Is There A School Finance Channel? Effects of Ambient Air Pollution on K-12 Education in USA

Biplab Datta

Georgia State University

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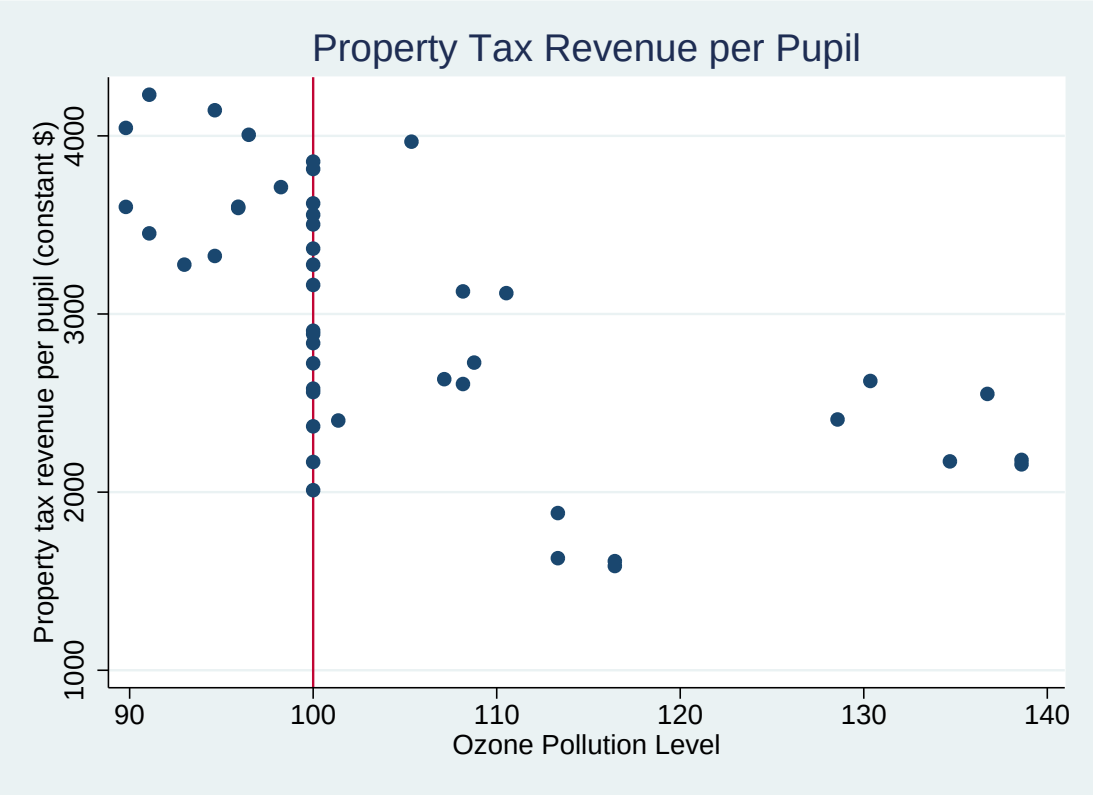
Motivation

Figure: Ozone Pollution and Property Tax Revenue per Pupil in Seattle-Tacoma-Bellevue CBSA, WA



What do I do?

- I derive a finance channel of pollution education nexus by extending the education production function framework.
- I analyze K-12 revenue and expenditure data for metropolitan school districts, and estimate a reduced form model.
- I use panel fixed effect model for empirical analysis.
- Unit of analysis: school district level.
- Sample Period: 1996 to 2008 (3-year intervals).

