ARE 261-B PS 1 (Shapiro)

2021-11-09

Contents

1 Replication

Possible columns: State, Facility Name, Facility ID (ORISPL), Unit ID, Associated Stacks, Date, Year, Program(s), Operating Time, Gross Load (MW-h), Steam Load (1000lb), SO2 (tons), Avg. NOx Rate (lb/MMBtu), NOx (tons), CO2 (short tons), Heat Input (MMBtu), EPA Region, NERC Region, County, Source Category, Facility Latitude, Facility Longitude, Owner, Operator, Representative (Primary), Representative (Secondary), SO2 Phase, NOx Phase, Operating Status, Unit Type, Fuel Type (Primary), Fuel Type (Secondary), SO2 Control(s), NOx Control(s), PM Control(s), Hg Control(s)

Come back to think about: - Operating Time - Avg. NOx Rate (lb/MMBtu) - Heat Input (MMBtu) - Source Category - latitude & longitude - NOx phase - operating status - unit type, fuel types - pollution controls

These estimates are obtained from an OLS regression of NO x emissions on six day-of-week indicators and a constant. The values in the graph equal the constant plus the regression residuals, so that the graph depicts fitted values for the reference category (Wednesday).

1.1 Data

Data for NO_x emssions in 2002 and 2005 for states participating in the EPA's Nitrogen Oxides (NO_x) Budget Program (NBP) were downloaded from the EPA's Air Markets Program Data database. Facilities missing NO_x data for a given day that also had measured Operating Time of 0 are assumed to have 0 NO_x for that day.

1.2 Total Daily Average NO_x Emissions

Figure 1 depicts total daily average NO_x emissions over the year, comparing 2002 to 2005 emissions as pre- and post-treatment observations. Even as a simple comparison, there's a dramatic affect on NO_x emissions during the days of the year when the NBP-participating states are required to restrict their emissions.

2 Polynomial regression discontinuity

2.1 The econometric equation

$$NOx_t = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot t^2 + \gamma \cdot 1(\text{NBP Operating at } t) + \varepsilon_t \tag{1}$$

$$\begin{aligned} \text{where } t &= \text{day of the year (an integer between 1 and 365)} \\ 1(\text{NBP Operating at } t) &= \text{ozone season indicator; 1 if } t \in [121, 273] \text{ (the ozone season*)} \\ NOx_t &= \text{sum of average daily NO}_x\text{emissions from NBP states on day } t \end{aligned}$$

*The ozone season is May-September. May 1^{th}, 2005 is the 121^{st} day of the year and September 30^{th}, 2005 is the 273^{rd} day of the year.

2.2 Polynomial Regression Discontinuity estimates at the beginning and end of the season

The first specification of the polynomial regression discontinuity is estimating the discontinuity around the beginning of the ozone season – estimating the impact of the restrictions turning on on May 1st. Column 1 of Table 1 show the estimation of equation (1) after restricting the data to a 2-month window around the beginning of the policy in 2005 (April-May). The estimated effect of imposing the restrictions of the NO_x Budget Trading Program in May 2005 was a reduction in NO_x emissions of about 2.109 thousand tons.

The second specification of the polynomial regression discontinuity is estimating the discontinuity around the end of the ozone season – estimating the impact of the restrictions turning off on October 1st. Column 2 of Table 1 show the estimation of equation (1) after restricting the data to a 2-month window around the end of the policy in 2005 (September-October). The estimated effect of removing the restrictions of the NO_x Budget Trading Program in October 2005 was an increase in NO_x emissions of about -2.566 thousand tons.

2.3 Inference and weighting in the polynomial RD

Because I have aggregated the data to the day-year-state level, the regression of NO_x emissions on day-of-year and the regulation indicator implicitly weights each state equally. The above results should then be interpreted as a reduction (increase) of 2109 tons (-2566 tons) of NO_x emissions in the average NBP state at the start (end) of the regulation season. We could instead rewight the regression using the number of firms in each state and interpret the estimated effects as an reduction or increase in the average firm's NO_x emissions.

