Bocconi University, Microeconometrics (cd. 20295)
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Problem Set 2: Difference in Differences

Due: April 14th by 11:59pm. Submit by email to `erick.baumgartner@unibocconi.it`.

Problem Set 2

This problem set will be based on the article "Did Unilateral Divorce Laws Raise Divorce Rates? A Reconciliation and New Results", published in the `American Economic Review` in 2006.

Instructions

No need to produce a pdf file with your answers. Save all graphics and tables requested (e.g., as `pset_2_exercise_1_question_1_a.xlsx`) and a do-file summarizing all of your work in a zipped folder identifying your group and the problem set (e.g., as `pset_X_group_Y.zip`) to `erick.baumgartner@unibocconi.it`. In the sub-questions where you are asked to write, please add your answer as a comment in your do file.

Hint: Type * to add a comment in your do-file (e.g., `* this is a comment line *`).

Hint: You can choose your preferred way of preparing tables: **(1)** one option is to use the command `outsheet` to construct the tables of summary statistics and the command `outreg2` to construct the regression tables (you can use them to export results of summary statistics and regressions to an excel file); **(2)** another option is to save results using the command `eststo` and then export these directly to a .tex (latex) file using the command `esttab`. If using *R*, one option for exporting results is the `stargazer` package. Read carefully `help` for each command you choose and try different options, so as to have well-formatted tables.

Hint: Have in mind that some commands have different default procedures in *Stata* and *R*. Since we are not asking you to specify some of these procedures, it is normal that sometimes the results are not exaclty the same between the two languages.

Exercise 1

Short Summary of Discussion

As in the previous problem set, in this exercise we want to guide you through developing research with a differences-in-differences design. Going then through the steps that we should follow; we should: (**S1**) perform diagnosis tests to **motivate** our parallel trends assumptions; (**S2**) estimate our treatment effects; (**S3**) check for the robustness of our results.

In this exercise, we will be asked to discuss, replicate and complement results as in Wolfers (2006).

Data

We will analyze data on divorces at the state level in the U.S. between 1956 and 1998 following the staggered implementation of unilateral divorce laws, allowing partners to file for a divorce without the consent of their spouse or the requirement of proof of wrongdoing by either party. As discussed by Wolfers (2006), this reform led to a fierce debate regarding its consequences, given the subsequent rise in divorce rates in the 1970s.

Questions

The data set used in the analysis of Wolfers (2006) is given as `pset_4.csv`. The main variables to be used are given below:

Variable Name	Description
`div_rate`	Divorces per 1,000 people, 1956-1998
`st`	State
`year`	Year
`stpop`	State population
`lfdivlaw`	Year of the introduction of the law

Table 1: Variable Names and Descriptions

1. Use the `pset_4.csv`.

(a) Note that one of the variables in the data set is `stpop`, the state population. In the next exercises, you should follow Wolfers (2006) in weighting both your descriptive output and your analysis by the state population. A short summary of the different weighting procedures in Stata is provided here ([1,2]). Given that divorce rates are an average computed in each state and the variable `stpop` provides the population in each of these states, which is the weight you should use when reporting the evolution of divorce rates or a regression of divorce rates on unilateral divorce laws to match the analysis in Wolfers (2006)?

(b) The article relies on the timing of the introduction of unilateral divorce laws to compare divorce rates in the two possible regimes. One of the assumptions of this analysis is that states with the previous divorce law and the ones that introduced unilateral divorce laws would both follow parallel trends in their divorce rates in the absence of the changes to the legislation. Create 2 different graphs to support this assumption: (i) the first graph should convey the same message as the one in Figure 1 of the original paper, comparing states that did not change their divorce laws during 1968 - 1988 (Friedberg's sample) and the ones that did; (ii) the second graph should perform the same description, but focusing on the simpler analysis we will perform in the next exercise: compare the states adopting the unilateral divorce law between 1969 and 1973 to the ones that introduced it in the year 2000, only reporting the time trend up to 1978 and including a vertical line between 1968 and 1969 (when the first reforms in our sample started). Do your results support the assumption of parallel trends?

