Spatial Environmental Economics

UEA Summer School

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Based on Chapter 9 of *Handbook of Regional and Urban Economics, Vol. 6, No. 1, 585-652, Elsevier, 2025*, joint work with Joseph Shapiro (UC Berkeley)

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Overview

Huge potential synergies between environmental and spatial economics

- Environmental goods and problems vary dramatically across space
- Spatial analyses focus on externalities where environmental effects key
- Geophysical forces driving environmental outcomes $\neq$ administrative boundaries
- Rapid progress in data and modeling tools, proliferation of spatial environmental policies

Motivating examples

- **Space as climate adaptation**
  - Extreme heat → reallocate across fields within a country (Costinot, Donaldson & Smith 2016)
  - Floods → people, capital, production move inland (Deryugina et al 2018; Desmet et al 2021)

- **Environment to understand amenities**
  - Environmental amenities central in spatial/urban models
  - Natural/environmental advantage large (Ellison & Glaeser 1999)
  - Persistent importance (Hornbeck 2012)
  - Air pollution, drinking/river water pollution, heat, wetlands, parks, ...

Key themes

- How do environmental goods shape spatial patterns of economic outcomes?
- How will climate change modify these impacts over the coming decades?
- How do spatial economic forces and policies affect environmental quality?
- How should we design environmental and spatial policy?

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- Complements related reviews: Cherniwchan, Copeland & Taylor (2017); Copeland, Shapiro & Taylor (2022); Dominguez-Iino (2023); Desmet & Rossi-Hansberg (2024); Lakshmanan & Bolton (1987); Gyourko, Kahn & Tracy (1999); Kahn & Walsh (2015)

Outline

1. Motivating facts on enviro-spatial links
2. Canonical environmental and spatial models
3. Building blocks in enviro-spatial analysis
4. Spatial links in environmental analysis and policy
5. Conclusions

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Motivating facts on enviro-spatial links

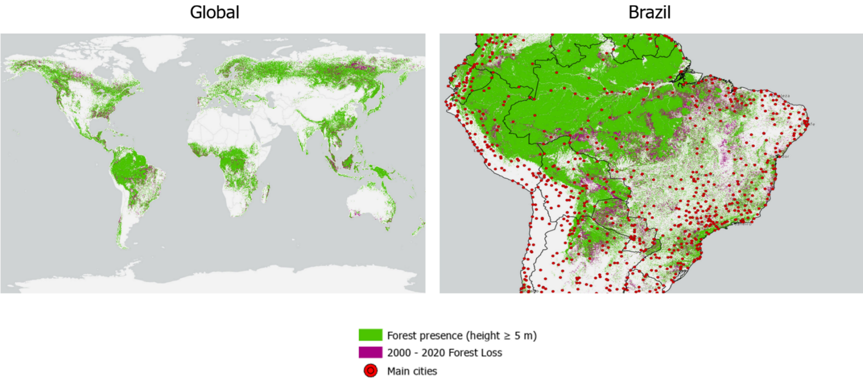
Polluting activity $\rightarrow$ environmental quality $\rightarrow$ social welfare

Motivating facts on enviro-spatial links

1. Spatial forces drive polluting activity
   a. Production and consumption emissions concentrated in different areas
   b. Variation driven by scale, composition and technique effects
   c. Natural endowments vary over space and drive environmental outcomes
2. Spatial geophysical forces drive environmental quality
3. Spatial variation in damage functions drives social welfare

#1. Spatial forces drive polluting activity

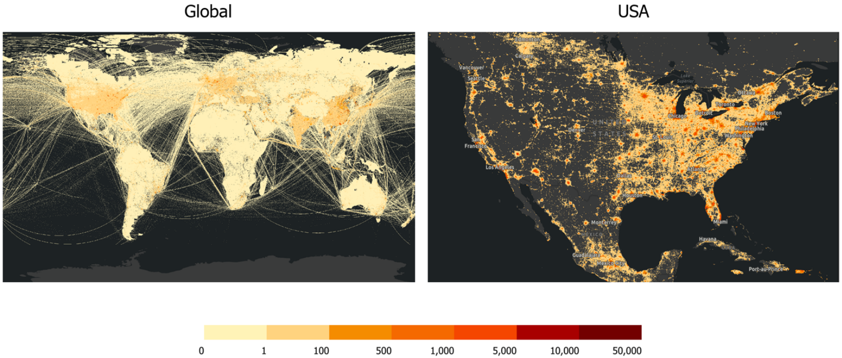
Forest extent in 2020 and Forest Loss in 2000–2020



Sources: GLAD Global Land Cover and Land Use dataset for forest extent; Global Forest Change 2000-2020 for forest loss.

#1. Spatial forces drive polluting activity

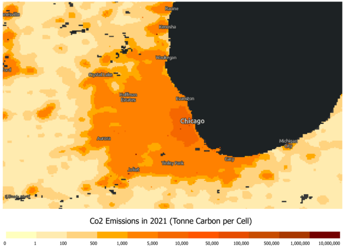
Tons of CO_2 per cell in 2021



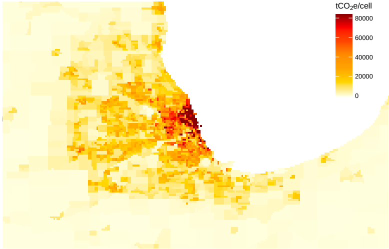
Sources: GridFed dataset for global map; ODIAC dataset for US map.

#1a Production and consumption emissions concentrated in different areas

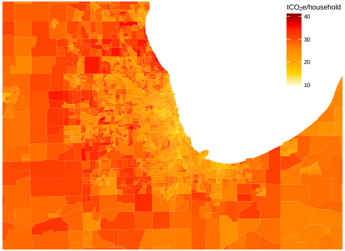
(a) CO2 emissions in 2021



(b) Total hh carbon footprint



(c) Average hh carbon footprint

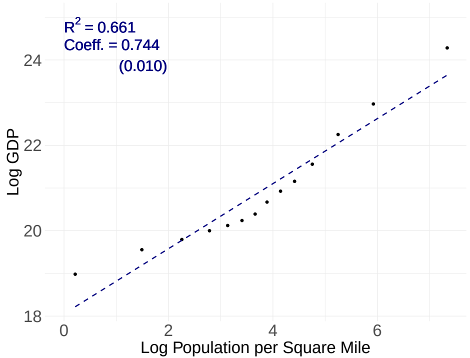


Sources: GridFed dataset for (a); Knittel (2020) and US Census Bureau 2019 American Community Survey for (b); Green & Knittel (2020) for (c).

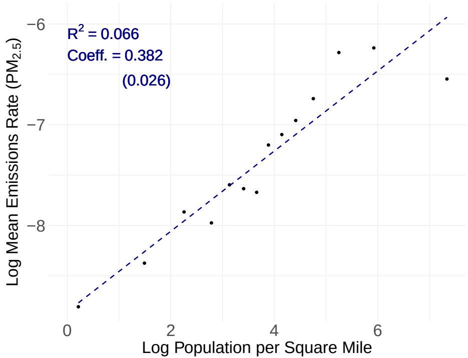
#1b Variation driven by scale, composition and technique effects

Grossman & Krueger (1993); Copeland & Taylor (1994)

(a) Scale



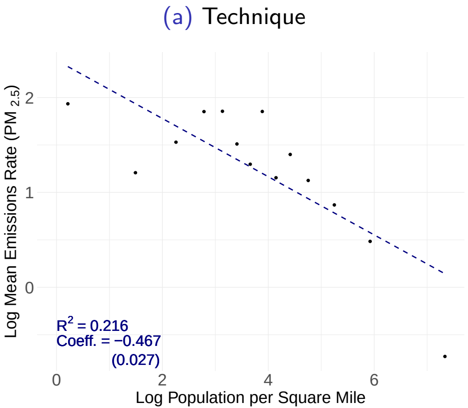
(b) Composition

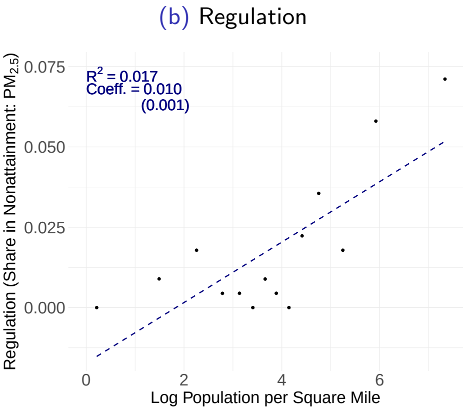


Notes: Binned scatter plots and linear trends based on 2017 US county observations.