3 Spline Regression Discontinuity

3.1 The econometric equation

$$\begin{aligned} NOx_t = &\beta_0 + \beta_1 \cdot t + \beta_2 \cdot t^2 \\ &+ \beta_3 \cdot t \cdot 1(\text{NBP Operating at } t) + \beta_4 \cdot t^2 \cdot 1(\text{NBP Operating at } t) \\ &+ \gamma \cdot 1(\text{NBP Operating})_t + \varepsilon_t \end{aligned} \tag{2}$$

3.2 Spline Regression Discontinuity estimates at the beginning and end of the season

The first specification of the spline regression discontinuity is estimating the discontinuity around the beginning of the ozone season – estimating the impact of the restrictions turning on on May 1st. Column 3 of Table 1 show the estimation of equation (2) after restricting the data to a 2-month window around the beginning of the policy in 2005 (April-May). The estimated effect of imposing the restrictions of the NO_x Budget Trading Program in May 2005 was a reduction in NO_x emissions of about 1.859 thousand tons.

The second specification of the spline regression discontinuity is estimating the discontinuity around the end of the ozone season – estimating the impact of the restrictions turning off on October 1st. Column 2 of Table 1 show the estimation of equation (1) after restricting the data to a 2-month window around the end of the policy in 2005 (September-October). The estimated effect of removing the restrictions of the NO_x Budget Trading Program in October 2005 was an increase in NO_x emissions of about -2.855 thousand tons.

4 Cross-Sectional Comparison

5 Pre/post differences-in-differences

6 East/west differences-in-differences

7 Differences-in-differences-in-differences

8 Discussion of Estimators

9 EPA emissions caps

10 Marginal Willingness to Pay for Improvements in Air Quality

10.1 First-order Conditions for the Consumer

10.2 Equation (2) [write title of meaning of Eq2]

10.3 ds/dc [write title of meaning of ds/dc]

