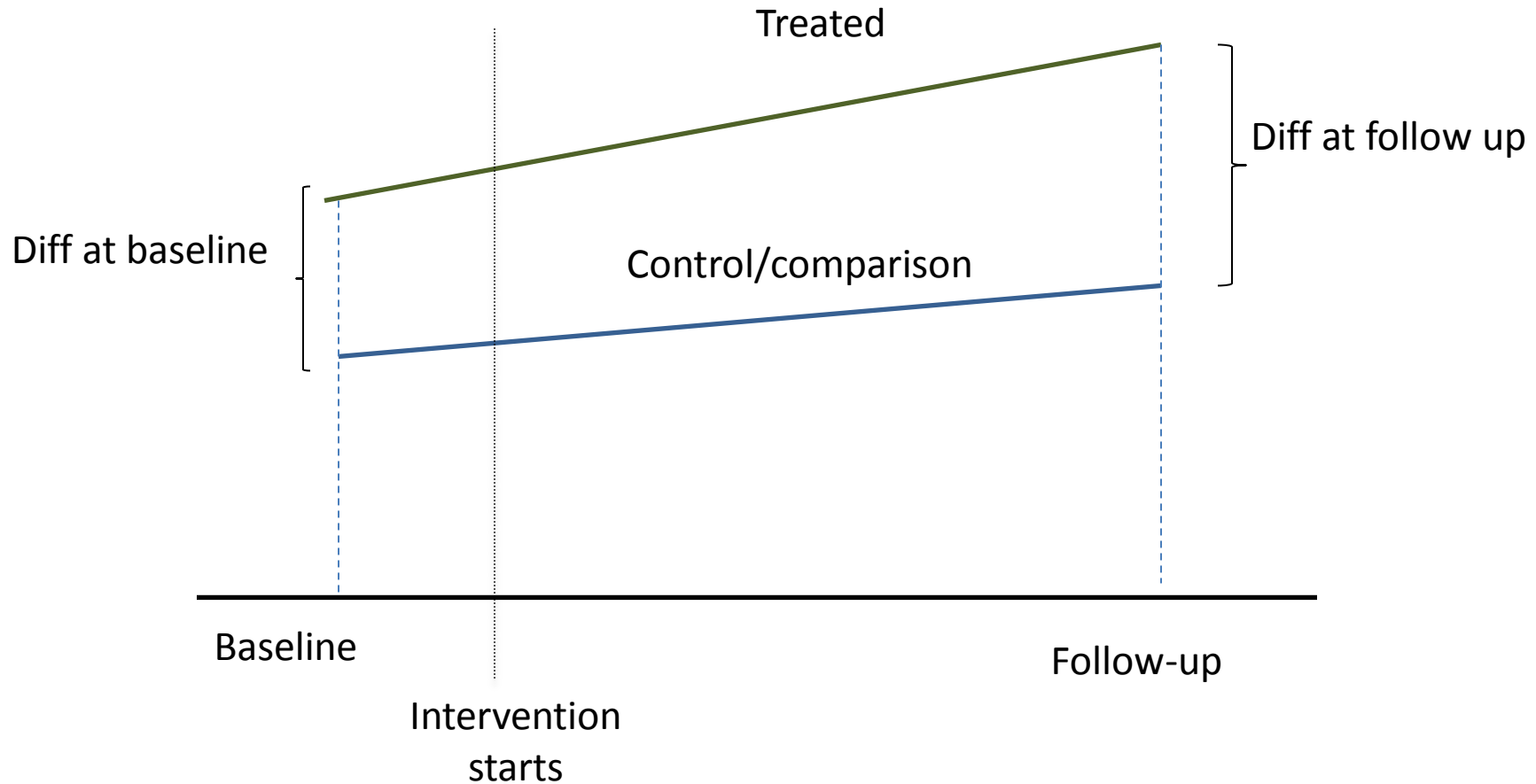
What is diff?