Let us now start an analysis of the effects of the introduction of unilateral divorce laws. As a first step, let us perform a 2-period difference-in-difference analysis using "long differences", focusing on the evolution of divorces between 1968 and 1978. Keeping only these 2 years in our sample, you should compare states adopting the unilateral divorce law between 1969 and 1973 to the ones that introduced it in the year 2000. On this restricted sample, you should create: (i) a variable UNILATERAL equal to 1 if a state introduced the unilateral divorce law during this period (as signaled by variable `lfdivlaw`); (ii) a variable POST equal to 1 if the year is 1978; and (iii) a variable POST_UNILATERAL when both POST and UNILATERAL are equal to 1.

(c) Now estimate the following regressions: (i) a pooled OLS regression of the divorce rate per 1,000 people (`div_rate`) on POST_UNILATERAL and POST; (ii) a full Difference-in-Differences specification, including POST, UNILATERAL and POST_UNILATERAL as regressors. Based on the graphs you created in section **(a)**, could you say something about the difference in the coefficients from regressions (i) and (ii)? What is the effect of introducing unilateral divorce laws according to this analysis?

Let us now show the same result observed in the Difference-in-Differences specification as a difference in means:

(d) Generate a 3 by 3 matrix with row and column labels as follows:

	UNILATERAL=1	**UNILATERAL=0**	**Difference 2**
POST=1			
POST=0			
Difference 1			

Difference 1 should show differences across columns while **Difference 2** across lines.

Complete this matrix with the averages of `div_rate`, replicating the results you have found in the previous regression.

Then, export the matrix to an Excel table named `TABLE_1`.

(e) We will now perform the analysis using our complete data set, as in the main results of Wolfers (2006). For this, always focus on the same sample as the one used in Table 2 of the original paper (**keeping observations between 1956 and 1988**). Load once again our data set and create the dummy variable IMP_UNILATERAL, which equals 1 whenever a state has already introduced unilateral divorce laws (as signaled by variable `lfdivlaw`). Now run the following regressions:

(i) A regression of `div_rate` on state and year dummies and the dummy IMP_UNILATERAL that you created.

(ii) Perform the same regression as the one described above, now including state-specific linear time trends.

(iii) In addition to state-specific linear time trends, include also quadratic state-specific time trends.

Interpret the results of all 3 regressions. Can you think of a reason for the results to change across specifications? Under which assumption should these results be the same?

(f) In our current case study, unilateral divorce laws have been introduced subsequently in different states at different points in time. In such cases, we say that there was a staggered implementation of the treatment. Regressions with a single coefficient, as the ones performed in exercise **e)**, may be biased in this setting. Let us now check some of the properties of these regressions. We will create a simulated data set of 3 periods and 2 states, where one state receives a treatment in the 2nd period and the other state only receives it in the 3rd period. The code below reproduces this simulation:

```
#d;

/* Creates simulated observations */
clear;
set         obs 6;
gen         obs = _n;
gen         state = floor(.9 + obs/3);
bysort      state: gen year = _n;
gen         D = state == 1 & year == 3;
replace     D = 1 if state == 2 & (year == 2 | year == 3);

/* Creates simulated outcomes */
gen         Y = 0.1 + 0.02*(year==2) + 0.05*(D==1) + runiform()/100;
gen         Y2 = 0.1 + 0.02*(year==2) + 0.05*(D==1) + 0.3*(state==2 & year==3) + runiform()/100;
gen         Y3 = 0.1 + 0.02*(year==2) + 0.05*(D==1) + 0.4*(state==2 & year==3) + runiform()/100;
gen         Y4 = 0.1 + 0.02*(year==2) + 0.05*(D==1) + 0.5*(state==2 & year==3) + runiform()/100;
```

```
# Load required package
library(dplyr)

# Creates simulated observations
df <- tibble(obs = 1:6) %>%
  mutate(
    state = floor(0.9 + obs / 3)
  ) %>%
  group_by(state) %>%
  mutate(year = row_number()) %>%
  ungroup() %>%
  mutate(
    D = as.numeric((state == 1 & year == 3) | (state == 2 & year %in% c(2, 3))),

    # Creates simulated outcomes
    Y  = 0.1 + 0.02 * (year==2) + 0.05 * (D==1) + runif(n()) / 100,
    Y2 = 0.1 + 0.02 * (year==2) + 0.05 * (D==1) + 0.3 * (state == 2 & year == 3) + runif(n())/100,
    Y3 = 0.1 + 0.02 * (year==2) + 0.05 * (D==1) + 0.4 * (state == 2 & year == 3) + runif(n())/100,
    Y4 = 0.1 + 0.02 * (year==2) + 0.05 * (D==1) + 0.5 * (state == 2 & year == 3) + runif(n())/100
  )

print(df)
```

