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# Problem Set 4 – Natural Experiments

*Estimated time: about an hour. Type your responses and submit a single PDF *ON CANVAS*. Most answers here are a sentence or two – there is no length requirement, and padding will not help you. Where a question asks you to compute an estimate, show the pieces you used to get there. A photo of a hand-drawn sketch is fine.*

## Part 1: Regression Discontinuity

1. A state requires any student scoring below 40 on the spring 3rd grade reading test to attend a mandatory summer reading program. A researcher compares 4th grade reading scores of students who scored just below 40 to students who scored just above.

   (a) State the identifying assumption in one sentence, in terms of this setting. Do not state it in general terms – name the cutoff and the outcome.

   (b) Give two testable implications of that assumption, and say what you would look at to check each one.

   (c) Suppose several predetermined covariates jump discontinuously at 40. The researcher proceeds anyway but controls for those covariates. Does she now get an unbiased estimate? Explain.

   (d) Give one example of something that, if it also switched on at a score of 40, would make this design uninterpretable.

2. A researcher wants to study the effect of being held back a grade. Retention is triggered by falling below a published cutoff. Which of the following would make the better running variable, and why?

   (a) A score on a centrally scored, computer-administered state exam.

   (b) A final course grade assigned by the student's own teacher, who knows the retention cutoff.

## Part 2: Differences in Differences

3. In 2022, State A capped class sizes in grades K–3. State B, a neighboring state, did not. Average 3rd grade reading scores were:

| | 2021 | 2024 |
|---|---|---|
| State A | 208 | 214 |
| State B | 210 | 212 |

   (a) Compute the differences-in-differences estimate. Show both differences.

(b) What would a simple before-and-after comparison within State A alone suggest? Why does it differ from your answer to (a)?

(c) State the identifying assumption for this specific comparison in one sentence.

(d) Name two pieces of evidence that would make that assumption more believable.

(e) Suppose State A also raised teacher pay in 2022. Can you still interpret your estimate as the effect of the class size cap? Explain.

4. Differences in differences requires a parallel trends assumption, but makes no assumption that the two groups start at the same level.

   (a) Why is no assumption about levels needed?

   (b) Sketch a case with two groups where the treated group was already on a steeper trend than the comparison group before treatment, and where the treatment has no effect at all. What would differences in differences estimate here? Label the true effect and the estimate on your sketch.

**Part 3: Putting It Together**

5. For each study below, name the research design and state in one sentence what you would have to believe for the estimate to be causal.

   (a) Researchers compare outcomes in districts that adopted a new reading curriculum in 2019 to districts that did not, before and after adoption.

   (b) A university awards a scholarship to every applicant with an admissions index of 1200 or above. Researchers compare graduation rates of applicants scoring just above and just below 1200.

   (c) A nonprofit ran a lottery for tutoring slots. Researchers compare test scores of lottery winners to losers, then scale the difference by the fraction of winners who actually attended.

   (d) Researchers compare the earnings of college graduates to non-graduates, controlling for high school GPA, family income, and demographics.

6. Rank the four designs above from the assumption you find easiest to believe to the one you find hardest. Defend your ranking in a few sentences. There is no single right answer here, but there is a wrong one: "they are all equally strong."