Problem Set - Energy Efficiency

Economics of Energy and the Environment

Econ 3391.01

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1 Estimating the savings from home energy audits

Background

This problem will demonstrate the nuances of different approaches to estimating the benefits of public policy. In this example, the policy of interest encourages consumers to have a home energy audit. During a home energy audit, an energy specialist comes to your house and takes a detailed inventory of your energy using capital (ie appliances, lightbulbs, etc). She also checks the status of the insulation, doors and windows. Finally, she runs this information, along with your electricity usage, through a computer program to produce a list of recommended energy efficiency investments.

The motivation for this policy is the so-called "energy efficiency paradox" we discussed in class: the notion that many underutilized energy efficient technologies would actually more than pay for themselves in reduced energy bills. One possible explanation for this low rate of investment is that households simply do not know which technologies to buy or how much money they would save. The audit is designed to assist that process.

Data

The data set audit_data.csv contains information on electricity usage for the 10,000 households in a utility's territory (one per row). The first column indexes the different households, and the remaining columns follow the notation used in the lecture slides.

- Let (y_i^{ta}) denote the electricity expenditure (in dollars) of household i in time period t.
- The data come from two time periods: a "pre" period (t=0) and a "post" period (t=1). Home energy audits were only available in the post period.
- The a subscript is equal to 1 if the household had a home energy audit that period, and zero otherwise.

You will notice that this is a very unique dataset, as we observe outcomes for each household in two parallel universes, one where they got an audit, and one where they didn't.

- The variable y00 is the amount the household spends on electricity in the pre period (where no one has had an audit).

- The variable y10 is the amount the household spends on electricity in the post period in the universe where **it does NOT get an audit**.
- The variable y11 is the amount that the household spends on electricity in the post period in the universe **it DOES get an audit**.
- Furthermore, we observe what each household *expected* their electricity consumption to be under each scenario (ey10 and ey11).
- Finally, we also observe the "hassle" cost each household faces undergoing a home energy audit. They might need to take the day off work, clean their attic etc, etc. These hassle costs are denoted in dollars, and can thus be compared to expected savings.

So for example, household 1 spent $1251 on electricity in the pre period. In the post period, it *believes* that with no audit it would spend $1843, and with an audit it would spend $1486. When the post period actually comes, it's true realized expenditures without out the audit are $1874, and without the audit are $1548.

Policy question

The regulator is considering a policy that will increase the takeup of home energy audits and wants to know the benefits of this proposal. Specifically, it would like to use data to answer the question: By how much do home energy audits reduce household energy bills?

However, it does not have access to the same data that we have. It only observes actual expenditures (so y10 if a household does not have an audit, and y11 if it does). It does not observe hassle costs or expectations.

1.1 If the utility could force everyone to get a home energy audit, how much money would households save on average in the post period?

Calculate the true savings, y10 - y11. Compute the mean and create a histogram of the electricity savings.

1.2 Home energy audits cost $250. Absent any subsidies or mandates, a household will opt for an audit if the *expected* savings exceed the cost of the audit plus any hassle costs.

- Compute the expected savings, ey10 - ey11.
- Predict that a household will adopt if the expected savings exceed the hassle cost and the cost of the audit.
- Create a dummy variable for these households (D_optin=1 if savings outweigh the costs, 0 otherwise).

Q: How many households chose to have audits?
Q: What is the average treatment effect (electricity savings from an audit) for each group?[ie one average for those who opt in and another for those who don't].

1.3 Calculate the difference in (realized) electricity consumption between audited and non-audited households in the post period.

- Specifically, calculate the *realized* electricity consumption: y11 of audited households, y10 for non-audited households. Then take the difference.

Q: Is this a good estimate of the population average benefits of an audit? Why or why not?

1.4 Recognizing that there may be selection into the program, one option is to use difference in differences to estimate the savings from an audit.

- Use the pre and post period data for each household to calculate the estimated savings.
- Hint: You could do this with a regression, but it is probably easiest to do this by calculating the means from each group, as in the first problem set. So you want to find (y11-y00) for households that got an audit, and (y10-y00) for those that didn't, and then take the difference in these two differences.

Q: How does this compare with your answers for 1.1 and 1.3?

1.5 Another option is to run an experiment.

- Imagine that the utility can randomly select 1000 households and force them to have a home energy audit.
- You can implement this by generating a random number for each household, sorting by that number.
- Assign the first 1000 sorted households to the audit "treatment" (D_treat = 1), and assign the rest to the no-audit "control" group (D_treat = 0).
- Compare the *realized* energy expenditure for the treatment group (y11) with the realized energy expenditure for the control households (y10).

Q: How does the difference between these two means compare to your answer from 1.1?

1.6 It turns out the utility can't force people to have an audit. All they can do is offer them free audits.

- Assume that the same 1000 households from 1.5 are offered free audits.
- Although the "control" 9000 households do not get offered free audits, they can still opt to pay $250 for one.
- As in part 1.2, predict which households opt for audits in each group now. Ie figure out which houesholds have expected savings higher than expected costs. Assign D_optin_rct=1 if expected savings outweigh the costs.

Q: How many households opt for audits now? Compare this to your answer from 1.2.

1.7 Intent to treat.

- Compare the average realized electricity expenditure across the treatment and control groups (where treatment is defined by whether you were randomly offered a free audit, not by whether you accepted).

Q: How does this compare to your answer from 1.1?

1.8 Local average treatment effect (LATE).

- Define the group "compliers" as those households in the treatment group that opted for an audit when it was free, but would not opt for an audit if they had to pay the $250 audit price.

Q: What fraction of the treatment group are "compliers"?
Q: Calculate the realized savings for this group (ie E[y10 - y11 | complier = 1]). This is a called the local average treatment effect (LATE).

1.9 If you multiply the LATE by the fraction of compliers, how does this number compare with your answer from 1.7?

Q: What is the intuition for this relationship?

1.10 What are the policy implications of these relationships?

If we are considering public policy to promote home energy audits, should we be trying to calculate the population average treatment effect (1.1), or the local average treatment effect (1.8)?