10.4 Equation (3) [write title of meaning of Eq3]

10.5 Price of (p_a)

11 Figures

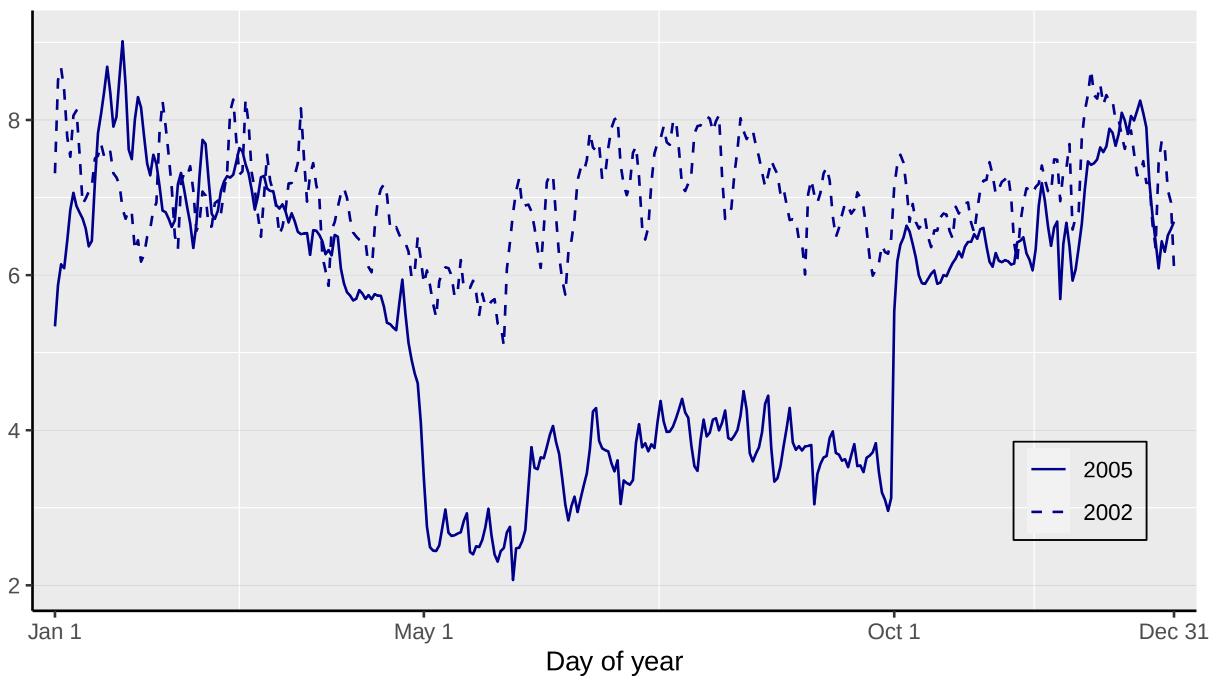

Figure 1: Total Daily nox Emissions in the NBP-Participating States

Notes: Figure 1 shows total average daily NO_x emissions (in 1000's of Tons) in the NBP participating states in 2002 and 2005. These estimates are obtained from an OLS regression of NO_x emissions on six day-of-week indicators and a constant. The values in the graph equal the constant plus the regression residuals, so that the graph depicts fitted values for the reference category (Wednesday). Total daily NO_x emissions on y-axis are measured in thousands of tons. The sample includes emissions from all the Acid Rain Units. NBP participating states include: Alabama, Connecticut, Delaware, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia, West Virginia, and Washington, DC. Facilities missing NO_x data for a given day that also had measured Operating Time of 0 are assumed to have 0 NO_x for that day. This slightly affects the regression of NO_x on the day-of-week indicators, but results in very little difference in total sums of daily average NO_x emissions.

Table 1: NBP Polynomial Regression Discontinuity Results for 2005

	Total Daily Emissions (1000 tons)			
	NBP Start (May)	NBP End (Sepember)	NBP Start (May)	NBP End (Sepember)
Ozone Season Indicator	-2.109^{***}	2.566^{***}	-1.859^{***}	2.855^{***}
	(0.167)	(0.213)	(0.240)	(0.322)
Separate Time Trend?	No	No	Yes	Yes
Observations	61	61	61	61
Adjusted R^2	0.956	0.909	0.960	0.908
Note:				$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Notes: The “Separate Time Trend?” row in Table 1 represents whether or not the regression discontinuity included separate time trends for while the NBP program was running and when it was not.

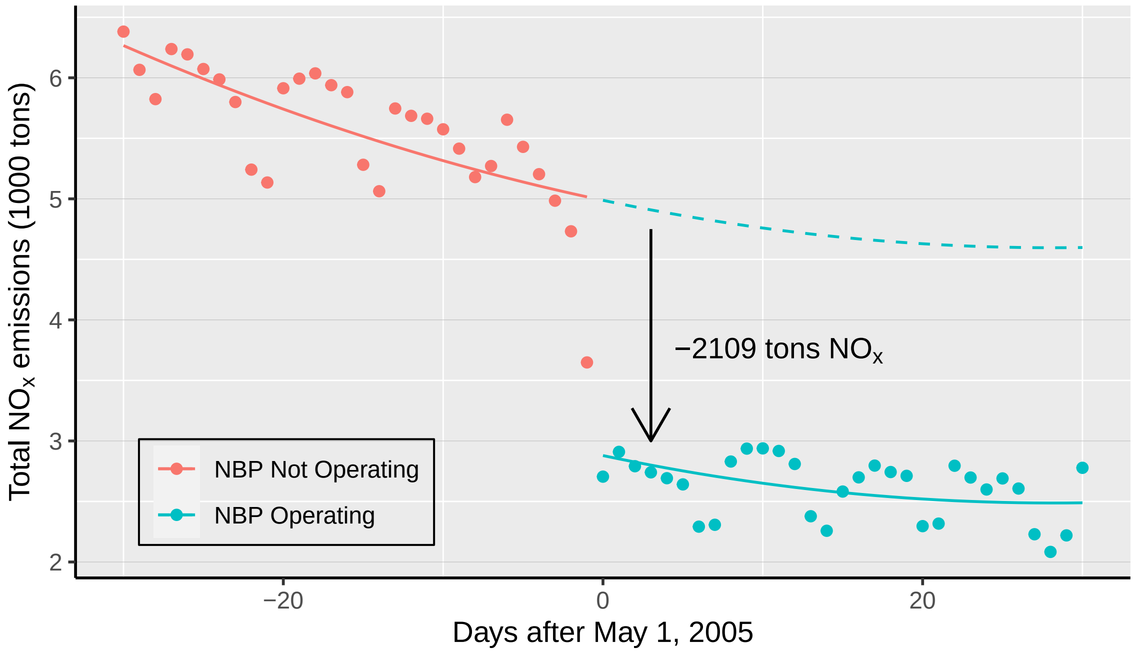

Figure 2: Regression Discontinuity plot with quadratic time trend for beginning of 2005 NBP season (constant shift only). The dependent variable is total average daily NO_x emissions (in 1000's of Tons) in the NBP participating states in April and May, 2005. The fitted RDD lines use a quadratic time trend, with shared time trend parameters on either side of the discontinuity – only the regression intercept term differs on either side.

