Strategic Polluter in China: Geographic Spillovers in Water Pollution

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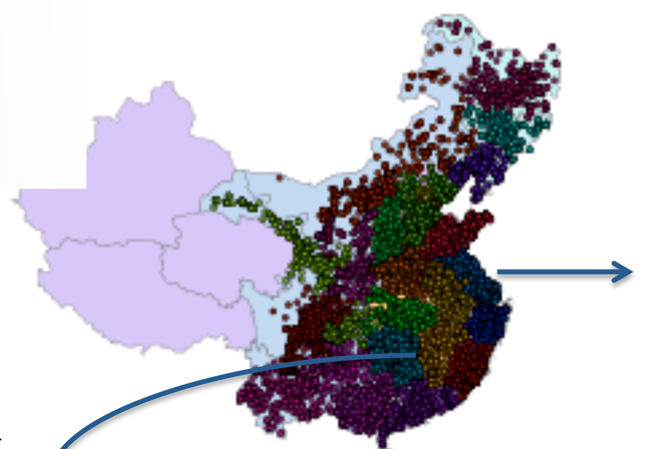
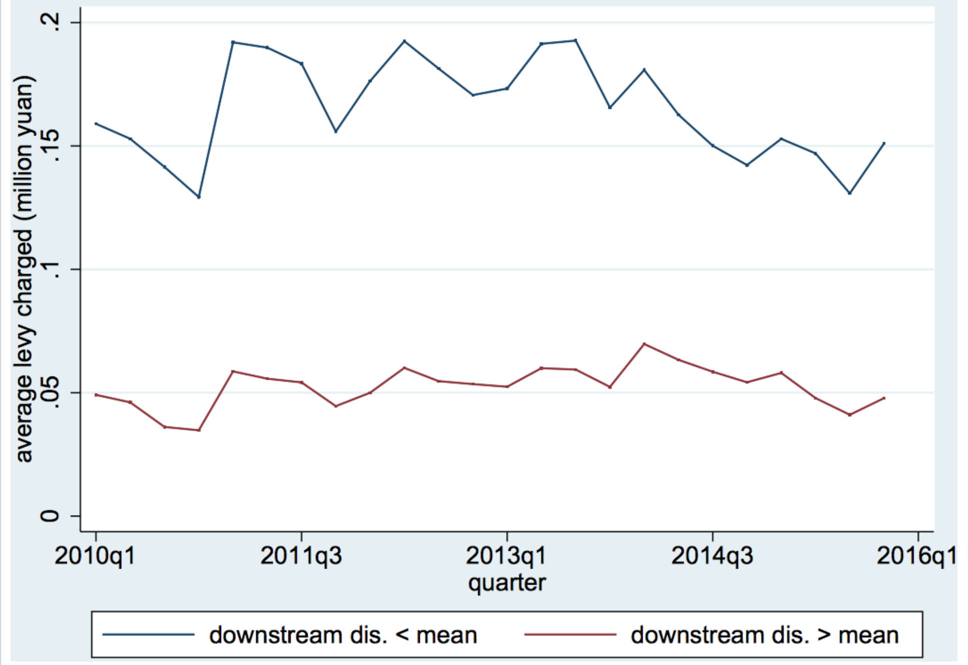


MOTIVATION & QUESTION

Motivation & Background

China's system of governance provides a good context to study the "downstream effect", i.e., pollution externality caused by political pressure as local governments tend to shift pollution burden to its downstream jurisdiction.



The central government levies taxes on emissions to fund pollution controls. It also evaluates local governments' environmental performance in addition to economic growth.

Question

Do we observe strategic pollution in China? How much pollution reduction can be achieved if inter-jurisdictional negotiation and transfers are allowed?