Sources: National Cancer Institute for population; Census Bureau for land area; Bureau of Economic Analysis for GDP in (a); National Emissions Inventory for emissions in (b); County Business Patterns for employment in (b).

#1b Variation driven by scale, composition and technique effects



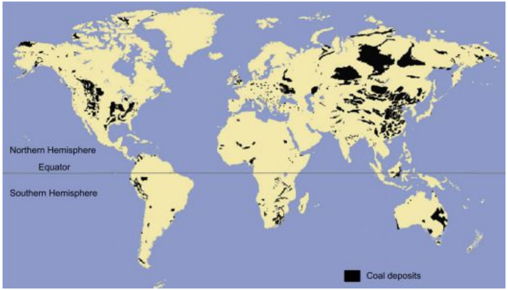


Notes: Obs. are 2017 US counties. (a) shows county FEs from regressing county × industry pollution intensity on county and industry FEs.

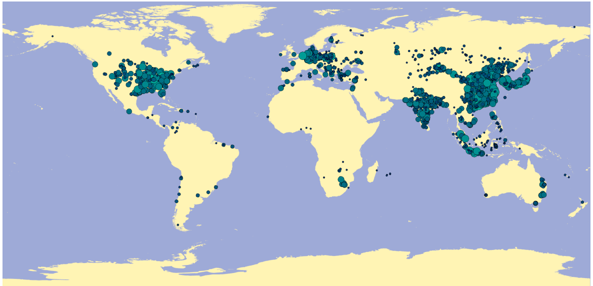
Sources: National Cancer Institute for population; Census Bureau for land area; National Emissions Inventory for emissions in (a); County Business Patterns for employment in (a).

#1c Natural endowments across space drive environmental outcomes

(a) Coal deposits



(b) Coal-fired power plants in operation in 2023



Sources: Suárez-Ruiz, Diez & Rubiera (2019) for figure (a); Global Energy Monitor Global Coal Plant Tracker for data underlying (b).

#2. Spatial geophysical forces drive environmental quality

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  - Not aligned with administrative boundaries or transport links
  - Ambient environmental problems can occur distant from pollution source
  - Non-linear functions translate pollutant emissions into air quality

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  - Non-linear functions translate pollutant emissions into air quality
- Pollution transport and dispersion models
  - Estimate radius describing typical transport distance (Currie et al 2015)
  - Econometric model relating pollutants to damaged areas (Rabotyagov et al 2014)
  - Source-receptor matrix (Muller & Mendelsohn 2009)
  - Trajectories based on meteorological/ geophysical processes (Hernandez-Cortes & Meng 2023)

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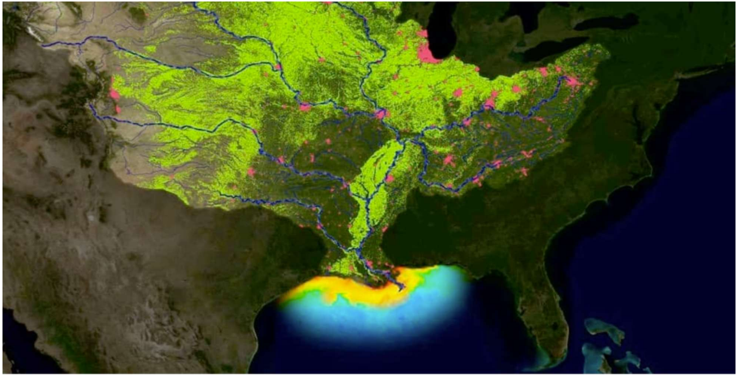

Source: NOAA (2019).

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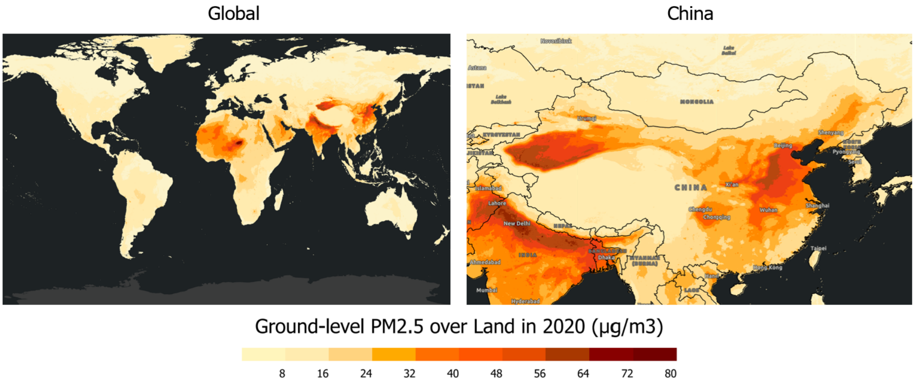

Source: GlobalHighPM2.5 dataset.

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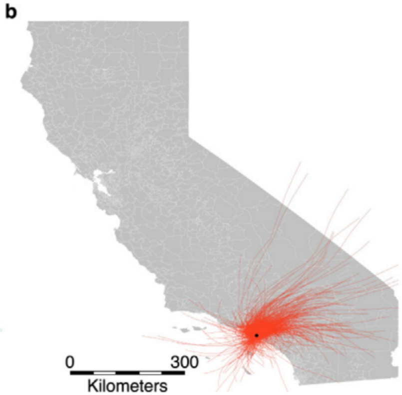

Source: Hernandez-Cortes & Meng (2023).

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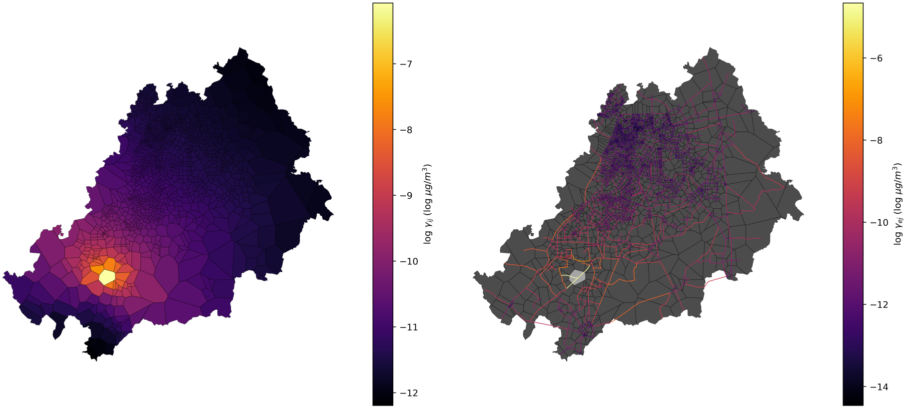
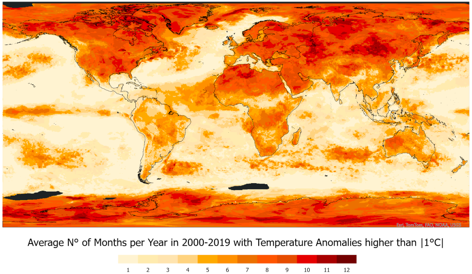


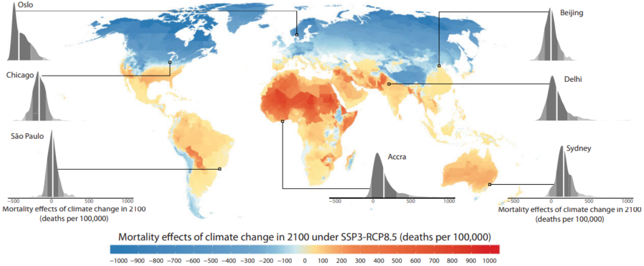
Source: Balboni et al (2026).