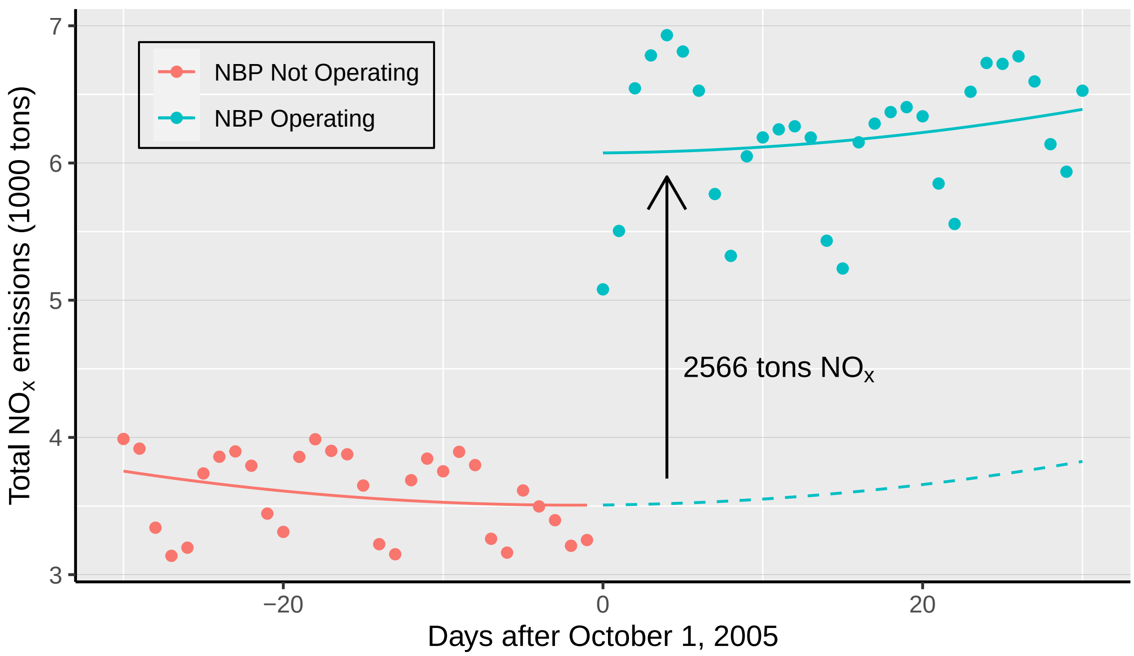

Figure 3: Regression Discontinuity plot with quadratic time trend for end of 2005 NBP season (constant shift only). The dependent variable is total average daily NO_x emissions (in 1000's of Tons) in the NBP participating states in September and October, 2005. The fitted RDD lines use a quadratic time trend, with shared time trend parameters on either side of the discontinuity – only the regression intercept term differs on either side.