THEORETICAL FRAMEWORK

Sub-game Perfect Equilibrium between firms and local government

- **Firm *i* in a representative jurisdiction**:

$$\pi(y,e,a,s) = \max_{y,e,a}\{py - C(y,e;w) - (1-s)A(e,a;q) - \tau(e-a)\}$$

profit function $\pi(y, e, a, s)$ is supermodular in $(-y, -e, a, s)$

y, e: intended & unintended output
a: abated amount
p: price of y
w, q: input prices
τ: levy rate of emission

- **Local government aggregates all the firms (1,…,n) and balances between economic growth and pollution damage inside the jurisdiction**:

$$U(s_1,\ldots s_n,\theta_1,\ldots\theta_n) = \max_{s_1,\ldots s_n}\Big\{t\sum_{i=1}^{n} y_i(s_i) + \tau\sum_{i=1}^{n}(e_i(s_i) - a_i(s_i)) - \sum_{i=1}^{n} A(e_i(s_i), a_i(s_i); q) - \sum_{i=1}^{n} D(e_i(s_i) - a_i(s_i), \theta_i)\Big\}$$

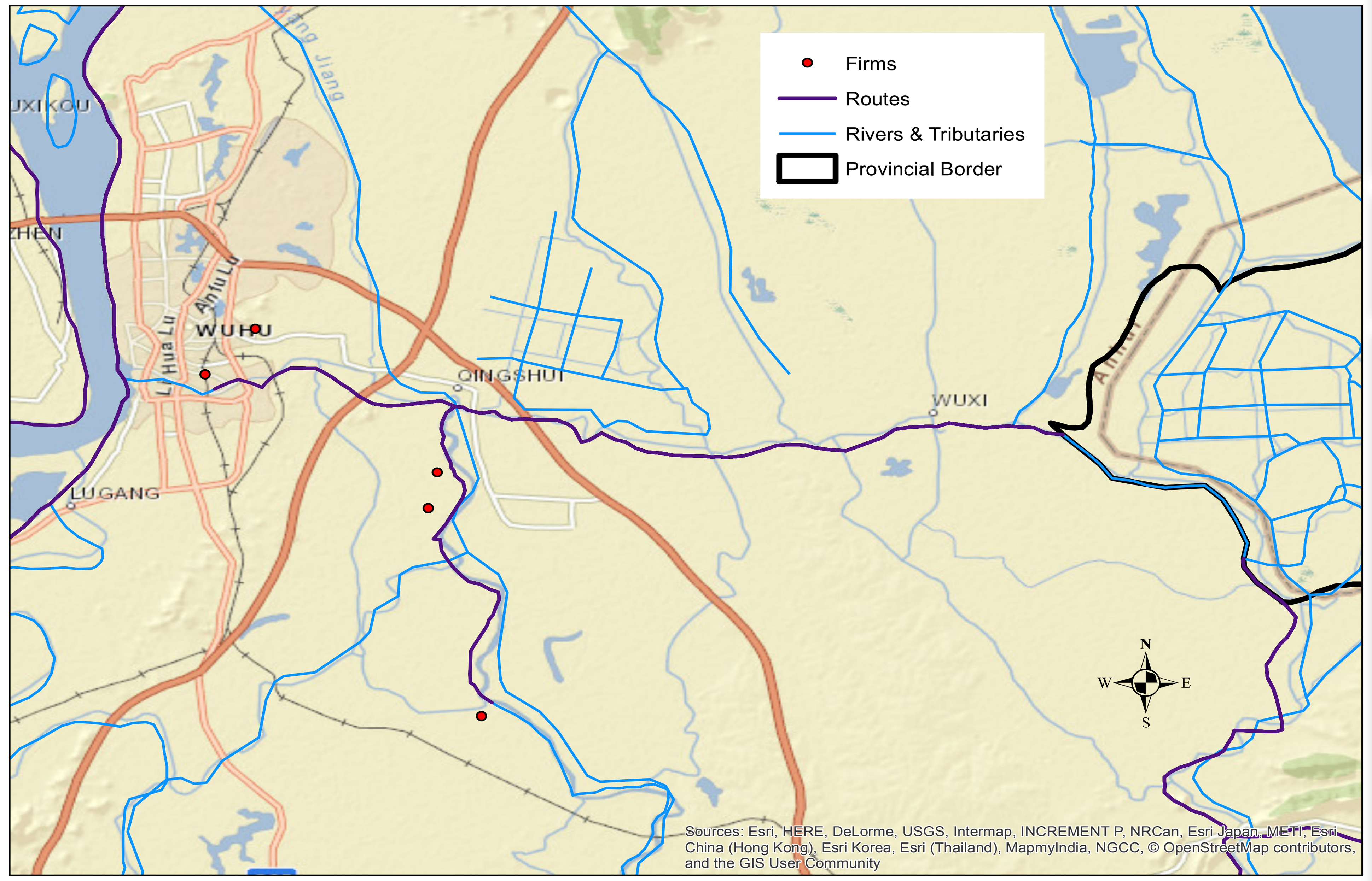
$U(s, \theta)$ is supermodular in $(s_1,\ldots s_n, \theta_1,\ldots\theta_n)$

