Problem Set
Berkeley ARE 261
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This problem set is due at noon on Tues Nov 9, by email to joseph.shapiro@berkeley.edu.

This problem set is based on the following paper: Deschenes, Olivier, Michael Greenstone, and Joseph S. Shapiro. 2017. "Defensive Investments and the Demand for Air Quality: Evidence from the NOx Budget Program." American Economic Review 107(10): 2958-89.

Please put your name at the VERY END and not the beginning of the problem set.

Parts 1 through 8 compare different estimators of the effects of this program. The goal is to make you comfortable with a standard array of reduced-form methods. If you complete these using Stata, I can give more detailed comments on how they are done than if you complete it with R or other languages, but you can ultimately choose the language. When you hand in your problem set, please write it and organize it like a paper (i.e., with main text explaining the results one by one, and then tables and figures numbered at the end, and present tables and text as you would for a publishable paper), and include your code at the end. Please also number your writeup, with numbers corresponding to the numbering below. When submitting your solutions, please hand in a printed copy (do not just email them).

1. (**Replication**). Download NOx emissions data from 2002 and 2005 at the unit level for Acid Rain units from the EPA's Air Program Markets Data (formerly the Clean Air Markets Database). Recreate Figure 1 from the paper, though using only year 2002 and 2005 data.
2. (**Polynomial regression discontinuity**). Use data from the year 2005 on states included in the NOx Budget Trading Program. Aggregate the data so you have 365 observations, each representing total NOx emissions from states regulated in the NBP. Consider a regression of NOx emissions on a quadratic polynomial in day-of-year and an indicator for the ozone season (May-September).
    a. Write out the econometric equation corresponding to this estimator.
    b. Estimate two versions of regression discontinuity for this equation, one for May 1 and one for Sep 30. In each, use a 2-month window (1 month on each side of the discontinuity). Report the estimated effect of the NOx Budget Trading Program on NOx emissions.
    c. Briefly explain how you deal with inference and weighting and why you use this approach.
3. (**Spline Regression Discontinuity**). Repeat the exercise of part 2, but let the quadratic polynomial terms differ to the left and to the right of the discontinuity.
    a. Write out the econometric equation corresponding to this estimator.
    b. Report the estimated effect of the NBP on NOx Emissions.
4. (**Cross-Sectional Comparison**). Using the same daily data as in part (2), using a regression, consider an estimator of the effect of the NOx Budget Trading Program on NOx emissions by comparing mean emissions in the May-September period against the other months of the year
    a. Write out the econometric equation corresponding to this estimator
    b. Report the estimated effect of the NBP on NOx emissions by applying this estimator in 2005.
5. (**Pre/post differences-in-differences**). Use daily data so each observation represents total emissions from the Eastern U.S. or from the Western U.S. in a given calendar date. Consider an estimator of the effect of the NOx Budget Trading Program on NOx emissions by taking the difference between May-September versus the rest of the year, and comparing this difference after the market began against that difference before the market began.
    a. Write out the econometric equation corresponding to this estimator.
    b. Report the estimated effect of the NBP on NOx emissions by applying this estimator for the Eastern U.S.

6. (**East/west differences-in-differences**). Like part 4, but estimate the model for the year 2005 only, for states in the NBP and states not in the NBP.
    a. Write out the econometric equation
    b. Report the estimated effects
7. (**Differences-in-differences-in-differences**). Estimate the effect of the NBP on NOx emissions by comparing summer versus winter, pre versus post, and East versus West, in a single equation.
    a. Write out the econometric equation
    b. Report the estimated effect of the NBP
    c. Briefly explain how you deal with inference and weighting and why you use this approach.
8. What are the potential threats to internal validity of the estimator in equation (7)? Which of the estimators in parts (1)-(7) represents the most reasonable approach to measuring the effects of this program, and why?
9. The EPA announced emissions caps on emissions for each year of the NBP. Why not use those caps to measure the effect of the program, rather than using these regressions?

Now consider the simple model in the paper which derives an expression for marginal-willingness-to-pay for improvements in air quality

10. Show the first-order conditions for the consumer's problem. Explain the meaning of each in words.
11. Derive equation (2).
12. Explain in words what ds/dc and $\partial s/\partial a$ represent. Why is it difficult to estimate $\partial s/\partial a$?
13. Derive equation (3)
14. What price does p_a in the model describe? What complications does this create in using medications to construct empirical analogues to equation (3)?