#3. Spatial variation in damage functions drives social welfare

(a) Temperature anomalies in 2000-2019



(b) Mortality effects of climate change in 2100



Sources: Berkeley Earth High-Resolution (Beta) dataset for (a). Carleton et al (2022) for (b).

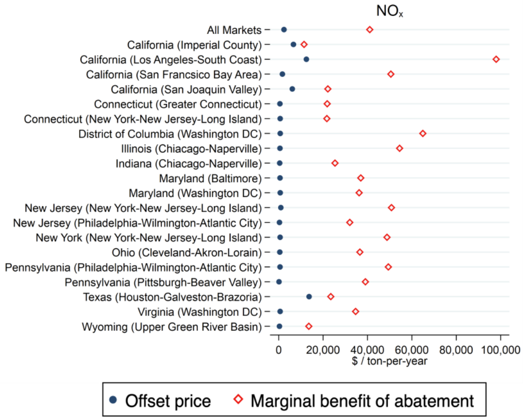
Outline

1. Motivating facts on enviro-spatial links
2. Canonical environmental and spatial models
   - Pollution models (Pigou 1932)
   - Resource extraction (Hotelling 1931)
   - Hedonic/classic spatial models (Rosen 1974; Roback 1982)
   - Quantitative spatial equilibrium
3. Building blocks in enviro-spatial analysis
4. Spatial links in environmental analysis and policy
5. Conclusions

Canonical frameworks: pollution models (Pigou 1932)

- Indirect role for economic geography, e.g. scope of market or policy
- Impact of environmental regulation on firm location choices
  - Leakage one exception

Figure 2: Offset Prices and Marginal Benefits of Abatement, Large Individual Markets



Source: Shapiro & Walker (2024).

Canonical frameworks: resource extraction (Hotelling 1931)

- Hotelling rule (non-renewable, no tech. progress, perfect competition, ...):

$$\frac{\dot{p}}{p(t)} = r$$

- Actual & optimal extraction paths depend on spatial variation in:
  - Endowments, ownership, discounting, innovation, ...
- Affects production, trade, migration
- But, typical resource paper ignores spatial links

TABLE IV

FIRST-STAGE PARAMETER ESTIMATES[a]
(A = DEMAND, B = LIFT-HEIGHT LAW OF MOTION,
C = PUMPING COSTS, D = NONPUMPING COSTS)

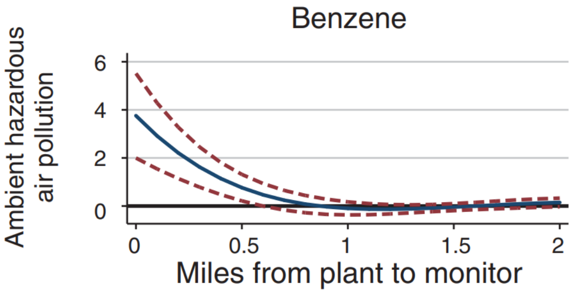
Variable		Coefficient	Standard Error
A:	Constant	7.27	0.17
	Price	7.49×10^{-3}	2.97×10^{-3}
	Virtual Income	4.03×10^{-5}	9.74×10^{-6}
	Rainfall	1.20×10^{-4}	5.37×10^{-5}
	Connections	1.70×10^{-4}	1.43×10^{-5}
B:	Lift-Height (−1)	0.97	1.32×10^{-2}
	Constant	0.80	2.55
	Extraction	6.35×10^{-4}	2.05×10^{-4}
	Artificial Recharge	4.73×10^{-4}	2.28×10^{-4}
	Rainfall (−1)	0.01	1.03×10^{-3}
	AVG	0.77	0.18
C:	Constant	−1.66	0.89
	Lift-Height	1.09	0.18
	Extraction	1.18	7.08×10^{-2}
D:	c_0	80.02	6.21
	c_{Clovis}	−15.37	11.60
	c_{Dinuba}	110.83	22.75
	c_{Exeter}	−32.24	9.06
	$c_{Firebaugh}$	24.19	13.88
	c_{Kerman}	−17.59	12.45
	c_{Madera}	−18.58	7.73
	$c_{Mendota}$	58.75	25.36
	c_{Sanger}	−14.73	10.75
	$c_{Shafter}$	−27.00	16.20

[a]Sample size = 195. GMM objective function value = 0.13 yielding a chi-squared instrument quality test statistic of 25.64 (i.e., with 15 degrees of freedom). Standard errors are heteroskedastic-consistent, and municipal heterogeneity terms are not shown.

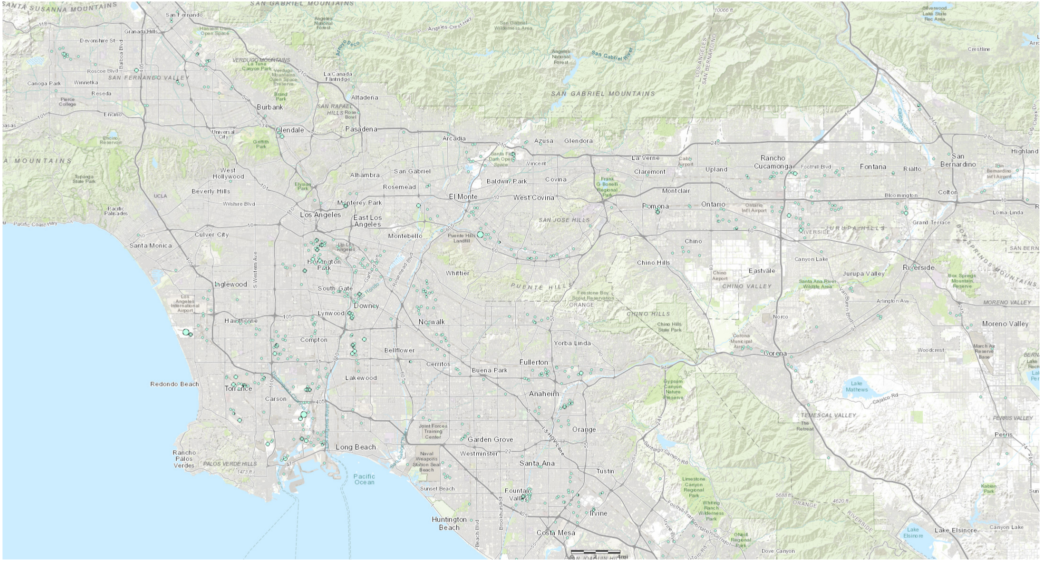
Source: Timmins (2002).

Canonical frameworks: hedonic/spatial models (Rosen 1974; Roback 1982)

- Estimate marginal willingness to pay for environmental goods, abstract from spatial links
- Leading approach in enviro econ with continuous (but limited) concept of space

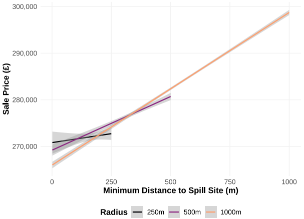


Source: Currie et al (2016).

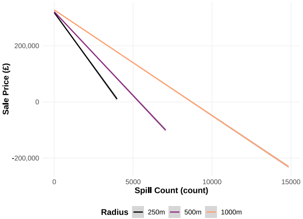


Source: USEPA Enviromapper (2024).

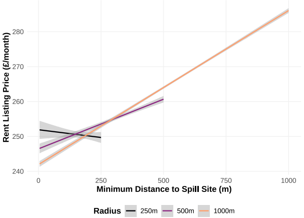
House prices, rents and sewage spills



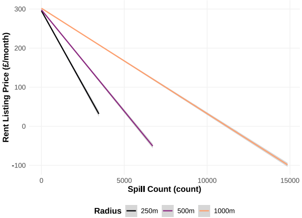
(a) Sales: Distance



(b) Sales: Spill count



(c) Rentals: Distance



(d) Rentals: Spill count

Source: Balboni & Dhingra (2026).

