PS C236A/ Stat C239A
Problem Set 3
Due: Sept. 25, 2009

Problem 1: Imagine a randomized experiment where 6 out of 30 students in a classroom are randomly exposed to a new type of teaching method. The 24 other students are exposed to the conventional teaching method. Under the Neyman-Rubin model and assuming SUTVA, there are 60 potential outcomes. Drop the SUTVA assumption (sometimes called the no-interference assumption). How many potential outcomes are there? For a succinct definition of SUTVA, see page 41-42 of Rosenbaum's *Observational Studies*.

Problem 2: The Lady Tasting Tea Consider the following variation of the Lady Tasting Tea example that we discussed in class. The Lady tastes six cups of tea, three of which have milk added first and three of which have tea added first. The cups are presented to the Lady in random order. The Lady knows the design, meaning she knows there are exactly three milk-first cups and three tea-first cups which will presented to her randomly.

a. In the case where the Lady makes no mistakes, what is the p-value for a test under the null hypothesis that the Lady has no ability to discriminate the order in which milk is added to tea?

b. In the case where the Lady makes one mistake (classifies one milk-first cup as a tea-first cup), what is the p-value for a test under the null hypothesis that the Lady has no ability to discriminate the order in which milk is added to tea?

Now, instead of using fixed margins, let's imagine that we conduct the Lady Tasting Tea experiment under binomial randomization. There are 6 cups, and each has a probability $p = 1/2$ of having milk first and a $1 - p$ probability of having tea added first. The Lady does not know the value of p, but does know that the cups are assigned randomly under binomial randomization.

c. In the case where the Lady makes no mistakes, what is the p-value for a test under the null hypothesis that the Lady has no ability to discriminate the order in which milk is added to tea?

d. In the case where the Lady makes one mistake (classifies one milk-first cup as a tea-first cup), what is the p-value for a test under the null hypothesis that the Lady has no ability to discriminate the order in which milk is added to tea?

e. Make the best argument you can for the fixed margin design. Also make the best argument you can for the binomial randomization design.

f. *Bonus:* Now suppose that each cup as a probability $p = 1/3$ of having milk first. Which null hypothesis would we prefer: The Lady has no ability to identify milk-first cups or The Lady has no ability to identify tea-first cups. Why?

Problem 3: According to David Freedman, under what circumstances might you get gains (reduction in asymptotic variance) from adjusting experimental data using a multiple regression (i.e. a regression with some set of covariates, Z, in addition to treatment assignment)? Under what circumstances might adjusting experimental data increase asymptotic variance? Explain briefly.

Problem 4: In this problem, you will analyze a famous experiment conducted by Leonard Wantchekon in Benin in 2001. Wantchekon wanted to examine the effectiveness of different types of campaign messages on voting behavior in a presidential election. For details, see:

`http://www.nyu.edu/gsas/dept/politics/faculty/wantchekon/research/WP_0331.pdf`

Wantchekon convinced the campaigns of the major presidential candidates to randomize the messages they employed in 24 villages. The three treatment conditions were as follows:

1. *Public Policy:* Wantchekon describes this treatment condition as: "It was decided that any public policy platform would raise issues pertaining to national unity and peace, eradicating corruption, alleviating poverty, developing agriculture and industry, protecting the rights of women and children, developing rural credit, providing access to the judicial system, protecting the environment, and/or fostering educational reforms."

2. *Clientelist*: Wantchekon describes this treatment as: "A clientelist message, by contrast, would take the form of a specific promise to the village, for example, for government patronage jobs or local public goods, such as establishing a new local university or providing financial support for local fishermen or cotton producers."

3. *Both*: These villages received both types of messages.

The structure of the experiment was *block* randomization. Villages were divided into groups of 3 based on geography and treatment status was randomized within the 8 groups of 3. The outcome variable is the vote share of the candidate participating in the experiment. The only covariate is the number of registered voters. In the dataset, `block` indicates block group, `reg.voters` is the registered voters covariate, `vote.pop` is the outcome variable, `treat` is a variable indicating treatment status.

In this problem, we are mainly interested in the difference between the clientelist and public policy conditions.

a. Estimate the effect the clientelist message compared to the public policy message, using the ITT estimator and the regression estimator. Note that the block structure of this experiment will affect how you calculate these quantities. See page 47 of Rosenbaum for how to compute the ITT estimator with blocking. For the regression estimate, include block level dummy variables in your regression equation.

b. Now test the sharp null of no treatment effect using randomization inference. Use two test statistics: the rank sum test and the difference in means (see Rosenbaum (2002), Chapter 2). If you don't want to enumerate every possible treatment assignment, just sample a large number of draws from the randomization distribution. What are the two sided p-values under these two tests?

c. Now perform randomization inference ignoring the block structure of the experiment using difference in means as your test statistic. In other words, pretend that treatment status was allocated randomly without regard to the block variable, sometimes known as "complete randomization". Are these results different from the result obtained in part b? Is this method of randomization inference valid?

d. What can you conclude about the effectiveness of clientelistic appeals in Benin?

e. Bonus: Perform randomization inference with covariance adjustment. How does this effect your results? For a very good article on covariance adjustment with randomization inference, see:

> Rosenbaum, Paul. 2002. "Covariance Adjustment in Randomized Experiments and Observational Studies." *Statistical Science* 17(3): 286-327.