Spatial Environmental Economics
Lecture 5: Elements of Spatial Models

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Roadmap

1. Locations and the Topography of Space
2. Spatial Links: Transportation
3. Spatial Forces
4. Summary

Roadmap

Locations

- A **location** is the geographic coordinates where economic activities take place
  - This could be a point in a map or an area
  - Definition will depend on the specific question(s) we want the model to answer
  - Definition can also depend on the available data
- The "topography" is the set of features of locations and their connections in space:
  - Productivities, amenities, spatial links
- More formally:
  - Define space S. **Locations** $i \in S$
  - Productivities, amenities, spatial links are functions over locations $i \in S$

Productivity of locations

- Productivity of a location is the units of output per unit of associated labor used
  - It reveals the productive capacity of a location
  - It depends on the access to natural resources, climate, etc.
  - When there are more than one factors we refer to total factor productivity: the units of output for a unit of combined inputs
- Formally:
  - Denote the labor used in location i by L_i
  - Then **productivity** A_i is the units of output per unit of labor L_i
  - With a simple production function, output $Y_i = A_i L_i$

Amenity of locations

- Amenity of a location is the intrinsic utility value of residing there
  - It depends on access to entertainment, playgrounds, climate, water, etc
  - Diamond (2016) suggests six broad categories relevant for amenities:
    - ⋆ retail, transportation, crime, environmental, schooling, and job quality amenities
    - ⋆ e.g spending on parks per capita (positive), pollution (negative)
- Formally:
  - Denote the (indirect) utility of a location by W_i
  - We can consider the **amenity**, u_i , such that $W_i = W_i(w_i, P_i, u_i)$
  - w_i is the wage, P_i is the price of consumption at the location

Spatial links between locations

- Spatial links are the geographical connections between locations
  - They describe social links, economic links, and trade potential
  - Examples include trade, commuting, knowledge spillovers
- Spatial links across locations are determined by
  - The transportation and communication infrastructure
  - The means of transportation and communication

Spatial links in the model

- We represent spatial links with a matrix (or a function in continuous space) with elements

$$\{\tau_{ij}\}_{i,j\in S}$$

- Each element of the matrix determines if two locations are directly linked
- The value (or the inverse) of each element represents the intensity of the link
  - E.g. i Munich, j Stuttgart, $j\prime$ is Berlin: it is cheaper and faster to take a train to Stuttgart than Berlin so that $\tau_{ij} < \tau_{ij'}$ where τ_{ij} represents the cost of traveling from i to j
  - We denote the cost of using each segment of the network as $\bar{t}_{ij}$, i.e. each τ_{ij} is a function of $\{\bar{t}_{ij}\}_{i,j\in S}$

Roadmap

Transportation infrastructure

- Transportation infrastructure is the network of installations that allows the transfers of goods through various means
  - Includes roads, rail tracks, airports, sea ports etc
  - It has significantly varied over time
  - Transportation revolutions correlate with significant economic and social progress
  - E.g. Persian empire, Ancient Athens/Hellenistic Period, Modern Roman Republic/Empire, Discovery of the New World, Industrial Revolution

Telecommunication infrastructure

- Telecommunication infrastructure is the network of installations that allows the transfer of information through various means
- Includes information of any nature (signals, messages, pictures, voice etc) and by any means (wire, radio, optical, electromagnetic)

Transportation technology

- The transportation technology also determines the intensity/quality of a link (and thus $\bar{t}_{ij}$)
- E.g. using donkey vs modern car vs plane
- Determines the speed or the type of objects that can be carried and as a result the overall cost, τ_{ij}

Roadmap

Spatial forces

- We have discussed the important elements of spatial economics
  - Productivities, amenities, transport costs
- Next: how to model some of the most significant economic forces that affect those
- We call these **spatial forces**:
  1. Agglomeration
  2. Amenity spillovers
  3. Transport congestion

Agglomeration

- **Agglomeration** economies or agglomeration spillovers are the production increase as a result of clustering of economic activities
- Related to the idea that small scale production is inefficient because of fixed costs
- Externalities between firms in the same industry (Marshall, 1890) because of:
  - Labor market pulling
  - Knowledge spillovers
  - Proximity to inputs
- Externalities between firms in different industries (Jacobs)
  - E.g. R&D activity spillovers between disparate industries

Agglomeration in our model

- Population/employment locally or elsewhere affects the productivity of a location i:

$$A_i = \bar{A}_i f^A \left(\{L_j\}_{j \in S} \right)$$

  - $\bar{A}_i > 0$
  - f^A is a function
  - If $\partial A_i / \partial L_i > 0$ we say that there are *local* productivity spillovers
  - If $\partial A_i / \partial L_j > 0$ for $i \neq j$ we say that there are *spatial* productivity spillovers

- Simplest example:

$$A_i = \bar{A}_i L_i^{\alpha}$$

with $\alpha \geq 0$

Amenity spillovers

- **Amenity spillovers** or externalities occur if amenities are affected as a result of clustering of economic activities
- Variety of reasons underlying these spillovers, e.g.
  - Rental or housing market spillovers – more people wanting to live somewhere bid up prices
  - Air pollution from traffic, noise pollution from nightlife
  - Consumption amenities such as restaurants – need enough customers to cover fixed costs
  - Local public services such as schools or police force

Amenity spillovers in our model

- Population/employment locally or elsewhere affects the amenity of a location i:

$$u_i = \bar{u}_i f^u \left(\{L_j\}_{j \in S} \right)$$

  - $\bar{u}_i > 0$
  - f^u is a function
  - If $\partial u_i / \partial L_i \neq 0$ we say that there are *local* amenity spillovers
  - If $\partial u_i / \partial L_j \neq 0$ for $i \neq j$ we say that there are *spatial* amenity spillovers

- Simplest example:

$$u_i = \bar{u}_i L_i^{-\beta}$$

with $\beta \neq 0$ (typically $\beta > 0$, congestion or dispersion force)

Transport congestion

- **Transport congestion**. Congestion of the transportation system happens if the flows of goods or people or other endogenous variables affect the intensity/cost of the link
- In our model, we say that τ_{ij} is a function of trade between two locations
  - As well as a function of the exogenous component $\bar{t}_{ij}$, as before

Roadmap

Basic elements of spatial models

- Locations: $i \in S$
- Topography: A_i, u_i, τ_{ij}
  - Geography (economic fundamentals, exogenous): $\bar{A}_i$, $\bar{u}_i$, $\bar{t}_{ij}$
  - Spatial forces: agglomeration (α), amenity spillovers (β), transportation congestion
- Endogenous variables: L_i, w_i, P_i

Appendix

References I

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