Equilibrium sorting models (Epple & Sieg 1999)

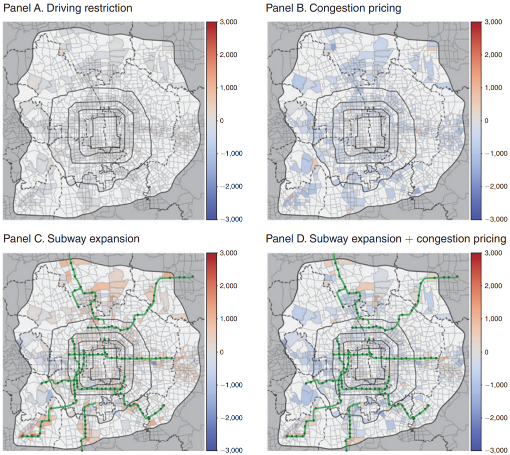


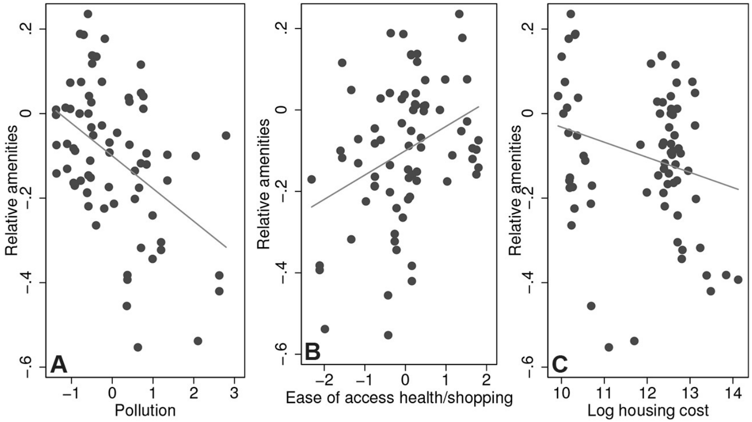
Figure 3. Changes in Commuting Distances from Sorting in Counterfactual Simulations (in Meters)

Source: Barwick et al (2024).

Quantitative spatial equilibrium models

- Infer regional amenity and productivity values, related to enviro (Bryan & Morten 2019)
- Implications of climate change
  - General equilibrium adjustments (Costinot et al 2016; Nath 2020; Conte et al 2021)
  - Long-run dynamics (Desmet et al 2021; Rudik et al 2022; Bilal & Rossi-Hansberg 2023)
  - Interaction with spatial policy and investments (Balboni 2025; Hsiao 2024)
- Water, timber resources (Carleton, Crews & Nath 2024; Farrokhi et al 2024)

Estimated vs. measured amenities (Bryan & Morten 2019)



Source: Bryan & Morten (2019).

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GE adjustments to shocks to crop yields (Costinot et al 2016)

- World GDP declines by **0.26%** with full GE adjustment
- Shutting down production adjustment $\Rightarrow$ losses triple to 0.78%
- Trade adjustment plays more minor mitigating role

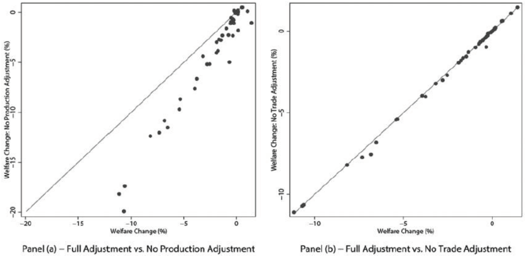

FIG. 6.—Comparison of simulated welfare changes. Panel *a* plots the real income change (as a percentage of total GDP) when allowing for full adjustment (*x*-axis) and when allowing for no change in production land shares (*y*-axis). Panel *b* does the same but when allowing for no change in trade shares (*y*-axis). In both cases, for expositional clarity, Malawi is omitted (but can be found in table 3). The 45-degree line is also shown.

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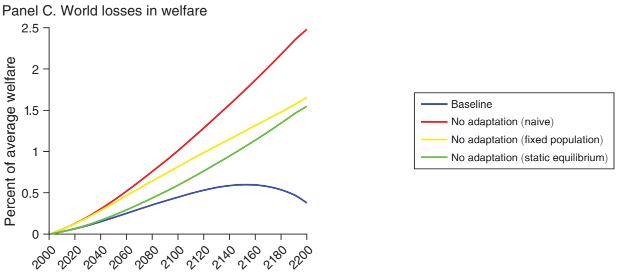
Dynamic adjustment to sea level rise (Desmet et al 2021)



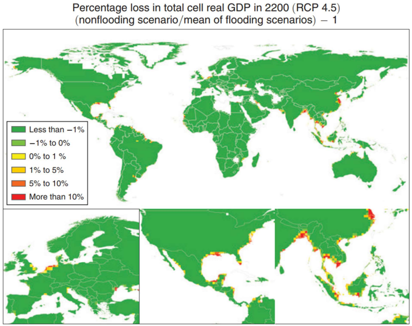


Figure 4. Percentage Mean Loss in Total Cell Real GDP in 2200 under RCP 4.5

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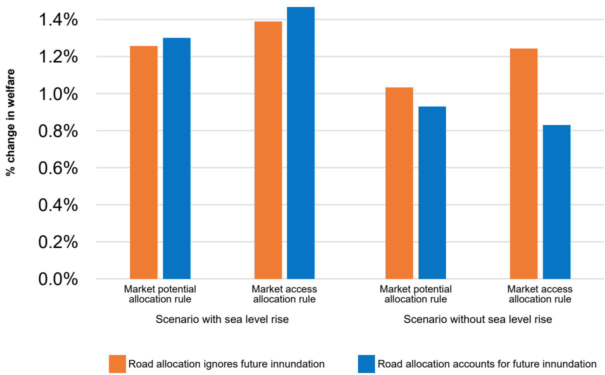
Returns to transport investments with sea level rise (Balboni 2025)

- Coastal favoritism has significant welfare costs under sea level rise
- Forward-looking allocations outperform myopic allocations under central sea level scenarios
- Ignoring future climate changes leads to erroneously conclusions about where to locate infrastructure

Welfare gains with 1m sea level rise over 100 years



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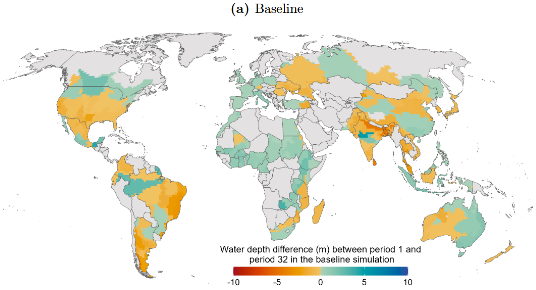
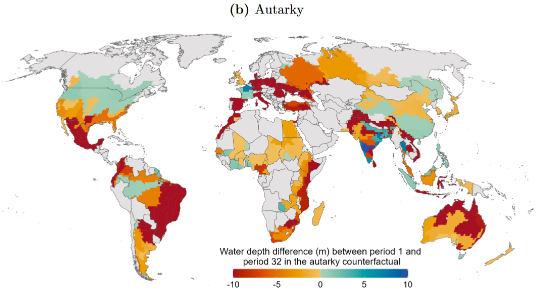
Change in water table depth (Carleton, Crews & Nath 2024)





Source: Carleton, Crews & Nath (2024).