Now perform regressions analogous to the one performed in exercise **e** question **(i)** for all 4 dependent variables created (that is, a state and year fixed-effects regression with an absorbing treatment dummy). Is it possible to estimate the treatment coefficient consistently in each of these cases?

(g) Use the Stata package "`twowayfeweights`" (or its `R` version, "`TwoWayFEWeights`"), based on De Chaisemartin and d'Haultfoeuille (2020), to estimate the weights attached to the regressions you estimated before. Can you explain why the sign of the estimated effect has changed between the regression on Y and the one on $Y4$?

(h) Let us now revisit our analysis following Wolfers (2006). We will do this based on the decomposition proposed by Goodman-Bacon (2021). The author provides commands in both Stata and R for his decomposition. To install it in Stata, run the code below:

```
ssc install bacondecomp
```

Now, perform the following steps:

(i) create a modified population variable `init_stpop` equal to the population of each state in the first observed period of each state.

(ii) Rerun regression **i** of exercise **(e)** (a regression of `div_rate` on state and year dummies and the dummy IMP_UNILATERAL that you created) using `init_stpop` as your weights.

(iii) Run the command `bacondecomp` (or the package with the same name in `R`) to analyze the decomposition of the treatment effect. Plot the graph showing the relationship between the treatment effect estimates and the corresponding weights. Briefly explain what is the analysis proposed by Goodman-Bacon (2021). Is there evidence of issues regarding negative weights?

(i) Let us now perform an `event-study` regression, allowing for the unilateral divorce law coefficients to vary across time. Your analysis will follow table 2 in Wolfers (2006). We will have the period right before the introduction of the law as our basis of comparison, creating dummies for leads and lags for all other distances between our observation period and the law introduction in that state. This means that for any time period t and state s, the dummy D_{st}^{τ} will be equal to one if in that specific period, state s has introduced unilateral divorce laws τ years before. Following the analysis in the main paper, we will set

$$D_{st}^{15} = D_{st}^{\overline{\tau}} = 1 \qquad \forall\, \tau \geq 15$$

That is, the dummy will be equal to one for all observations with 15 or more years of unilateral divorce law. For the lead dummies, let us restrict

$$D_{st}^{-10} = D_{st}^{\underline{\tau}} = 1 \qquad \forall\, \tau \leq -10$$

So that this dummy will equal 1 for all observations 10 or more years before the introduction of the unilateral divorce law in that state. Notice that this specification has some deviations from the one performed in table 2 of the original paper.

(i) Run the regresson below, using the unilateral divorce dummies D_{st}^{τ} you created and sector (π_s) and year (γ_t) fixed effects.

$$div\_rate_{st} = \sum_{\tau=-10}^{-2} \beta_\tau D_{st}^{\tau} + \sum_{\tau=15}^{0} \beta_\tau D_{st}^{\tau} + \pi_s + \gamma_t + \epsilon_{st}$$

(ii) Perform the same regression as the one described above, now including state-specific linear time trends.

(iii) In addition to state-specific linear time trends, include also quadratic state-specific time trends.

Interpret the results of all 3 regressions. What can we see in the behaviour of divorce rates through this analysis that was not possible in the single coefficient analysis?

(j) Use the Stata command `coefplot` (or any other command of your choosing) to create a graph reporting the coefficients and the 95% confidence intervals of your 3 `event-study` regressions.

(k) Wolfers (2006) presents a summary of the debate regarding the influence of the unilateral divorce law in the divorce rates. How do the conclusions of the paper differ from Friedberg (1998)? How does the author rationalize the difference in his findings?

