Spatial Environmental Economics
Lecture 1: Introduction

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Roadmap

1. What is spatial economics? And environmental economics? Why together?

2. Motivating facts on enviro-spatial links
   - Spatial forces drive polluting activity
   - Spatial geophysical forces drive environmental quality
   - Spatial variation in damage functions drives social welfare

3. Spatial links in environmental analysis and policy
   - Agglomeration forces
   - Dispersion forces
   - Geography and links between regions
   - Environmental spatial policy and the role of geography

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What is spatial economics?

- Broadly: aims to explain the causes and consequences of economic activity being concentrated across space
  - "Despite spectacular drops in communication and transport costs, distance and location have not disappeared from economic life." (Proost and Thisse, 2019)
- Constituent (?) subfields:
  - Urban economics
  - Regional economics
  - Transportation economics
- Relation to Trade?
  - Trade studies locations' comparative advantage and production patterns
  - Trade typically holds factor endowments fixed, while Spatial emphasizes labor mobility

Why do we care about spatial economics?

1. Economic outcomes exhibit spatial **variation**: wages, employment, output
2. Many economic **mechanisms** have a spatial nature or depend on distance
   - Housing is large part of household consumption basket, school choice
   - Labor demand & supply: migration, commuting
   - Knowledge/productivity/amenity spillovers
   - Impact of transportation infrastructure
3. Many **policies** are spatially concentrated
   - Opportunity Zones, discretionary tax breaks, Low Emission Zones (LEZs)
   - Infrastructure investment
4. Political representation is spatial

What is environmental economics?

- The study of the efficient allocation, use, and protection of the world's limited natural resources
- Analysis of problems and policies arising from the fact that ... (Tol, 2022)
  - natural resources are scarce
  - environmental externalities are substantial
  - environmental services are valuable

Environmental externalities and services

- An **externality** is the unintended and uncompensated effect of one economic agent on a third party. E.g.:
  - Intent: hold bees to make honey
  - Unintended: pollinate flowers
  - Compensation: pollination is not compensated
  - Third party: the beneficiaries of pollination do not engage in a transaction with the pollinator
  - If pollination is remunerated, externality is less pronounced; or may disappear if price is right
- Environmental **services**:
  - Direct use value: oxygen, water for consumption or production; recreation, tourism, amenity
  - Indirect use values: regulating services such as pollination of crops by wild insects
  - Option values: known (or unknown) future uses; e.g. expanding ecotourism, new medicines

Why study environmental and spatial economics jointly?

- The rest of this **lecture** outlines an answer to this question:
  - Examples of spatial settings where the environment matters, and vice versa
  - Discussion of spatial links and policy
- The rest of the **course** delves deeper into some of these topics, taking the opportunity to:
  - Teach you some of the key models in spatial and urban economics
  - Cover some of the key ideas and issues in environmental economics
  - Review applications of these frameworks in spatial-enviro settings

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Motivating facts on enviro-spatial links

Useful distinction between **polluting activity**, **environmental quality**, and **social welfare**:

Polluting activity	$\rightarrow$	**Environmental quality**	$\rightarrow$	**Social welfare**
Manufacturer emits particulate matter (PM)		PM concentration increases nearby		Risk of asthma increases for nearby residents