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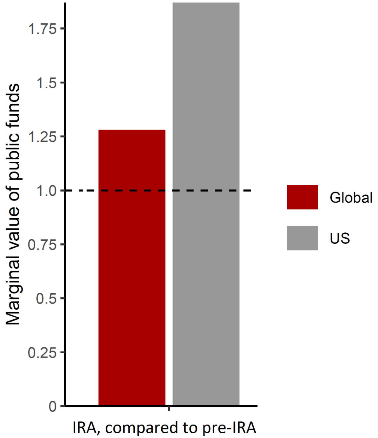
1. Motivating facts on enviro-spatial links
2. Canonical environmental and spatial models
3. Building blocks in enviro-spatial analysis
    - General choices (planner/inequality/dynamics)
    - Households
    - Firms (abatement, enviro inputs, enviro impacts)
4. Spatial links in environmental analysis and policy
5. Conclusions

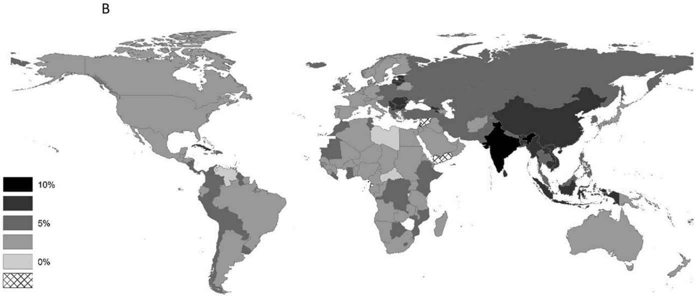
General choices: which planner?

- Local, regional, national, global?
- Planner preferences (e.g., discount rates) vary by region?



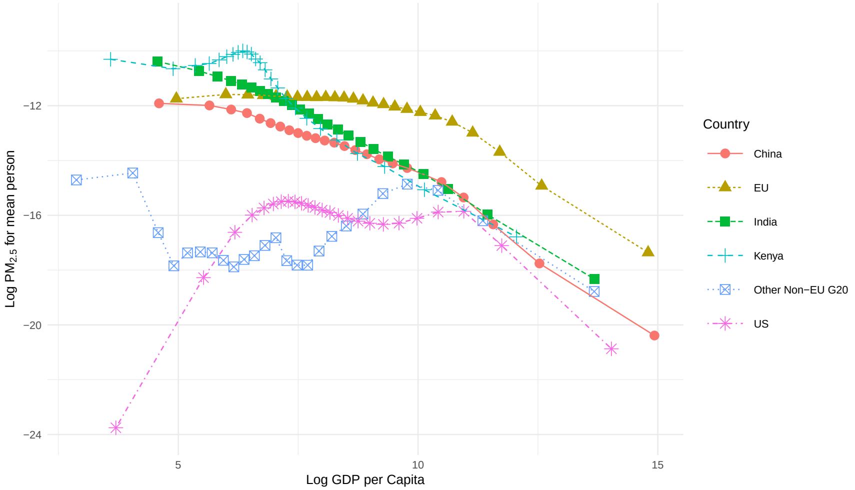
Source: Allcott et al (2024).

General choices: social discount rate



Source: Addicott et al (2020).

General choices: environmental inequality



Sources: GlobalHighPM2.5 for $PM_{2.5}$; GHS-POP (R2023) for population; Global Gridded GDP for GDP.

General choices: dynamics

- Fully dynamic (DP) v. static v. intermediate
- Ryan & Sudarshan (2022) India groundwater example. Static problem:

$$\max_{H} \sum_{i} \left[\tilde{\Pi}_i(W_i(\bar{H}, D_i)) - c_E P_i \bar{H} - \rho \frac{P_i}{D_i} \bar{H} \lambda_W \right]$$

  Dynamic problem determines λ_W:

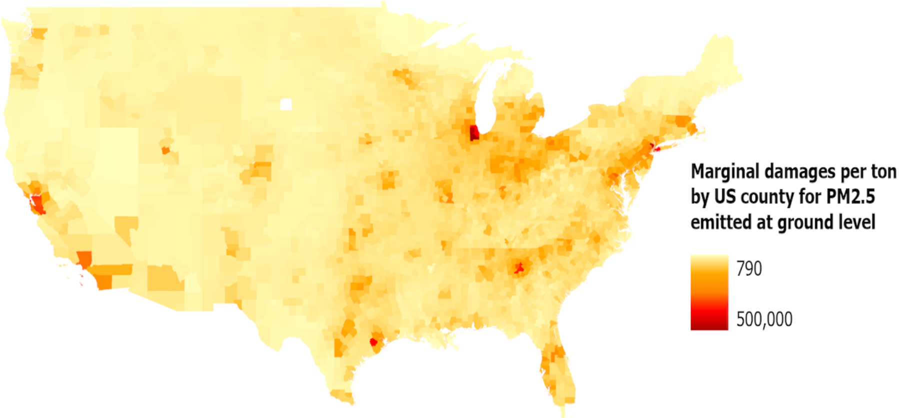
$$S(D_t) = \sum_{t=0}^{\infty} \beta^t \left[\Pi(W_t(H_t^*(D_t), D_t)) - (c_E - p_E) P H_t^*(D_t) \right]$$

Notation: Π profit, W water, i farm, $\bar{H}$ rationed hours of electricity, D groundwater depth, c_E electricity cost, P pump capacity, ρ constant, λ_W opportunity cost of water, p_E electricity price, H^* chosen hours of electricity

Households

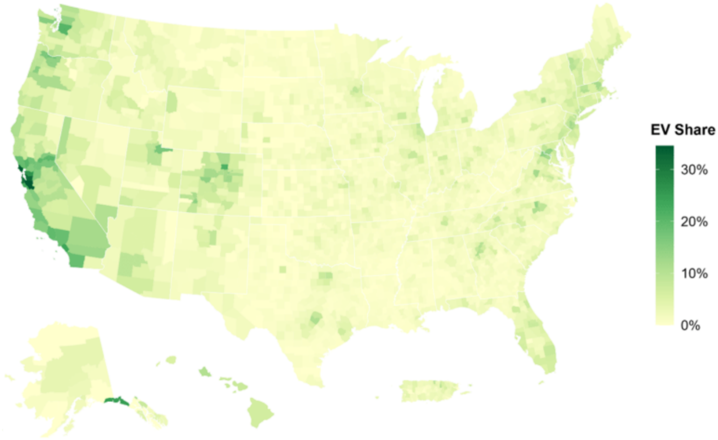
- How do marginal damages of pollution relate to utility and MWTP?
    - Impacts on productivity vs utility
    - Imperfect information about environmental amenities / impacts on wellbeing
    - Warm glow motives / signaling value of conspicuous green consumption
    - Access to defensive / avoidance / adaptive investments
- Why does demand for environmental quality and goods vary widely over space?
- What do these spatial patterns imply for optimal policy design?

Households: marginal $PM_{2.5}$ damages



Source: Holland et al (2016).

Households: electric vehicle market shares



Source: Kane (2023).

Firms

- Assumptions about emissions and abatement
- Impacts of the environment on firms
  - Environmental quality as production inputs
  - Natural disasters relocate economic activity
  - Environmental factors
- Impacts of firms on the environment
  - Returns to scale
  - Learning by doing
  - Spatial product differentiation
  - Upstreamness
  - Sunk costs

Assumptions about emissions and abatement

- Fixed emission rates (establishment i, industry s):

$$\mathcal{E}_{is} = e_s f(L_{is})$$

- Abatement approach:

$$\mathcal{E}_{is} = (1 - a_i)^{1/\beta_s} f(L_{is})$$
$$y_{is} = (1 - a_i) f(L_{is})$$
$$y_{is} = \mathcal{E}_{is}^{\beta} f(L_{is})^{1-\beta}$$

- Input markets ($\mathcal{M}$ identifies fossil fuel mining)

$$\mathcal{E}_{is} = \begin{cases} e_s f(L_{is}), & s \in \mathcal{M} \\ 0, & s \notin \mathcal{M} \end{cases}$$

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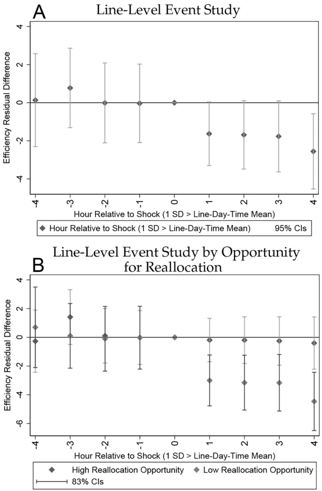
Environmental quality as production inputs

- Environmental quality affects firm productivity:
  - Air pollution and heat ⇒ ↓ labor productivity (Adhvaryu et al 2022; Chang et al 2016; Somanathan et al 2021)
  - Ground-level ozone ⇒ ↓ agri yield (Boone et al 2019)
  - Acid rain and natural disasters depreciate capital stocks (Bilal & Rossi-Hansberg 2023; Restout et al 2024)



Source: Adhvaryu et al (2022).

