Homework for Chapter 18: Difference-in-Differences

*How Does It Work?*

1. In the Event Studies chapter we estimated the effect of something that occurs at a specific time by just comparing before-event to after-event, without really using a control group. What assumption is made by no-control-group event studies that we *don’t* have to make with difference-in-differences?
2. Which of the following potential back doors is controlled for by comparing the treated group to a control group?
   1. The treated group may be following a trend, unique to the group, that would make the outcome change from before-treatment to after-treatment anyway
   2. There may be events affecting everyone that would change the outcome from before-treatment to after-treatment anyway
   3. There may be differences in typical outcome levels between the treated group and the untreated group
   4. The decision to treat the treated group, rather than some other group, may be based on factors that are related to the outcome
3. Consider a treatment and control group. Looking only at the pre-treatment period, they have exactly the same outcomes (zero gap between them in each period).
   1. Despite having exactly the same outcomes pre-treatment, it happens to be the case that parallel trends is violated for these two groups. How is this possible? Explain what it means for parallel trends to be violated in this case, or give an example of how it could be violated.
   2. If we estimate the causal effect in this case using difference-in-differences, even though parallel trends is violated, how much would our effect be off by? (note you won’t be able to give a specific number)
4. Consider the below graph showing the average outcome for treated and control groups in the leadup to treatment (indicated by the dashed line), and also after treatment.  
   Chart, line chart

   Description automatically generated
   1. Based on the prior trend, does it seem likely that parallel trends holds in this instance?
   2. If we estimate difference-in-differences anyway, are we likely to overestimate the actual causal effect, underestimate it, or get it right on average?
5. In mid-2020, during the COVID-19 pandemic, different countries pursued different courses of action. Some locked down fully, imposing harsh penalties to most people for leaving the house outside certain proscribed times. Some were looser and only suggested staying at home, and some had hardly any restrictions at all. You notice that COVID rates tend to spike dramatically in different countries at seemingly-random times, and want to know if certain restrictions helped.  
     
   From March through May 2020, US and Canada COVID case rates followed similar trends (US rates were higher, but the trends were similar). You want to look at the effect of COVID restrictions enacted in Canada in late May 2020 on case rates. Is DID, with the US as a control group, a good way to estimate this effect? If not, what concerns would you have about this research design?
6. Consider the below table of mean outcomes, and calculate the difference-in-difference effect of treatment. Write out the equation you used to calculate it (i.e. show how the four numbers in the table are combined to get the estimate)

|  |  |  |
| --- | --- | --- |
|  | Before | After |
| Treated | 5 | 9 |
| Untreated | 6 | 7.5 |

*How is it Performed?*

1. You are planning to estimate whether voter-protection laws increase voter turnout. You note that, in 2015, a lot of new voter-protection laws were enacted in some provinces but not in others. Conveniently, no new laws were enacted in 2012, 2014, or 2016, so you decide to use 2012 and 2014 as your “before” periods and 2016 as “after”.
   1. Which of the following best describes what you’d want to regress state-and-year level “voter turnout” measures on?
      1. An indicator for whether the state is treated, and an indicator for whether the year is 2016.
      2. A set of fixed effects for state, and a set of fixed effects for year.
      3. An indicator for whether the state is treated, a set of fixed effects for year, and an indicator for whether the state is currently treated.
      4. A set of fixed effects for state, and for year, and an interaction between “is 2016” and “is a treated state”.
      5. This design should not be estimated using a regression.
   2. Unless you chose the final option in the previous question, specify which coefficient in that regression would give you the DID estimate.
2. You are looking at a difference-in-difference design to estimate the effect of providing laptops to school children on their test scores. Look at the below regression output, in which “Treated” is an indicator that the school received laptops in 2008 as part of a new program (the untreated group did not receive any laptops until years after the sample window for this study ended), and “After” is an indicator for being after the year 2008.  
     
   Using the table, fill in the blanks in the sentence “Assuming that \_\_\_\_\_, the effect of laptops on test scores was \_\_\_\_\_, and this effect (was/was not) statistically significant at the 95% level.”

|  |  |
| --- | --- |
|  | **Test Scores** |
| (Intercept) | 80.342\*\*\* |
|  | (0.501) |
| After | 3.369\*\*\* |
|  | (0.696) |
| Treated | 4.116\*\*\* |
|  | (0.718) |
| After× Treated | 5.034\*\*\* |
|  | (0.993) |
| Num.Obs. | 1523 |
|  | 0.188 |
| Standard errors in parentheses.  + p < 0.1, \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001 | |

1. A standard “prior trends” test might estimate a regression using the model (only using data from before-treatment), where is a time variable, is an indicator for being in the treated group, and is an outcome variable, and look for a large/significant estimate of . Explain why this test is performed, and specifically what it shows.
2. Consider the below graph with estimates from a dynamic difference-in-differences model for a treatment that occurs between periods 4 and 5, with 95% confidence intervals shown.  
   Chart, line chart

   Description automatically generated
   1. What about this graph might make us concerned about our identification assumptions?
   2. Ignoring any concerns we have, what would we say is the effect of treatment on Y in this case? (note the height of the line in period 5 is about 3, in period 6 is about 1, and in period 7 is about .5).
3. Chapter 18.2.5 points out a problem with two-way fixed effects in cases where treatment is not all assigned at the same time, but rather different groups get treated at different times (a “rollout” design). In these designs, two-way fixed effects treats “already-treated” units, who were treated in earlier periods, as “control” units, as though they hadn’t gotten treated at all. However, there’s nothing theoretically wrong about using an already-treated unit as a control; the DID assumptions don’t require that the control group be untreated, just that the gap between treated and control doesn’t change when the treated group’s treatment goes into effect. Why are we so concerned, then, about using an already-treated group as a control? You can answer generally, or use as an example a DID with only two groups – an already-treated group and a newly-treated group. (hint: to do the example, try assuming the treatment only has an effect for the single period after treatment, and the already-treated group is treated exactly one period before the treated group)

Coding (which includes any how-the-pros-do-it questions)