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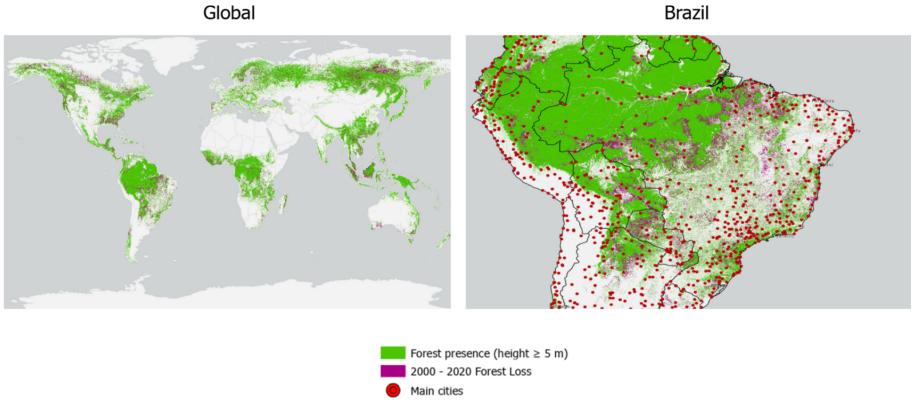
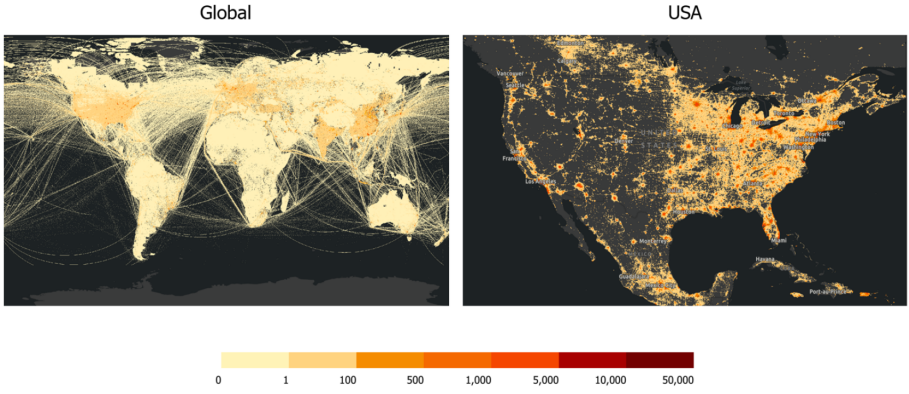
Spatial variation in forest cover and deforestation



Source: Balboni and Shapiro (2025)

- Earth's forests are concentrated in a boreal band and a tropical band
- Deforestation in Brazil at the interface of non-forested areas, especially near cities

Spatial variation in CO_2 emissions

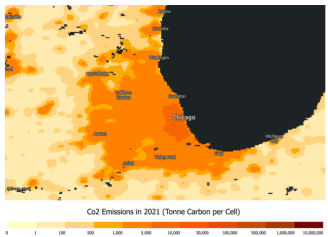


Source: Balboni and Shapiro (2025)

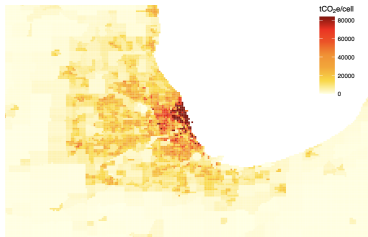
- Higher emissions in regions with greater population density and higher income
- Emission footprints also along major trade routes, such as between US, EU, and China

Spatial variation in CO_2 emissions: production vs. consumption

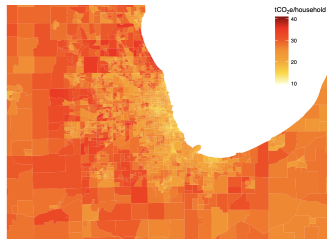
(a) CO_2 emissions in 2021



(b) Total HH carbon footprint



(c) Mean HH carbon footprint



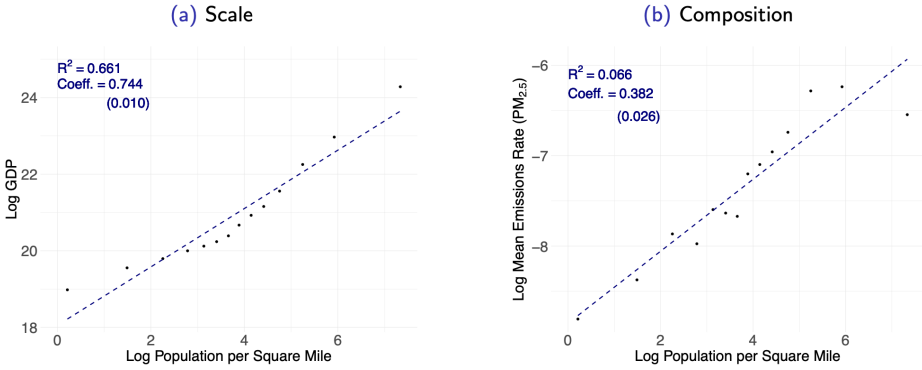
Source: Balboni and Shapiro (2025)

- Aggregate emissions highest near city center where industry and populations are densest (a and b)
- Emissions per household are highest in city outskirts and suburban areas (c)
- Therefore, measuring emissions from consumption or production may alter conclusions

Spatial drivers of emissions: scale, composition, technique

- Literature has separated the determinants of environmental quality into 3 categories (following Grossman and Krueger, 1993; Copeland and Taylor, 1994)
  1. The **scale** of output
  2. The **composition** of output across industries (dirtier vs. cleaner industries or goods)
  3. The **techniques** of production within an industry (dirtier vs. cleaner technologies)
- Next: illustrate how 3 categories relate to population density and emissions across US counties
  - X-axis: population per square mile
  - Y-axis: measures of emissions to capture scale, composition, or technique