s_i: share of abatement costs $A(e,a;q)$ subsidized by local government.
θ_i: firm i's health-risk index, i.e., the relative pollution damage based on its location in a jurisdiction.
Pollution damage $D(e\text{-}a, \theta)$ increase in θ.

- **Conclusion**: emission increases as firm's health-risk index is decreasing. A firm pollutes more if it locates at a less environmental sensitive area.

GIS EXAMPLES

- **Elevation Map**: locate downstream estuaries
- **ArcGIS Network Analyst Tool**: create *Network* & find routes



DATA & DATA SOURCES (2010-2015)

$Levy_{it}$: firm's quarterly pollution (China's Ministry of Env. Protection)

Dis_i: distances from firm to its downstream estuary, the closest main stem river, and the closest tributary (Google API and ArcGIS)

X_{it}: economic and demographic controls including firm's abatement technology adoption and abated amount (MEP), county-level sector-wise production level, governmental expenditure, public good provision, local employment and income, etc. (Statistical Yearbooks), and local weather information (NOAA)

u_i: distances from firm to the nearest main road, railroad, and main residential-commercial center (Google API and ArcGIS)

EMPIRICAL MODEL

Within-Between Random Effect Model (Mundlak (1978)) with IV

Dis_i are instrumented by u_i, because firm's relative location on a river network could be endogenous.

$$Levy_{it} = \alpha + \beta\widehat{Dis_i} + \gamma_1(X_{it} - \overline{X_i}) + \gamma_2\overline{X_i} + e_i + e_{it}$$

PRELIMINARY RESULTS

Firm's Locational Impact on Charged Pollution Levy (in CHY), China 2010-2015

distance in km to	Power	Cement	Paper	Chemical	Manufacture	Food/Bev	Clothing
downstream boundary	-122.1***	-58.38***	-102.3***	-116.9***	-108.9***	-16.25***	-67.61***
	(1.728)	(1.303)	(3.862)	(2.491)	(2.913)	(1.148)	(0.994)
closest major river	-74.73***	-190.2***	-37.34***	-148.7***	-9.738*	-4.683***	-89.79***
	(16.70)	(24.02)	(4.582)	(19.95)	(4.950)	(1.372)	(5.659)
closest tributary	-708.4***	-321.9***	-216.7***	-232.9***	-146.9***	-14.50***	-689.3***
	(26.19)	(25.64)	(31.68)	(17.22)	(12.25)	(3.138)	(24.28)
N	69236	20848	32296	45328	46476	39280	29220

Standard errors in parentheses. The first stage is significant yet not reported.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Pollution Levy Reduction with Inter-jurisdictional Negotiation (Estimated)

Sector	Power	Cement	Paper	Chemical	Manufacture	Food/Bev	Clothing
Reduction Percentage	23.113%	32.676%	21.271%	25.938%	29.381%	23.936%	13.662%
In CHYuan	9.922×10^9	7.179×10^8	2.582×10^8	1.209×10^9	4.107×10^8	2.303×10^8	9.424×10^7

CONCLUSION

- Pollution level has a significant geographic pattern.
- Local officials may strategically allocate less effort in places where environmental impacts are less likely to be internalized by their residents. (Environmental Federalism)
- Heavy polluting sectors exhibit stronger downstream effects.
- Internalize pollution externality: Total pollution will drop 14%-33% if inter-jurisdictional negotiation and transfers are allowed.