Model

- Education Production Function

$$Y = y(H, E, \vec{F}, \vec{S}) \tag{1}$$

Model

- Education Production Function

$$Y = y(H, E, \vec{F}, \vec{S}) \tag{1}$$

- Existing Literature

$$Y = y(h(P), E, \vec{F}, \vec{S}) \tag{2}$$

Model

- Education Production Function

$$Y = y(H, E, \vec{F}, \vec{S}) \tag{1}$$

- Existing Literature

$$Y = y(h(P), E, \vec{F}, \vec{S}) \tag{2}$$

- My Contribution

$$Y = y(h(P), e(P), \vec{F}, \vec{S}) \tag{3}$$

Model

- Property Tax Revenue

$$R = m(V)v(P) \tag{4}$$

Model

- Property Tax Revenue

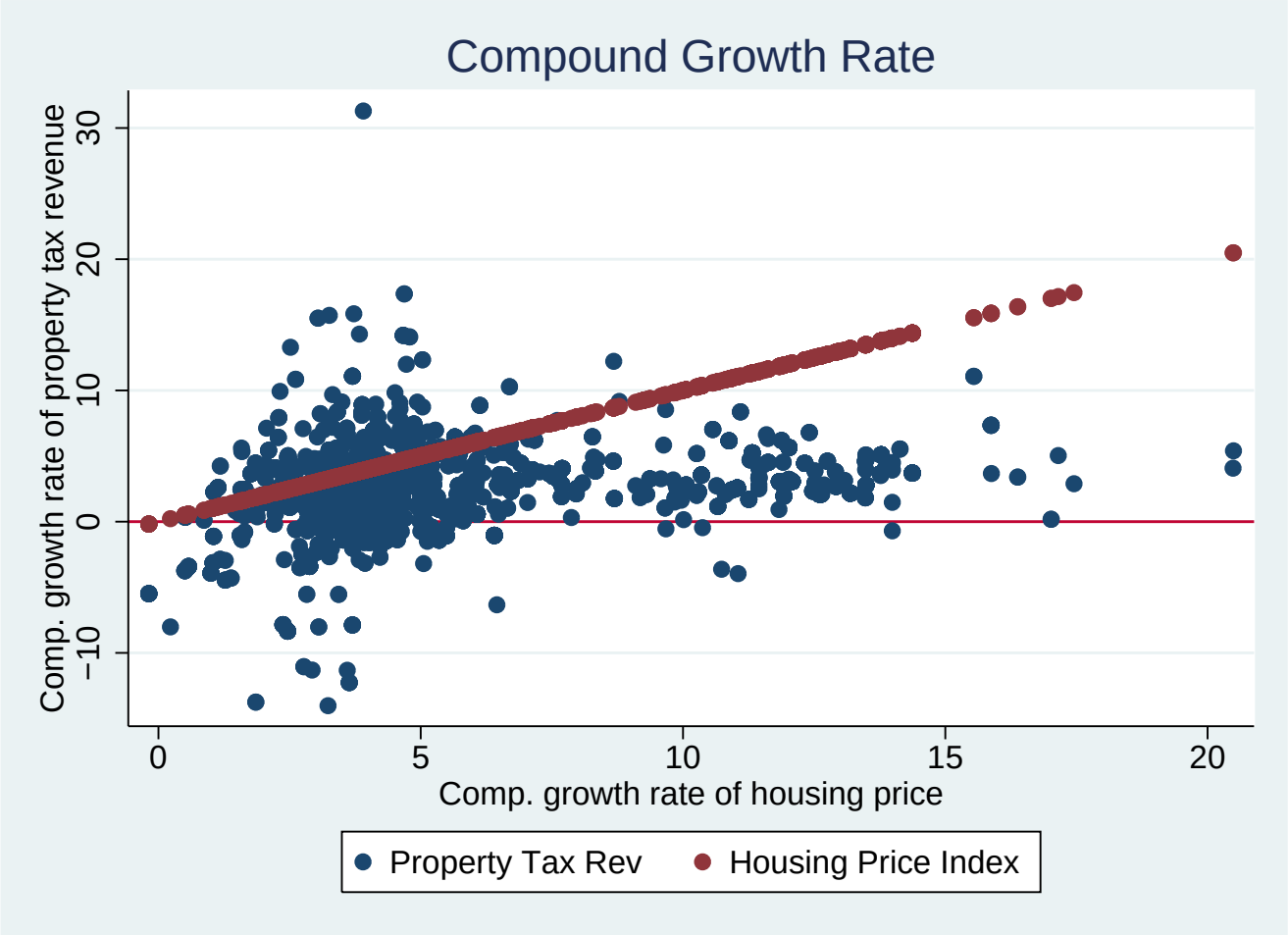
$$R = m(V)v(P) \tag{4}$$

- Total differentiating equation (1) yields:

$$\frac{dR}{dP} = \left(\frac{\delta r}{\delta V}\frac{\delta v}{\delta P} + \frac{\delta r}{\delta M}\frac{\delta m}{\delta V}\frac{\delta v}{\delta P}\right) \tag{5}$$