(l) Several different procedures to estimate a staggered `Difference-in-Differences` analysis have been proposed recently. Let us now perform one of these procedures. You will use command `eventstudyinteract` in `Stata`, based on Sun and Abraham (2021), or its implementation in `R` using package `fixest`.[1] You may install the `Stata` command and check its help file by typing:

```
ssc         install avar
ssc         install eventstudyinteract
help        eventstudyinteract
```

Now perform an analogous analysis to the `event-study` regression in exercise **(i)** based on the Sun and Abraham (2021) estimation. Once again, report your results in an `event-study` graph. Are your results consistent with the ones from the original paper? Briefly explain what kind of correction your proposed algorithm is performing.

Exercise 2

1. We will now use causal forests to assess if there's any evidence of heterogeneous treatment effects of unilateral divorce laws on divorce rates. The original data set used in

[1] If you wish, you may also run this analysis in any of the other papers of the recent TWFE literature, such as `csdid` based on Callaway and Sant'Anna (2021), `did_imputation` based on Borusyak et al. (2021) or `did_multiplegt` and `did_multiplegt_dyn` based on De Chaisemartin and d'Haultfoeuille (2022). You can also propose other options, though note that some of these algorithms are currently being updated.

Wolfers (2006) did not provide a rich set of variables for this analysis, so we'll use an expanded version based on simulated observations (the data set is provided on Blackboard as `expanded_data.csv`. These will depict a data set where you would have access to county level observations in each of the states of the original sample, including several characteristics of the population in each county. A table with all variables in the updated data set and their description is provided below.

Variable	**Description**
`div_rate_sim`	Simulated number of divorces per 1,000 people
`year`	Calendar year of observation
`lfdivlaw`	Year the unilateral divorce law was enacted in the state
`education_rate`	Percentage of population with at least a high school diploma
`childcare_availability`	Proportion of families with access to childcare services
`unemployment_rate`	Unemployment rate in the county (%)
`median_income`	Median household income (USD)
`urbanization`	Categorical variable indicating if the county is urban or rural
`marriage_rate`	Number of marriages per 1,000 people
`religious_adherence`	Percentage of population affiliated with a religion
`alcohol_consumption`	Annual per capita alcohol consumption (liters)
`domestic_violence_rate`	Reported domestic violence cases per 1,000 people
`women_labor_force_participation`	Percentage of women participating in the labor force
`housing_cost`	Average monthly housing cost (USD)
`crime_rate`	Total reported crimes per 100,000 people
`social_services_spending`	Annual social services spending per capita (USD)
`st`	U.S. state abbreviation
`county_id`	Unique identifier for counties within each state

Table 2: Description of Variables Used in the Analysis

Hint: Causal forests currently do not have a package in `Stata`, so you'll have to perform your analysis in R. If you don't have R installed in your computer, a simple procedure to run your analysis is to upload the data set and run your analysis in Google Colab. The implementation is very well described in the grf package GitHub page, which you're expected to read to perform your analysis. Also note that population weights are not provided for this version of the data set, and you won't need to reweight observations for this exercise.

(a) Structure your data set accordingly to assess whether the introduction of the unilateral divorce law had an effect on divorce rates for our sample at the county level. Estimate a causal forest using the `causal_forest` command from package `grf`. What is the estimated averate treatment effect in this instance? Is it consistent with your answer in exercise **1.c**?

b. Now make an analysis of the causal forest results regarding potential heterogeneous treatment effects. Check the results on (i) the Best Linear Projection; (ii) the Targeting Operator Characteristic; (iii) Plot the distribution of CATEs throughout the distribution of the variables you believe could drive heterogeneity (if you'll report heterogeneous treatment effects, include graphs for its drivers). Explain what is being performed in each point and interpret your output.

c. Discuss your results. Did you find any evidence of heterogeneous treatment effects? Justify your answer based on your output in the previous items.

d. An important aspect in the implementation of causal forests is the use of "honest trees", as explained in section 2.4 of Wager and Athey (2017). Explain this procedure and why it is important for our estimation of CATEs. Rerun your analysis without "honest trees" by selecting `honesty = FALSE`. Is your average treatment effect the same? When would you expect this to not be the case?

References

Borusyak, K., Jaravel, X., and Spiess, J. (2021). Revisiting event study designs: Robust and efficient estimation. *arXiv preprint arXiv:2108.12419*.

Callaway, B. and Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of econometrics*, 225(2):200–230.

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