Environmental quality as production inputs

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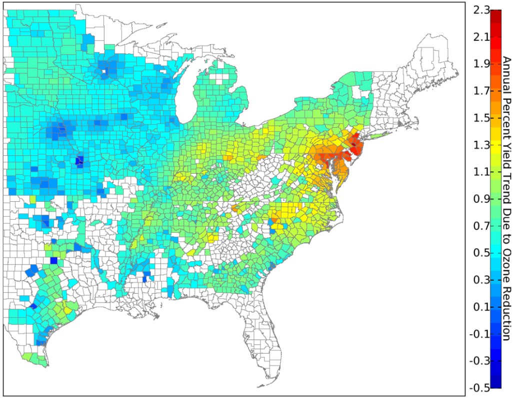
  - Air pollution and heat ⇒ ↓ labor productivity (Adhvaryu et al 2022; Chang et al 2016; Somanathan et al 2021)
  - Ground-level ozone ⇒ ↓ agri yield (Boone et al 2019)
  - Acid rain and natural disasters depreciate capital stocks (Bilal & Rossi-Hansberg 2023; Restout et al 2024)
- Spatial heterogeneity in environmental quality ⇒ spatial variation in productivity

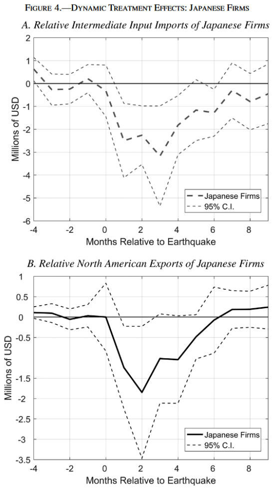
Figure 14: Yield Trend Due to Trends in Peak Ozone Levels



Source: Boone et al (2019).

Natural disasters relocate economic activity

- Floods, hurricanes, wildfires etc $\Rightarrow \downarrow$ output and productivity of affected firms
- Effects propagate upstream and downstream along supply chains (Barrot & Sauvagnat 2016; Boehm et al 2019; Carvalho et al 2021)

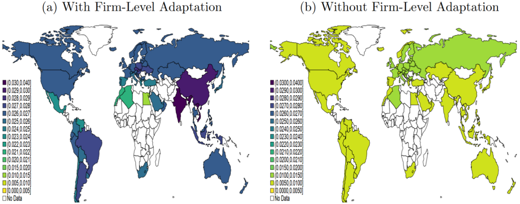


Source: Boehm et al (2019).

Natural disasters relocate economic activity

- Floods, hurricanes, wildfires etc $\Rightarrow \downarrow$ output and productivity of affected firms
- Effects propagate upstream and downstream along supply chains (Barrot & Sauvagnat 2016; Boehm et al 2019; Carvalho et al 2021)
- Firms adapt to disaster risk:
  - Across plant networks (Castro-Vincenzi 2024)
  - Through supplier networks (Balboni et al 2024; Pankratz & Schiller 2024)

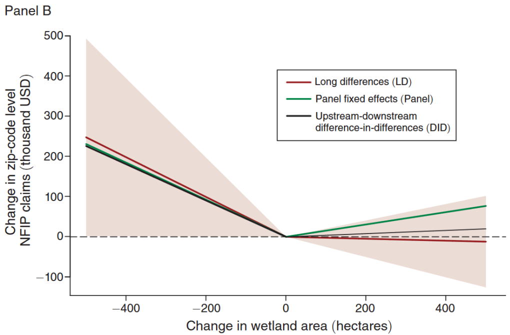
Figure 11: Log Change in the Price Index for SSP5-8.5



Source: Castro-Vincenzi (2024).

Environmental factors

- **Land**
  - Land quality shapes agricultural productivity (Costinot et al 2016)
  - Wetland conversion increases downstream flood damage (Taylor & Druckenmiller 2022)

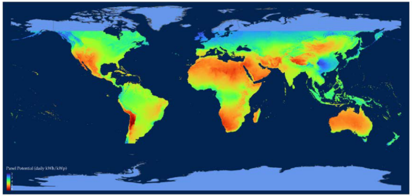


Source: Taylor & Druckenmiller (2022)

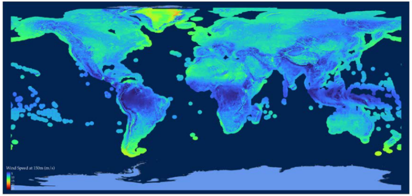
Environmental factors

- **Land**
  - Land quality shapes agricultural productivity (Costinot et al 2016)
  - Wetland conversion increases downstream flood damage (Taylor & Druckenmiller 2022)
- **Energy resources**
  - Fossil fuel extraction underpins regional economies; decarbonisation costs vary by fuel and location (Cruz & Rossi-Hansberg 2024; Welsby et al 2021)
  - Renewable endowments (solar, wind) also vary across space (Arkolakis & Walsh 2023)

(a) Solar Potential



(b) Wind Potential



Source: Arkolakis & Walsh (2023)

Firms

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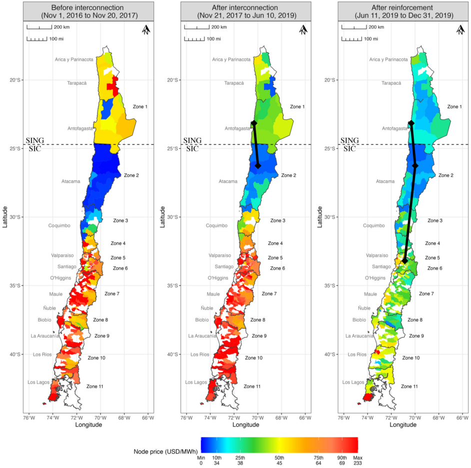
  - Sunk costs

Returns to scale

- Classic proximity-concentration tradeoff (Brainard 1997): few large plants (exploit scale) vs. many smaller plants (closer to customers)
- Environmental considerations add new dimensions:
  - Locating near population centers raises marginal damages and may trigger stricter regulation
- **Cement**: second-largest industrial GHG source, high returns to scale (Ganapati et al 2020)
- **Wind**: turbine output increases quadratically with size, size of wind power plant matters for local pollution and land use (Covert & Sweeney 2024)

Learning by doing

- Dynamic returns to scale affect productivity and location choice in energy industries
- Produces spatially divergent energy investments, driven by natural resources and infrastructure access (Arkolakis & Walsh 2023; Davis et al 2023; Gonzales et al 2023)
- Place-based policies shape location of clean energy production (Banares-Sanchez et al 2023)



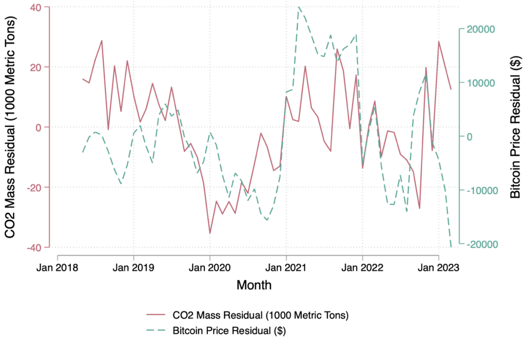
Source: Gonzales et al (2023).