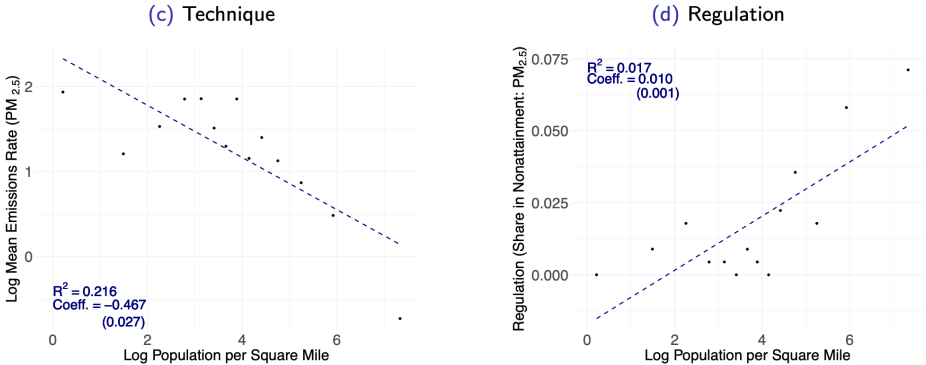
Scale and composition of production drive higher pollution in US cities



Notes: Binned scatter plots and linear trends based on 2017 US county observations. *Source*: Balboni and Shapiro (2025)

- Panel a: y-axis is GDP, measuring the scale of economic activity
- Panel b: y-axis describes the extent that a county is specialized in dirty industries

Denser areas in the US have lower emissions per worker



Notes: Binned scatter plots and linear trends based on 2017 US county observations. *Source*: Balboni and Shapiro (2025)

- Panel a: y-axis is emissions per worker net of industry composition differences
- Panel b: y-axis indicates whether a county is under stricter air pollution regulation

Spatial drivers of emissions in the US: scale, composition, technique

In summary:

More densely populated US counties

= more GDP (scale)

+ dirtier industries (composition)

+ cleaner production (technique, thanks partly to regulation)

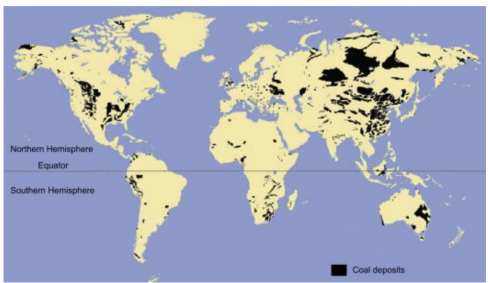
Spatial drivers of emissions: resource endowments

- Natural resource endowments also vary over space
  - Can drive both environmental and economic outcomes
  - Can change the total scale of production, industry composition, and factor intensity
- E.g.: water access, forests, fertile soils, mineral deposits, and solar and wind availability
- Within cities, tree canopy cover can moderate extreme temperatures and reduce energy consumption (Han et al., 2024)

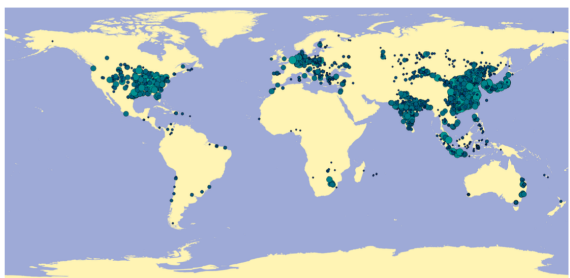
Location of natural resources and productive specialization

- Example of coal deposits and coal-fired power plants:

(a) Coal deposits



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

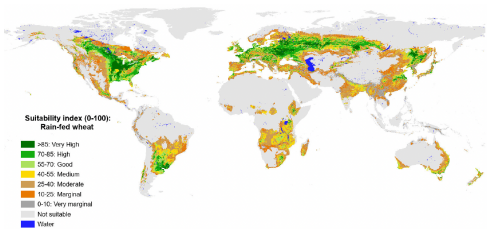


Sources: Suárez-Ruiz et al., 2019, Balboni and Shapiro (2025)