Deriving School Finance Channel

Figure: Policy Offsetting Effect



Model

- Total differentiating equation (1) yields:

$$\frac{dY}{dP} = MPH\frac{\delta h}{\delta P} + MPE(\frac{\delta r}{\delta V}\frac{\delta v}{\delta P} + \frac{\delta r}{\delta M}\frac{\delta m}{\delta V}\frac{\delta v}{\delta P}) + MPS\frac{\delta s}{\delta P} \quad (6)$$

  - Health Channel: $MPH\frac{\delta h}{\delta P}$
  - Finance Channel: $MPE(\frac{\delta r}{\delta V}\frac{\delta v}{\delta P} + \frac{\delta r}{\delta M}\frac{\delta m}{\delta V}\frac{\delta v}{\delta P})$
  - Socioeconomic Channel: $MPS\frac{\delta s}{\delta P}$

Empirical Model

- Current expenditure per pupil:

$$E_{jst} = \gamma_0 + \gamma_1 \ln Pollution_{j,s,t-k} + \gamma_2 \ln Pollution_{j,s,t-k}{}^2 + \mathbf{State}'_{st}\ \boldsymbol{\gamma}_3 + \alpha_j + \lambda_t + \epsilon_{jt} \tag{7}$$

- State level controls are -
  - state revenue as percentage of total K-12 revenue, and
  - a state level index for average current expenditure per pupil.

Empirical Model

- Property tax revenue per pupil:

$$\begin{aligned} R_{jst} = \beta_0 + \beta_1 \ln Pollution_{j,s,t-k} + \beta_2 \ln Pollution_{j,s,t-k}{}^2 \\ + \mathbf{State}'_{st}\ \beta_3 + \mathbf{Local}'_{j,s,t-k}\ \beta_4 + \mathbf{District}'_{jst}\ \beta_5 \\ + \beta_6\ HPI_{s,t-k+1} + \alpha_j + \lambda_t + \epsilon_{jt} \end{aligned} \tag{8}$$

- District includes -
  - total debt outstanding, and
  - other local revenue share.
- Local includes -
  - a measure of school quality
  - capital outlay expenditure

Empirical Model

- Marginal effects:

$$\frac{\delta E_{jt}}{\delta \ln Pollution_{j,s,t-k}} = \gamma_1 + 2\gamma_2 \ln Pollution_{j,s,t-k} \tag{9}$$

$$\frac{\delta R_{jt}}{\delta \ln Pollution_{j,s,t-k}} = \beta_1 + 2\beta_2 \ln Pollution_{j,s,t-k} \tag{10}$$

Pollutants and Pollution Measure

- Ground level ozone, NO_2, PM_{10}, SO_2
- 3-year average annual pollution measure
- All pollution monitor located within 25 mile radius of the school district centroid, with at least 1 monitor within 12 mile radius.
- Weighted average of monitor readings, weighted by inverse of distance squared.

Results

- Current expenditure per pupil marginal effects:

Pollutant
Ozone
NO_2
PM_{10}
SO_2

Results

- Current expenditure per pupil marginal effects:

Pollutant	M.E.
Ozone	$49,030 - 5,810 \ln(P)$
NO_2	$12,541 - 2,207 \ln(P)$
PM_{10}	$-12,078 + 1,659 \ln(P)$
SO_2	$-4,446 + 515.2 \ln(P)$

Results

- Current expenditure per pupil marginal effects:

Pollutant	M.E.	50^{th} *Pc Value*
Ozone	$49,030 - 5,810 \ln(P)$	4.454
NO_2	$12,541 - 2,207 \ln(P)$	3.091
PM_{10}	$-12,078 + 1,659 \ln(P)$	3.332
SO_2	$-4,446 + 515.2 \ln(P)$	4.094

