Homework 2

Environmental Economics II
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In this assignment, we are given imaginary data on an energy-efficiency retrofit program in Atlanta. The research hypothesis is whether the program reduced energy use. The experiment done in such way that after recruiting the households for the program, we assigned them to treatment and control groups. Treatment homes received the retrofits on the first of the month and control homes did not have any work done.

1. Suppose that for for a home i, the underlying relationship between electricity use and predictor variable is given by

$$y_i = e^{\alpha}\delta^{d_i} z_i^{\gamma} e^{\eta_i} \tag{1}$$

where y_i is the electricity use, e is Euler's number or the base of the natural logarithm, d_i is a binary variable equal to one if home i received the retrofit program, z_i is a vector of the other control variables, and η_i is unobserved error, and $\{\alpha, \delta, \gamma\}$ are the parameter to estimates.

(a) Show that $\ln(y_i) = \alpha + \ln(\delta)d_i + \gamma \ln(z_i) + \eta_i$
Answer
Rewrite Equation (1) by taking natural log on both sides and distribute the natural log on the right hand side of the equation, we have

$$\begin{aligned}
\ln(y_i) &= \ln\left(e^{\alpha}\delta^{d_i} z_i^{\gamma} e^{\eta_i}\right) \\
\ln(y_i) &= \ln(e^{\alpha}) + \ln(\delta^{d_i}) + \ln(z_i^{\gamma}) + \ln(e^{\eta_i}) \\
\ln(y_i) &= \alpha + \ln(\delta^{d_i}) + \gamma \ln(z_i) + \eta_i \\
\ln(y_i) &= \alpha + \ln(\delta)d_i + \gamma \ln(z_i) + \eta_i.
\end{aligned}$$

□

(b) What is the intuitive interpretation of δ?
Answer
Let's take the expectation of Equation (1) conditional on d_i, we have

$$\mathrm{E}[y_i|d_i = 1] = e^{\alpha}\delta z_i^{\gamma} e^{\eta_i} \tag{2}$$
$$\mathrm{E}[y_i|d_i = 0] = e^{\alpha} z_i^{\gamma} e^{\eta_i} \tag{3}$$

Dividing the first equation by the second equation, we have

$$\delta = \frac{\mathrm{E}[y_i|d_i = 1]}{\mathrm{E}[y_i|d_i = 0]} \tag{4}$$

which means δ translates to the ratio of the expected electricity use of the treatment group to the expected electricity use of the control group.

(c) Show that $\frac{\Delta y_i}{\Delta d_i} = \frac{\delta - 1}{\delta^{d_i}} y_i$. What is the intuitive interpretation of $\frac{\Delta y_i}{\Delta d_i}$?
Answer
Taking the e

(d) Show that $\frac{\delta y_i}{\delta z_i} = \gamma \frac{y_i}{z_i}$. What is the intuitive interpretation of $\frac{\delta y_i}{\delta z_i}$ when z_i is the size of the home in square feet?

(e) Estimate the log-transformed equation via OLS on the transformed parameters. Save the coefficient estimates and the average marginal effects estimates of z_i and d_i $\left(\frac{\delta y_i}{\delta z_i} \text{ and } \frac{\Delta y_i}{\Delta d_i}\right)$. Bootstrap the 95% confidence intervals of the coefficient estimates and the marginal effects estimates using 1000 sampling replications. Display the results in a table with three columns (one for the variable name, one for the coefficient estimates, and once for the marginal effect estimate). Show the 95% confidence intervals for each estimate under each number.

(f) Graph the **average marginal effects** of outdoor temperature and square feet of home with bands for their bootstrapped confidence intervals so that they are easy to interpret and compare.