Command diff is easily downloadable from SSC by running
- ssc install **diff**
- help **diff**

Examples with Card & Krueger (1994):
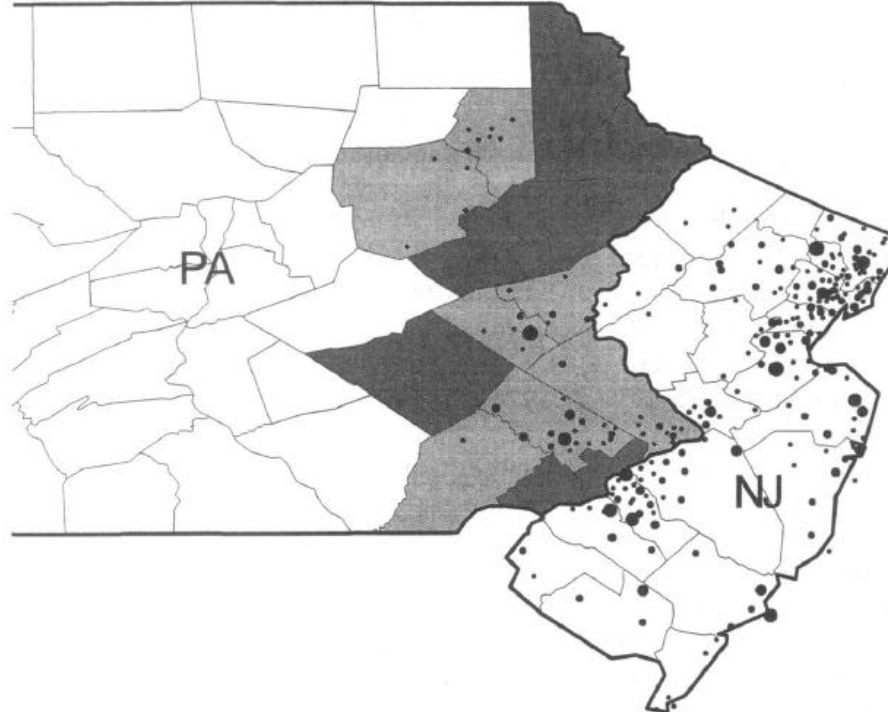
What is diff?

```
diff outcome_var [if] [in] [weight],
```

<u>Required</u>:
```
period(varname) treated(varname)
```

<u>Optional</u>:
```
cov(varlist)
```

```
Kernel  bw(#)  ktype(kernel)  pscore(varname)  logit
support
```

<u>SE/Robust</u>:
```
cluster(varname) robust bs reps(int)
```

<u>Balancing test</u>:
```
test report nostar
```

What is diff?

```
Contains data from cardkrueger1994.dta
  obs:            820                          Dataset from Card&Krueger (1994)
 vars:              8                          27 May 2011 20:36
 size:          18,860 (99.9% of memory free)
-------------------------------------------------------------------------------------
              storage  display     value
variable name   type   format      label      variable label
-------------------------------------------------------------------------------------
id              int    %8.0g                   Store ID
t               byte   %8.0g                   Feb. 1992 = 0; Nov. 1992 = 1
treated         long   %8.0g       treated     New Jersey = 1; Pennsylvania = 0
fte             float  %9.0g                   Output: Full Time Employment
bk              byte   %8.0g                   Burger King == 1
kfc             byte   %8.0g                   Kentuky Fried Chiken == 1
roys            byte   %8.0g                   Roy Rogers == 1
wendys          byte   %8.0g                   Wendy's == 1
-------------------------------------------------------------------------------------
Sorted by:  id  t

summ
 Variable  |       Obs       Mean    Std. Dev.       Min        Max
-----------+--------------------------------------------------------
        id |       820   246.5073    148.1413         1        522
         t |       820         .5    .5003052         0          1
   treated |       820   .8073171    .3946469         0          1
       fte |       801   17.59457    9.022517         0         80
        bk |       820   .4170732    .4933761         0          1
-----------+--------------------------------------------------------
       kfc |       820    .195122    .3965364         0          1
      roys |       820   .2414634    .4282318         0          1
    wendys |       820   .1463415    .3536639         0          1
```