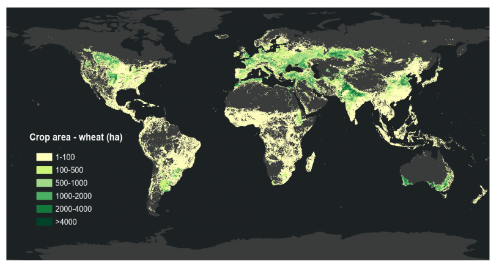
Location of natural resources and productive specialization

- Example of agro-ecological suitability for wheat and wheat cultivation:

Agro-ecological suitability



Grown area



Source: Balboni and Shapiro (2025)

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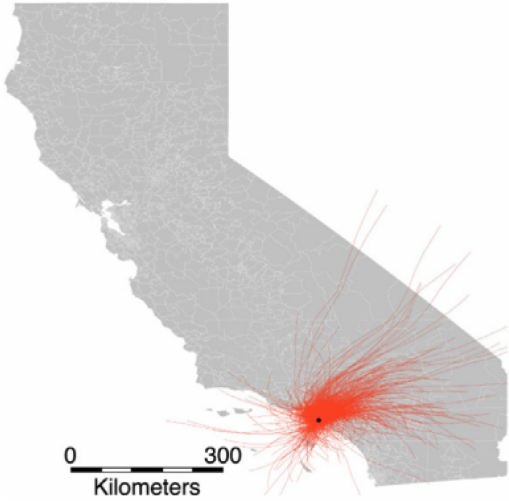
Spatial geophysical forces drive environmental quality

- We just discussed spatial variation in polluting emissions
- But environmental problems can happen in different places that the original emission
  - Pollution transport
  - Geophysical forces $\neq$ administrative boundaries
- Recall distinction between polluting activity, environmental quality, social welfare (p. 10)
- Relationships can be complex. For example:

  Industrial plant emits chemicals $\rightarrow$ aquatic ecosystem transforms chemicals into other pollutants $\rightarrow$ river transports pollution downstream $\rightarrow$ drinking water treatment plant treats pollution $\rightarrow$ pipes then distribute the water to household faucets

Particle trajectories from an industrial facility in Southern California



Source: Hernandez-Cortes and Meng (2023)

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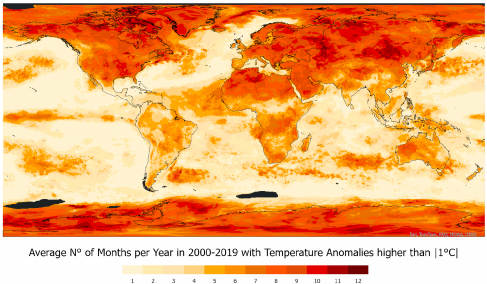
Spatial variation in damage functions drives social welfare

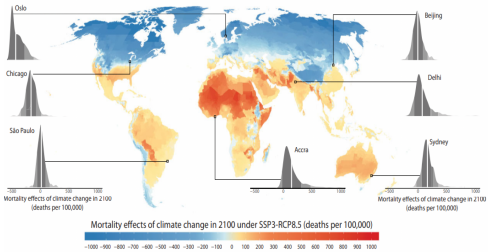
- We discussed spatial variation in pollution emissions and environmental quality
- The damages from environmental quality, and their valuation, also vary over space
- The effects of the environment on the well-being of people and firm profits depend on
  - Endowments (e.g. increasing temperature may be worse in areas already hot)
  - Technology (e.g. adaptive investments such as AC)
  - Choices (e.g. service sectors allow staff to work indoors)

Spatial variation in climate change and its mortality effects

Warming in 2000-2019



Projected mortality in 2100



Source: Carleton et al. (2022), Balboni and Shapiro (2025)

- Climate change expected to increase temperatures the most in North/South
- But expected to increase mortality most near the equator

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Agglomeration can benefit the environment

- **Pollution control** exhibits increasing returns from scale
  - E.g. in monitoring cost for drinking water systems (Keiser et al., 2023)
- **Transport and housing** may lead to lower emissions
  - Denser cities have less driving, smaller housing units, and lower associated energy bills (Duranton and Turner, 2018; Glaeser and Kahn, 2010)
- **Adaptation infrastructure**: local goods with fixed costs
  - E.g. sea walls, levees, cooling centers, and warning systems for natural disasters
- **Reduced sprawl** protects wildland
  - E.g. some cities have growth boundaries or greenbelts

