Problem Set 2

Research Design for Causal Inference
Due: April 14, 2015

Part I – Concepts

Complete the following exercises from FEDAI:

Chapter 2, Exercise 8:

Chapter 2, Exercise 12:

Part II – Application

In this section, you will calculate descriptive statistics and estimate treatment effects for a subset of the data from a very famous experiment, Project STAR (Student-Teacher Achievement Ratio). As part of the Project STAR study, teachers, kindergarten students, and schools in Tennessee were randomly assigned into classrooms of varying sizes in order to estimate the effect of classroom size on student achievement. This study has launched dozens of papers, and you can read a brief summary of it on pp. 36-37 of the Willett & Murnane book. For a similar analysis of a different experiment, you may want to review Table 4.1 of Willett & Murnane on p. 49 and the surrounding discussion.

We'll be looking at a simplified cross-section of the data from 1985-1989 and will only compare the effects of one of the treatment conditions – a small classroom with 13-17 students – against the control condition – a regular classroom with 22-25 students – on one of the outcomes – reading test scores. For the purpose of this assignment do not worry about either the school-level aspects of the randomization/analysis or the additional control condition in the study. **In other words, pretend that random assignment occurred at the individual level and exclusively between the small and regular classroom size conditions.**

You can download the dataset for this assignment from:

http://aaronshaw.org/teaching/2015/causal/data/star.csv

The units of analysis (rows in the dataset) are individual students. The variables are listed in Table 1:

Table 1: Variables in simplified STAR experiment dataset

Variable name	Definition
`class.size`	Indicator of the student's class size ("small" or "regular").
`free.lunch`	Does the student receive free lunch or not?
`race`	The student's race (coded "black," "white," or "other").
`read.score`	The student's reading test score.
`gender`	The student's gender (coded either "male" or "female").
`teach.exper`	The number of years experience of the student's teacher.
`id`	A unique numeric identifier for each subject.

Question 1 – descriptive statistics

Report summary statistics for all of the pre-treatment covariates – both for the whole dataset and for the treatment and control groups respectively. For the continuous variable `teach.exper`, include minimum, mean, maximum, and standard deviation. For the categorical variables (`gender`, `free.lunch`, and `race`), present the number of subjects in each category.

Question 2 – assess covariate balance

Use t-tests and χ^2 tests to assess whether the treatment and control groups are "balanced" on the observed covariates. Summarize the results of these tests in a couple of sentences.

Question 3 – estimate treatment effects

Estimate the Average Treatment Effect (ATE) using the average difference in the outcome variable (difference-in-means) as your estimator. Formally (using notation preferred by Willett & Murnane), I want you to calculate $\hat{\tau}$ when:

$$\hat{\tau} = \overline{y}_t - \overline{y}_c \tag{1}$$

Question 4 – interpretation

What do you conclude about the effect of this intervention based on these analyses?

Question 5

Why would you compare pre-treatment covariates (like I asked you to do in Question 2)? What do you learn from such comparisons?

Question 6

Now, relax the assumption that random assignment occurred at the individual level. In other words, some of the individuals assigned to treatment may have been in the same classroom and/or school together (and likewise some of the individuals assigned to control). How and why might this change your interpretation of the estimate from Question 3?

Part III – Key Concepts

Make sure to focus on understanding the following concepts as you read Gerber & Green, FEDAI, Chapter 3 this week:

- Sampling (or randomization) distribution.
- Standard deviation.
- Standard error.
- Variance.
- Covariance.
- P-value.
- Null hypothesis of no (average) effect.
- Randomization inference.
- Confidence intervals.
- Block random assignment.
- Cluster random assignment.