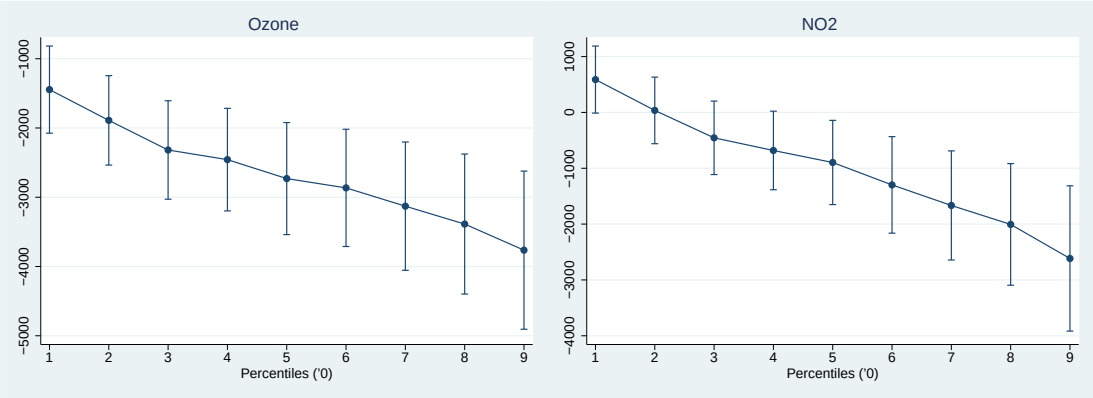
Results

- Current expenditure per pupil marginal effects:

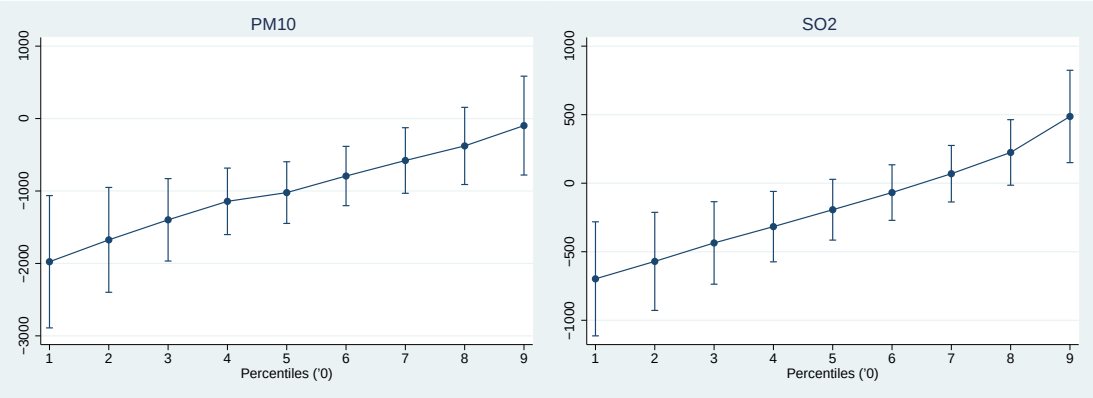
Pollutant	M.E.	50^{th} *Pc Value*	M.E. at 50^{th} *Pc*
Ozone	$49,030 - 5,810 \ln(P)$	4.454	-2,730***
NO_2	$12,541 - 2,207 \ln(P)$	3.091	-896.5**
PM_{10}	$-12,078 + 1,659 \ln(P)$	3.332	-1,022***
SO_2	$-4,446 + 515.2 \ln(P)$	4.094	-193.4*