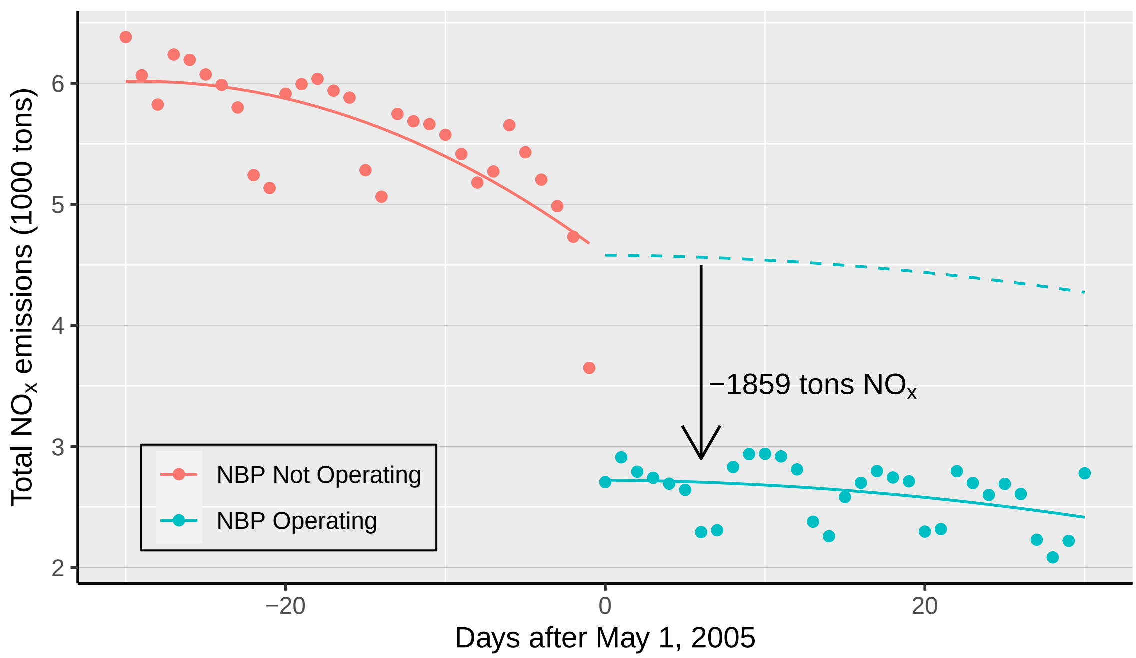

Figure 4: Regression Discontinuity plot with quadratic time trend for beginning of 2005 NBP season (constant and trend shifts). The dependent variable is total average daily NO_x emissions (in 1000's of Tons) in the NBP participating states in September and October, 2005. The fitted RDD lines use a quadratic time trend, with separate time trend parameters on either side of the discontinuity (a spline RDD) – both the intercept and time trend parameters differs on either side of the regulation threshold (October 1st).

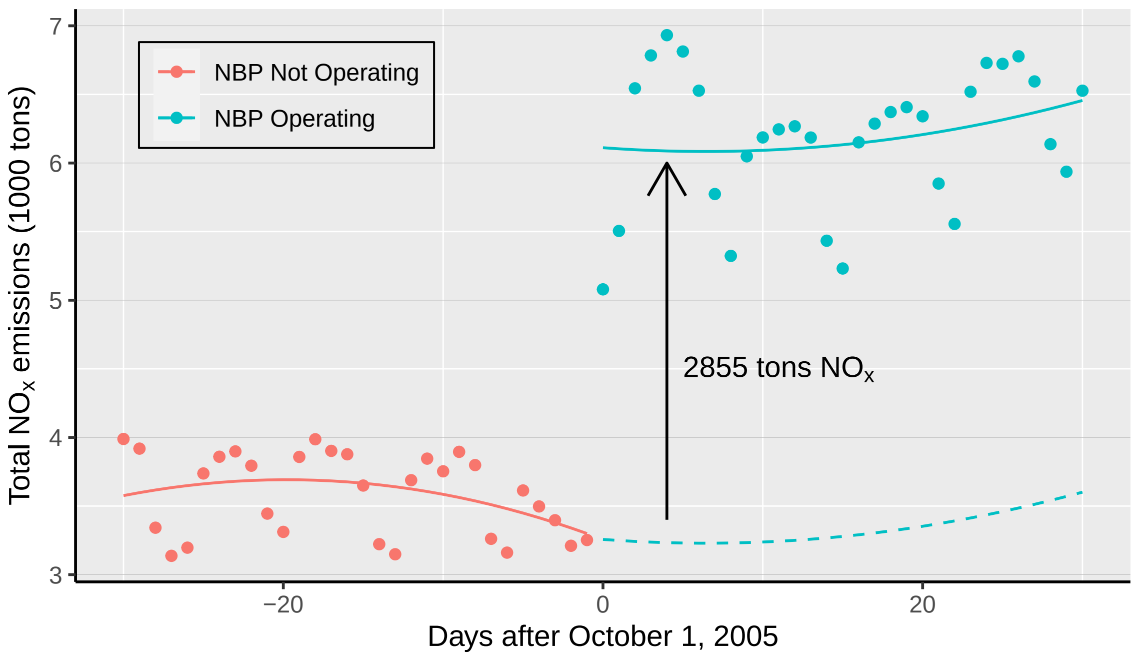

Figure 5: Regression Discontinuity plot with quadratic time trend for beginning of 2005 NBP season (constant shift only). The dependent variable is total average daily NO_x emissions (in 1000's of Tons) in the NBP participating states in April and May, 2005. The fitted RDD lines use a quadratic time trend, with shared time trend parameters on either side of the discontinuity – only the regression intercept term differs on either side.

12 Code

13 References

Hlavac, Marek (2018). stargazer: Well-Formatted Regression and Summary Statistics Tables. R package version 5.2.2. https://CRAN.R-project.org/package=stargazer

Deschênes, Olivier, Michael Greenstone, and Joseph S. Shapiro. "Defensive Investments and the Demand for Air Quality: Evidence from the NOx Budget Program." American Economic Review 107, no. 10 (October 2017): 2958–89. https://doi.org/10.1257/aer.20131002.

14 Authorship Info

Aaron Watt