Difference in differences

Single diff-in-diff

```
. diff fte, t(treated) p(t)

Number of observations: 801
            Baseline        Follow-up
   Control: 78              77              155
   Treated: 326             320             646
            404             397


R-square:  0.00805


                            DIFFERENCE IN DIFFERENCES ESTIMATION
--------------------- ------------ BASE LINE --------- ----------- FOLLOW UP ---------- -------------
 Outcome Variable(s) | Control |  treated  | Diff(BL) | Control |  treated  | Diff(FU) | DIFF-IN-DIFF
---------------------+---------+-----------+----------+---------+-----------+----------+------------
fte                  | 19.949  | 17.065    | -2.884   | 17.542  | 17.573    | 0.030    | 2.914
Std. Error           | 1.019   | 0.499     | 1.135    | 1.026   | 0.503     | 1.143    | 1.611
t                    | 19.57   | 14.17     | -2.54    | 17.60   | 20.45     | -0.33    | 1.81
P>|t|                | 0.000   | 0.000     | 0.011**  | 0.000   | 0.000     | 0.979    | 0.071*
-----------------------------------------------------------------------------------------------------
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1
```

Difference in differences

Diff-in-diff with covariates

```
. diff fte, t(treated) p(t) cov(bk kfc roys) report

*** DIFFERENCE-IN-DIFFERENCES WITH COVARIATES ***


Number of observations: 801
            Baseline        Follow-up
   Control: 78              77              155
   Treated: 326             320             646
            404             397


R-square:  0.18784
                         DIFFERENCE IN DIFFERENCES ESTIMATION
--------------------- ------------ BASE LINE --------- ----------- FOLLOW UP ---------- -------------
Outcome Variable(s) | Control |  treated  | Diff(BL) | Control |  treated  | Diff(FU) | DIFF-IN-DIFF
--------------------+---------+-----------+----------+--------+----------+---------+------------
fte                 | 21.161  | 18.837    | -2.324   | 18.758 | 19.369   | 0.611   | 2.935
Std. Error          | 1.142   | 0.851     | 1.031    | 1.158  | 0.853    | 1.037   | 1.460
t                   | 18.53   | 18.43     | -2.25    | 19.09  | 19.87    | 0.51    | 2.01
P>|t|               | 0.000   | 0.000     | 0.024**  | 0.000  | 0.000    | 0.556   | 0.045**
-------------------------------------------------------------------------------------------------
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1


.
```

Difference in differences

Kernel PSM Diff-in-diff

```
. diff fte, t(treated) p(t) kernel id(id) ktype(gaussian) pscore(_ps)

*** KERNEL PROPENSITY SCORE MATCHING DIFFERENCE-IN-DIFFERENCES ***
Number of observations: 801
            Baseline       Follow-up
   Control: 78             77              155
   Treated: 326            320             646
            404            397

R-square:  0.02698
```

```
                               DIFFERENCE IN DIFFERENCES ESTIMATION
--------------------- ------------ BASE LINE --------- ----------- FOLLOW UP ---------- -------------
Outcome Variable(s) | Control |  treated  | Diff(BL) | Control |  treated  | Diff(FU) | DIFF-IN-DIFF
>
---------------------+---------+-----------+----------+--------+-----------+----------+------------
fte                 | 21.648  | 17.065    | -4.583   | 18.907 | 17.573    | -1.335   | 3.249
Std. Error          | 0.564   | 1.177     | 1.306    | 0.569  | 1.188     | 1.317    | 1.855
t                   | 38.36   | 17.76     | -3.51    | 16.83  | 17.06     | -2.12    | 1.75
P>|t|               | 0.000   | 0.000     | 0.000*** | 0.000  | 0.000     | 0.311    | 0.080*
--------------------------------------------------------------------------------------------------
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1
```

Difference in differences

Quantile Diff-in-diff

```
. diff fte, t(treated) p(t) qdid(0.25)

Number of observations: 801
            Baseline        Follow-up
    Control: 78              77              155
    Treated: 326             320             646
             404             397


R-square:  0.00297


                        DIFFERENCE IN DIFFERENCES ESTIMATION
--------------------- ------------ BASE LINE --------- ----------- FOLLOW UP ---------- -------------
Outcome Variable(s) | Control |  treated  | Diff(BL) | Control |  treated  | Diff(FU) | DIFF-IN-DIFF
--------------------+---------+-----------+----------+---------+-----------+----------+-------------
fte                 | 12.500  | 11.000    | -1.500   | 11.500  | 11.500    | -0.000   | 1.500
Std. Error          | 1.411   | 0.720     | 1.584    | 1.490   | 0.728     | 1.658    | 2.293
t                   | 8.86    | 10.42     | -0.95    | 11.83   | 12.06     | -0.60    | 0.65
P>|t|               | 0.000   | 0.000     | 0.344    | 0.000   | 0.000     | 1.000    | 0.513
-----------------------------------------------------------------------------------------------
* Values are estimated at the .25 quantile
**Inference: *** p<0.01; ** p<0.05; * p<0.1
```