Marginal Effects for Current Expenditure

Figure: Marginal Effects at Different Percentiles



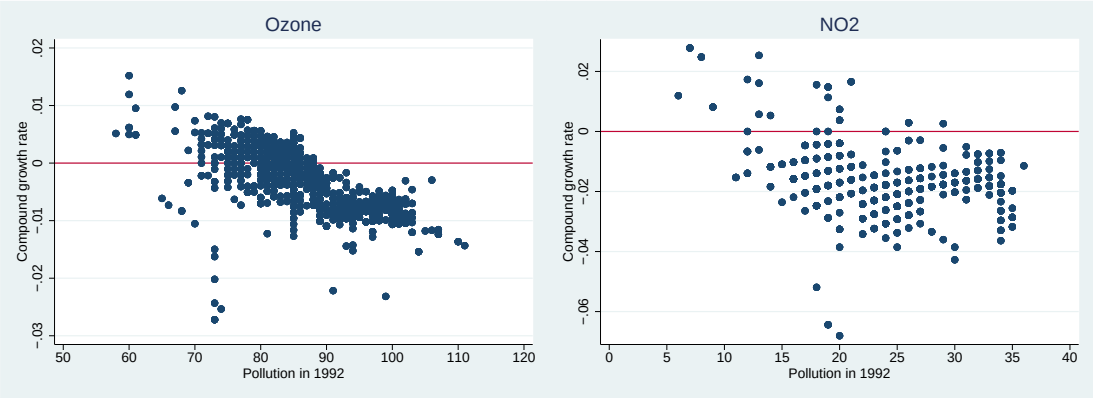
(a) Ozone (b) NO_2



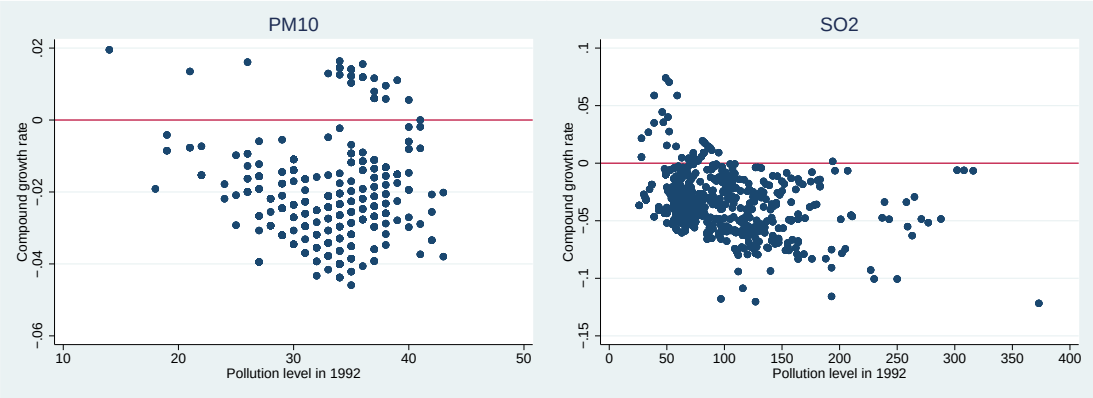
(c) PM_{10} (d) SO_2

Change in Pollution and Initial Pollution Level

Figure: Compound Growth Rate of Pollution - 1992 to 2004 and Initial Pollution



(a) Ozone (b) NO_2



(c) PM_{10} (d) SO_2

Results

- Current expenditure per pupil transmission channel:

Pollutant
Ozone
NO_2
PM_{10}
SO_2

Results

- Current expenditure per pupil transmission channel:

Pollutant	Original
Ozone	-2,730***
NO_2	-896.5**
PM_{10}	-1,022***
SO_2	-193.4*

Results

- Current expenditure per pupil transmission channel:

Pollutant	Original	State Rev Control
Ozone	-2,730***	-2,667***
NO_2	-896.5**	-958.6***
PM_{10}	-1,022***	-825.5***
SO_2	-193.4*	-121.8

Results

- Current expenditure per pupil transmission channel:

Pollutant	Original	State Rev Control	Property Tax Rev Control
Ozone	-2,730***	-2,667***	-1,712***
NO_2	-896.5**	-958.6***	186.6
PM_{10}	-1,022***	-825.5***	-664.6***
SO_2	-193.4*	-121.8	-124.8

Results

- Property tax revenue per pupil marginal effects:

Pollutant
Ozone
NO_2
PM_{10}
SO_2

Results

- Property tax revenue per pupil marginal effects:

Pollutant	M.E.
Ozone	$40,600 - 4,791 \ln(P)$
NO_2	$12,401 - 2,411 \ln(P)$
PM_{10}	$-7,870 + 1,125 \ln(P)$
SO_2	$-2,301 + 260.9 \ln(P)$

Results

- Property tax revenue per pupil marginal effects:

Pollutant	M.E.	50^{th} *Pc Value*
Ozone	$40,600 - 4,791 \ln(P)$	4.454
NO_2	$12,401 - 2,411 \ln(P)$	3.091
PM_{10}	$-7,870 + 1,125 \ln(P)$	3.332
SO_2	$-2,301 + 260.9 \ln(P)$	4.094