Agglomeration can increase environmental damages

- Increases the **marginal damages** of *local* pollutants
  - A unit of air pollution has greater social cost when emitted in a dense place, because it affects more people
  - The same unit of pollution emitted in a desert affects virtually no-one
  - Logic does not apply to *global* pollutants (like greenhouse gases), where the location of pollution is irrelevant
- Increases the vulnerability to **natural disasters**
  - When one hits a dense area, it affects more people
  - Moreover, fires spread between homes (Baylis and Boomhower, 2021)

Environmental goods can also drive agglomeration

- Spatial clustering of **natural resources** can lead to agglomeration spillovers
  - As discussed, concentrated resources attract industries using the resource as input
  - But other industries or firms downstream in the value chain may concentrate there too
  - And benefit from agglomeration spillovers
- Environmental **amenities** can also drive urban development patterns
  - Coastlines and hills anchor neighborhoods to high incomes (Lee and Lin, 2018)

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Environmental goods can drive dispersion

- Negative externalities from production, transport, sewage (Cutler and Miller, 2005)
- Challenging to provide good municipal environmental services in dense city centers
  - E.g. rat infestation in New York City
  - Informal housing in the dense centers of many megacities today still lacks piped water, sewage conveyance, or trash collection
- Urban heat islands
- Natural resources can constrain urban development
  - Limited ability to develop sloped and wetland areas (Saiz, 2010)

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Spatial links affect environmental externalities

- Spatial links: **flows** of goods, people, and ideas between regions, and **frictions** to these
- **Transport can be good and bad for the environment**
  - Generates emissions (as discussed)
  - Market access aids resource extraction (e.g. deforestation and roads, Araujo et al., 2023)
  - Commuting generates noise, pollution
  - But, commuting also separates residential from dirty industrial areas
- **Flow of ideas can affect the environment**
  - Spread of green technology such as renewable energy, solar
  - Innovation in agriculture re-directed to crops with increasing exposure to rising temperatures

Environmental goods and policies affect spatial links

- **Many environmental policies regulate the transportation sector**
  - Exhaust, energy efficiency, electrification, etc standards
  - Spatially-targeted congestion charges
- **Natural disasters drive migration**
  - Within-country: e.g. migration to urban areas in aftermath of Typhoon Ketsana in Vietnam (Gröger and Zylberberg, 2016)
  - Across countries: e.g. weather variations in source countries translates into asylum applications to EU (Missirian and Schlenker, 2017)
- **Future climate change drives adaptive adjustments**
  - Affects spatial transmission of climate change costs
  - Migration frictions important for estimating climate damages

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Enviro-spatial policy: (1) place-based policies

- Many enviro policies regulate **specific polluted locations**
  - US Clean Air Act: industrial location, employment, capital, output, productivity, wages, ...
  - China's 2013 pollution monitoring program
  - Market-based instruments and tradable performance standards
- Policies targeting **spillovers across locations** are an open topic for research and policy
  - E.g. gasoline taxes accounting for spatial differences in the externalities from automobile use

Enviro-spatial policy: (2) environmental federalism

- Different levels of government often regulate the same environmental problem
  - A related issue to the spillovers discussed before
- **Theory of fiscal federalism**: a given environmental problem may have an optimal level of government to regulate it, depending on the structure of the externality
- E.g. wildland firefighting in western US (Baylis and Boomhower, 2023)
  - Local municipal governments permit home building next to federal forests
  - Federal government is responsible for fighting fires that start in federal forests

Enviro-spatial policy: (3) leakage

- Environmental regulation can cause "leakage" of dirty activities to unregulated regions
- **Policy-driven carbon leakage**
  - Offshoring emissions-intensive production
  - Policy debates, e.g., EU Carbon Border Adjustment Mechanism
- **Natural resource exploitation**
  - E.g. PES (payments for environmental services) may just shift the location of deforestation
- **Adaptive infrastructure**
  - E.g. levees may increase flood risk downstream

Enviro-spatial policy: (4) land use

- **Zoning, development, land use restrictions**
  - Affected by and affect the environment
  - Affect spatial patterns of density, pollution, development in wildland-urban interface
  - Concession rights in tropical forest areas affect fire-setting, forest loss (Balboni et al., 2023)

Enviro-spatial policy: (5) insurance

- **Spatial moral hazard** occurs when agents do not face the full consequences of locating in environmentally risky areas
- Regional **insurance** policies, as well as **disaster aid**, can effectively subsidize development in areas prone to natural hazards
  - Federally-managed US National Flood Insurance Program, development in flood-prone areas
  - "Last resort" state insurance policies in the US for wildfires, hurricanes

Appendix

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