Difference in differences

Quantile Kernel PSM Diff-in-diff

```
. diff fte, t(treated) p(t) qdid(0.50) cov(bk kfc roys) kernel id(id)

*** KERNEL PROPENSITY SCORE MATCHING QUANTILE DIFFERENCE-IN-DIFFERENCES ***


Number of observations: 801
            Baseline        Follow-up
    Control: 78              77            155
    Treated: 326             320           646
             404             397


R-square:  0.00477

                           DIFFERENCE IN DIFFERENCES ESTIMATION
--------------------- ------------ BASE LINE --------- ----------- FOLLOW UP ---------- -------------
Outcome Variable(s) | Control |  treated  | Diff(BL) | Control |  treated  | Diff(FU) | DIFF-IN-DIFF
---------------------+---------+-----------+----------+---------+-----------+---------+-------------
fte                 | 18.500  | 16.000    | -2.500   | 18.500  | 17.500    | -1.000  | 1.500
Std. Error          | 1.578   | 0.732     | 1.739    | 1.614   | 0.727     | 1.770   | 2.482
t                   | 11.72   | 15.08     | -1.44    | 18.50   | 18.06     | -1.65   | 0.60
P>|t|               | 0.000   | 0.000     | 0.151    | 0.000   | 0.000     | 0.572   | 0.546
---------------------------------------------------------------------------------------------------
* Values are estimated at the .5 quantile
**Inference: *** p<0.01; ** p<0.05; * p<0.1
```

Balancing test

Single t-test

```
. diff fte, t(treated) p(t) cov(bk kfc roys wendys) test

*** TWO-SAMPLE T TEST ***

Number of observations: 801
          Baseline        Follow-up
   Control: 78            77              155
   Treated: 326           320             646
           404            397

t-test at period = 0:
--------------------------------------------------------------------------------------
 Variable(s)         |  Mean Control  | Mean Treated |   Diff.   |  |t|   |  Pr(|T|>|t|)
--------------------+----------------+--------------+----------+--------+--------------
fte                 | 19.949         | 17.065       | -2.884    | 2.44   | 0.0150**
bk                  | 0.443          | 0.411        | -0.032    | 0.52   | 0.6035
kfc                 | 0.152          | 0.205        | 0.054     | 1.08   | 0.2818
roys                | 0.215          | 0.248        | 0.033     | 0.61   | 0.5448
wendys              | 0.190          | 0.136        | -0.054    | 1.22   | 0.2241
--------------------------------------------------------------------------------------
*** p<0.01; ** p<0.05; * p<0.1
```

Balancing test

Kernel PSM t-test

```
. diff fte, t(treated) p(t) cov(bk kfc roys wendys) test id(id) kernel

*** TWO-SAMPLE T TEST ***

Number of observations: 801
         Baseline      Follow-up
  Control: 78              77            155
  Treated: 326            320            646
          404            397

t-test at period = 0:
--------------------------------------------------------------------------------------
Weighted Variable(s) |  Mean Control  | Mean Treated |   Diff.   |  |t|   |  Pr(|T|>|t|)
---------------------+----------------+--------------+-----------+--------+--------------
fte                  | 21.656         | 17.065       | -4.591    | 3.22   | 0.0014***
bk                   | 0.618          | 0.408        | -0.210    | 3.55   | 0.0004***
kfc                  | 0.104          | 0.209        | 0.104     | 2.60   | 0.0097***
roys                 | 0.183          | 0.252        | 0.068     | 1.42   | 0.1570
wendys               | 0.095          | 0.132        | 0.037     | 1.01   | 0.3123
--------------------------------------------------------------------------------------
*** p<0.01; ** p<0.05; * p<0.1
Attention: option kernel weighs variables in cov(varlist)
Means and t-test are estimated by linear regression
```