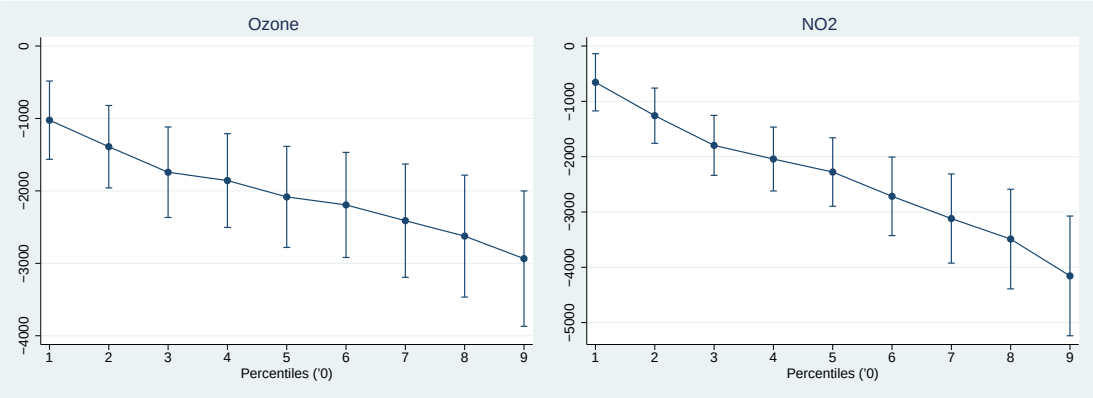
Results

- Property tax revenue per pupil marginal effects:

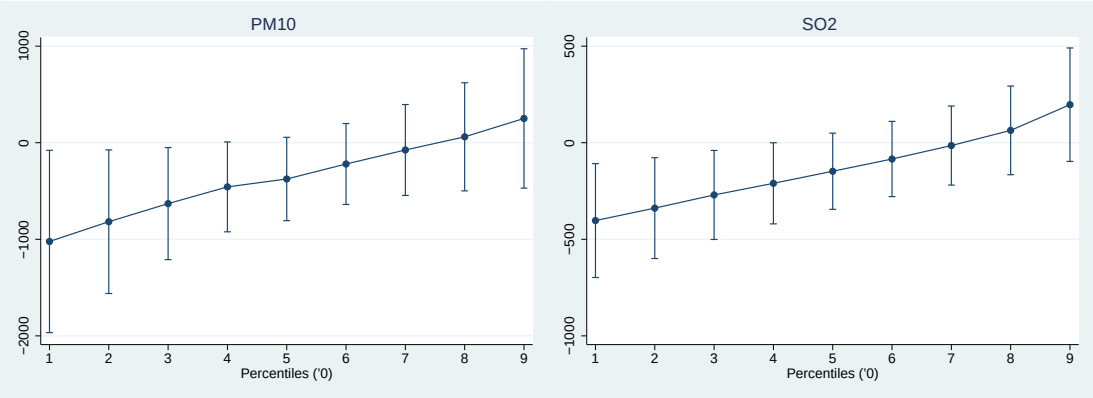
Pollutant	M.E.	50^{th} *Pc Value*	M.E. at 50^{th} *Pc*
Ozone	$40,600 - 4,791 \ln(P)$	4.454	-2,083***
NO_2	$12,401 - 2,411 \ln(P)$	3.091	-2,278***
PM_{10}	$-7,870 + 1,125 \ln(P)$	3.332	-375.6*
SO_2	$-2,301 + 260.9 \ln(P)$	4.094	-147.6

Marginal Effects for Property Tax Revenue

Figure: Marginal Effects at Different Percentiles



(a) Ozone (b) NO_2



(c) PM_{10} (d) SO_2

Robustness Check

- State-year fixed effect and state specific linear time trend.
- Regression weighted by number of students.
- Multiple pollutants.
- Different sample interval and different lag period.
- Geographic cost difference.
- CBSA relative pollution measure.

Summary

- School resources have effects on student achievements.
- Distribution of school resources in depends on property tax revenue.
- Property values affect property tax revenue collection.
- Pollution level affects property values.
- Hence, school resources are affected by pollution.
- For a median school district with around 3880 students, this accounts for around 442,000 dollars a year.