Spatial product differentiation

- Dirty goods (cement, steel, coal) disproportionately homogeneous
- *Spatial* differentiation matters more for polluting industries
  - High weight-to-value ratios $\Rightarrow$ high transport costs $\Rightarrow$ local markets
  - High elasticities of substitution (Shapiro 2023)
- Complex interactions between spatial markets for dirty goods and transportation markets
  - Railroads captured surplus from low-sulfur coal demand (Busse & Keohane 2007)
  - Pipeline-to-rail crude oil shift changes externalities and economics (Covert & Kellogg 2023)

Upstreamness

- Dirty goods are disproportionately upstream, supplying firms rather than final demand (Copeland et al 2022; Shapiro 2021)
- Trade costs incentivize downstream firms to locate near upstream suppliers
- Cryptocurrency mining: limited direct pollution but large upstream electricity demand (Papp et al 2023)



Source: Papp et al (2023).

Sunk costs

- Sunk costs shape spatial patterns of capital-intensive polluting industries: power plants, oil refineries, airports, roads
- Rust belt partly reflects sunk, difficult to re-purpose dirty capital in industrial regions, some renewable plants use transmission infrastructure on decommissioned fossil sites

Steel Stacks, Bethlehem PA: decommissioned factory repurposed as entertainment venue

Outline

Agglomeration forces

- Benefits of agglomeration for environmental outcomes
  - Returns to scale in pollution control technology (Keiser et al 2024)
  - Lower emissions from transport / housing (Duranton & Turner 2018; Glaeser & Kahn 2010)
  - High fixed costs of adaptation infrastructure
  - Reduced urban sprawl preserves ecosystem services (Koster 2024)

Gasoline consumption vs. population

Source: Glaeser and Kahn (2010).

Agglomeration forces

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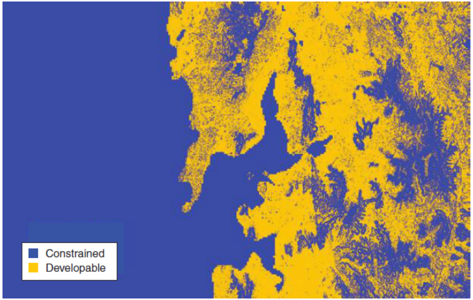
  - Lower emissions from transport / housing (Duranton & Turner 2018; Glaeser & Kahn 2010)
  - High fixed costs of adaptation infrastructure
  - Reduced urban sprawl preserves ecosystem services (Koster 2024)
- Risks of agglomeration for environmental outcomes
  - Higher marginal damage of local pollutants
  - Increased vulnerability to fires, floods, natural disasters, insurance costs (Baylis & Boomhower 2021; Keys & Mulder 2024; Boomhower et al 2024)
- Environmental goods and resources drive agglomeration (Ellison & Glaeser 1999)
  - Limited work on interactions of environment with labor market pooling, flow of ideas

Dispersion forces

Environmental forces can also drive dispersion:

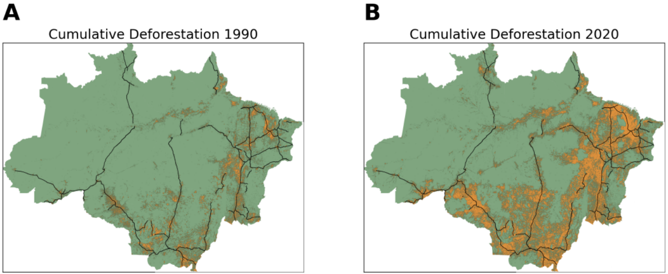
- Negative externalities from production, transport, sewage (Cutler & Miller 2005)
- Challenge of providing high-quality municipal environmental services in dense city centers
- Local supply constraints (Saiz 2010; Harari 2020)



Constrained land in the Mumbai area
Source: Harari (2020).

Spatial links affect generation of environmental externalities

- Transport generates emissions and facilitates resource extraction (Araujo et al 2023)

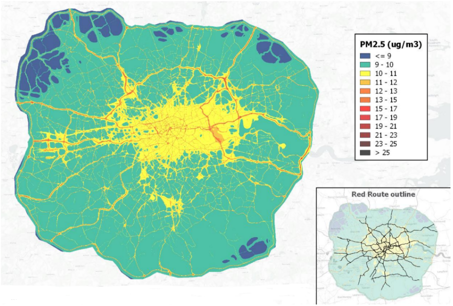


Roads and deforestation

Source: Araujo et al (2023).

Spatial links affect generation of environmental externalities

- Transport generates emissions and facilitates resource extraction (Araujo et al 2023)
- Commuting generates noise and pollution (Anderson 2020) ...

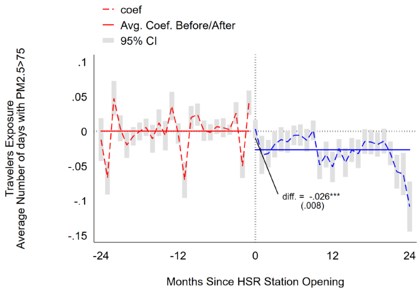


Mean $PM_{2.5}$ concentrations in London in 2019

Source: Camargo & Lord (2021).

Spatial links affect generation of environmental externalities

- Transport generates emissions and facilitates resource extraction (Araujo et al 2023)
- Commuting generates noise and pollution (Anderson 2020) ...
- ... but separates residential from polluting industrial areas (Barwick et al 2024)



Effect of HSR on intensive margin $PM_{2.5}$ exposure

Source: Barwick et al (2024).

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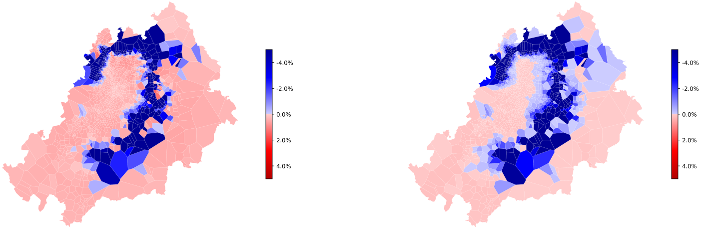
- Accounting for externalities alters evaluation of spatial investments (Balboni et al 2026)



(a) Overall changes (b) Excluding pollution

Source: Balboni et al (2026)

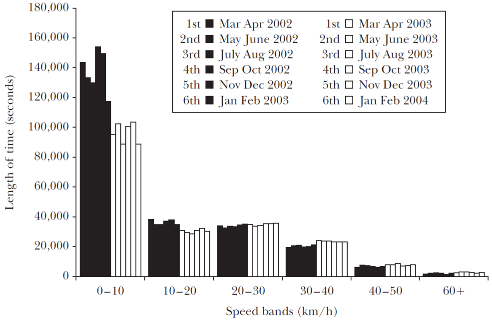
Spatial links affect generation of environmental externalities

- Transport generates emissions and facilitates resource extraction (Araujo et al 2023)
- Commuting generates noise and pollution (Anderson 2020) ...
- ... but separates residential from polluting industrial areas (Barwick et al 2024)
- Accounting for externalities alters evaluation of spatial investments (Balboni et al 2026)
- Flow of ideas may also affect environmental externalities
  - Local innovation affects pollution, global warming (Desmet & Rossi-Hansberg 2014; 2015)
  - Spread of green technologies (Arkolakis & Walsh 2023; Banares-Sanchez et al 2023)

Environmental goods and policies affect spatial links

- Environmental regulation of transportation sector
  - Exhaust, energy efficiency, electrification, etc standards (Jacobsen et al 2023)
  - Spatially-targeted congestion charges (Leape 2006; Almagro et al 2024)

Time spent at different speeds before vs. after London congestion charge



Notes: Sample only includes charging zone during charging hours.

Source: Leape (2006).

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- Natural disasters drive migration
  - Within-country (Hornbeck 2023; Groger & Zylberberg 2016; Mueller et al 2014)
  - Across countries (Missirian & Schlenker 2017; Jessoe et al 2018)
  - Shift firms' supply chain decisions (Balboni et al 2026)

	Δ Supplier Flood Risk (cm)		
	(1)	(2)	(3)
Own max flood extent	-0.0489	-0.0830	-0.0681
	(0.0958)	(0.0915)	(0.113)
Suppliers' max flood extent	-0.627***	-0.646***	-0.742***
	(0.157)	(0.161)	(0.178)
Average effect of mean flooded supplier buffer	-0.009	-0.010	-0.011
Average effect of 10% flooded supplier buffer	-0.063	-0.065	-0.074
Time × District FE	Yes		
Time × District × Risk decile FE		Yes	
Time × District × Industry FE			Yes
R^2	0.0116	0.0319	0.0611
N	144,566	143,857	139,302

Source: Balboni et al (2026)

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    - Across countries (Missirian & Schlenker 2017; Jessoe et al 2018)
    - Shift firms' supply chain decisions (Balboni et al 2026)
- Future climate change drives adaptive adjustments
    - Affects spatial transmission of climate change (Bilal & Rossi-Hansberg 2023)
    - Migration frictions key in estimating climate damages (Desmet et al 2021)

Enviro-spatial considerations key for policy design

- Place-based environmental policy
- Environmental federalism
- Leakage
- Land use
- Insurance

Place-based environmental policy

- Many environmental policies regulate specific polluted locations
  - Impact of Clean Air Act Amendments on industrial location, employment, capital, output, productivity, wages, ... (Henderson 1996; Walker 2011; Greenstone et al 2012)
  - China pollution monitoring program (Xie & Yuan 2023)
  - Market-based instruments (Newell & Rogers 2003; Greenstone et al 2023)

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- Fewer policies reflect inter-jurisdictional spillovers

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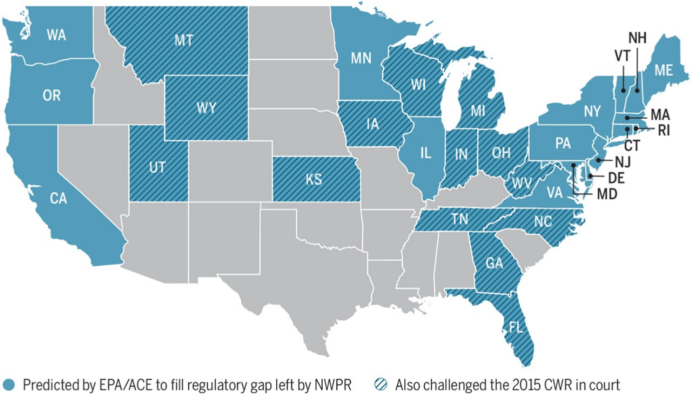
  - China pollution monitoring program (Xie & Yuan 2023)
  - Market-based instruments (Newell & Rogers 2003; Greenstone et al 2023)
- Fewer policies reflect inter-jurisdictional spillovers
- Open topic: optimal spatial variation in enviro policy stringency to reflect environmental, agglomeration, congestion externalities (Parry & Small 2005; Fajgelbaum & Gaubert 2006)

Environmental federalism

- Fiscal federalism: **optimal regulator** depends on externality structure
  - Actual regulator may not match
- **Cooperative solutions**: Chesapeake Bay agreement spans 7 US jurisdictions, combining federal funding with regional implementation to address nutrient inflows (Carey 2021)
- **US wetland regulation**: scope repeatedly changed by Supreme Court and administrations (by up to half of regulated areas); state and local laws vary further
  - May reflect Tiebout sorting, but also generates **inter-jurisdictional externalities** and raises compliance costs (Aronoff & Rafey 2023; Greenhill et al 2024; Keiser et al 2021)

Environmental federalism

States assumed to protect newly-deregulated wetlands



Source: Keiser et al (2021).

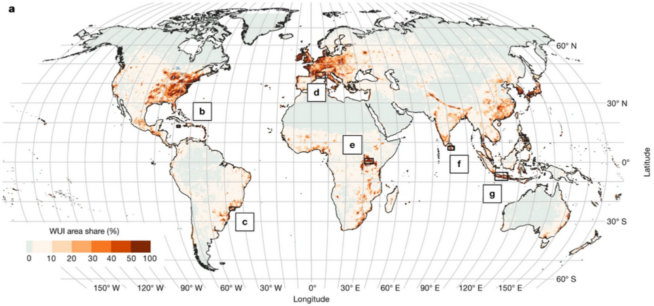
Leakage

- Environmental regulation can cause leakage of dirty activities away from regulated regions
- Carbon leakage
  - Offshoring emissions-intensive production (Goulder et al 2012; Kortum & Weisbach 2021)
  - Advancing policy debates, e.g. EU Carbon Border Adjustment Mechanism (Fowlie et al 2021)
- Natural resource exploitation, e.g. PES (Jayachandran et al 2017)
- Adaptive infrastructure shifts natural disaster risk elsewhere (Wang 2021)

Land use restrictions

- **Zoning, development, land use restrictions**
  - Affected by and affect the environment
  - Affect spatial patterns of density, pollution, development in wildland-urban interface (Schug et al 2023; Ostriker & Russo 2024)

Area share of the wildland-urban interface



Source: Schug et al (2023).

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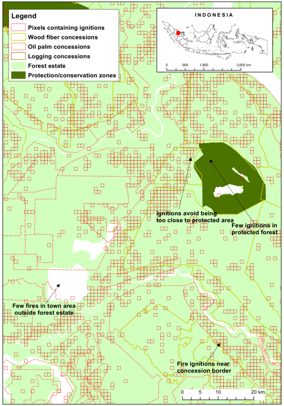
  - Affected by and affect the environment
  - Affect spatial patterns of density, pollution, development in wildland-urban interface (Schug et al 2023; Ostriker & Russo 2024)
  - Concession rights in tropical forest areas affect fire-setting, forest loss (Balboni et al 2023)

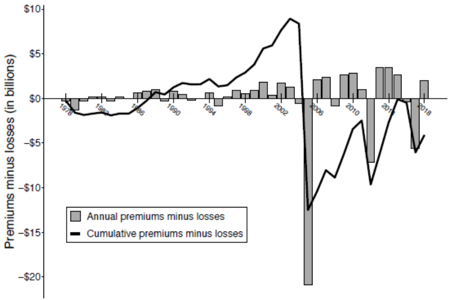


Source: Balboni et al (2025).

Insurance

- **Spatial moral hazard**
  - Development in flood-prone areas (Fried 2022; Marcoux & Wagner 2023)
  - “Last resort” state insurance policies
  - Dropping customers (Boomhower et al 2024)

Premiums and Losses of the National Flood Insurance Program



Source: Marcoux & Wagner (2023).

Potential topics for future research

- **Implications of different spatial scales**
  - Political economy of environmental policy evaluation from local / global perspective
  - When should analysis use global vs national social cost of carbon?
  - Leakage across and within countries, and associated policies (e.g. CBAM)
  - Coase Theorem and spatial analysis (e.g. bargaining partners downstream / downhill)

Potential topics for future research

- **Micro-foundations of cross-regional environmental differences**
  - Why does demand for environmental quality vary widely across space?
  - How do marginal pollution damages relate to utility and MWTP?
  - What does this imply for optimal policy?
  - Within-country decomposition of environmental change into scale, composition, technique

Potential topics for future research

- **Spatial natural resources**
  - Extend spatial insights to dynamic natural resource problems
  - More limited research vs static environmental goods (e.g. pollution) in spatial settings
  - Middle ground combining static models with parameters from dynamic analysis (e.g. SCC)
  - How do optimal extraction paths depend on spatial links and fundamentals?
  - Tragedy of the Commons

Potential topics for future research

- **Dynamic adaptation to climate change**
  - Combine developments in dynamic spatial modeling with evidence on climate impacts
  - Spatial variation in inter- and intra-national migration frictions
  - Adaptation via relocation of production

Potential topics for future research

- **Methods and settings**
  - Closer ties between remote sensing data, machine learning algorithms and spatial models
  - Closer connections between QSE models and environmental goods and policies
    - Spatial equilibrium models help interpret impacts of environmental goods and policies
    - Variation in environmental goods and policies help validate / interpret spatial models
  - Regions besides US and China, goods besides PM and climate change

Outline

Conclusions

- Enormous complementarities between spatial and environmental economics
- Several promising avenues for future research
- Salient for prominent policy debates
    - Justice40, Not In My Back Yard, Day Zero, $40 billion Jakarta sea wall, ...