MIT Graduate Public Economics II (14.472)

Lectures on Spatial Public Finance

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Princeton
Fall 2019

Lecture 1

What's special about Spatial PF?

- Mobility of factors (and goods)
- Spillovers
    - Agglomoration
    - Congestion
- Spatial Heterogeneity in Endowments (and Outcomes)
- Hierarchy
    - Federalism
    - Competition with many neighbors

Spatial PF

Academic Motivation:

1. Key policy debates, large spatial disparities, labs of democracy
2. Rich setting for economics and great data
3. Overlap w/ many fields (labor, urban, trade, development, macro)

Goals:

1. Provide context and guidance on open questions
2. Present benchmark models and new research
3. Focus on theory more than empirics (per Amy's request)
4. Complement Parag's lecture on Tiebout and other local PF topics

Questions

1. Taxation: how should we pay for government services?
    - What should we tax? With what structure? At what rate?
    - Taxation of capital, labor, and goods in a spatial setting
    - Incidence, efficiency, and policy implications
2. Spending: how big should government be and what should it provide?
    - Are local services being under or over provided (level and composition)?
    - How are local services allocated? E.g., How much police spending allocated to rich/poor neighborhoods?
    - Redistribution, safety net, and mobility responses to benefit generosity
3. Hierarchy: How should governments be organized?
    - When is local provision efficient?
    - Fiscal federalism and Tax Competition
4. Dynamics: Growth, Economic Development, and Poverty
    - Big push and Industrial policy? Local vs Aggregate Consequences?
    - Should we have special economic zones? Bail outs? Pension reform?
    - Opportunity and growth across locations: causes, consequences, and policy implications

Outline of Lectures on Spatial Public Finance

1. **Baseline Rosen-Roback spatial model**
    - Theory: Rosen-Roback model and value of amenities
    - Application: Albouy (2009) unequal geographic burden of fed taxes
2. **Place-based Policies**
    - Background, model with worker heterogeneity, and welfare
    - Other considerations, second best, place-based redistribution
3. **State and local business tax incentives**
    - Conceptual framework (Slattery Zidar, 2019)
    - Firm location and model with firm heterogeneity
    - Local and national welfare effects of local business tax policy

Graduate Public Finance

The Rosen-Roback Spatial Model[1]

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Lecture 1

Outline

1. Model
   - Overview
   - Workers: Indirect Utility Condition
   - Firms: No Profit Condition
2. Equilibrium
   - Components of Economic Models
   - Exogenous Model Parameters
   - Endogenous Model Outcomes
   - Equilibrium: Indifference Conditions
   - Solving Model
3. Comparative Statics and Value of Amenities
   - Price effects under different assumptions about amenities
   - Inferring Amenity Values
   - Extensions (Albouy JPE, 2009)

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Overview

1. Goals
   - Characterize effect of amenity s change on prices (wages and rents)
   - Infer the value of amenities
2. Markets
   - Labor: price w, quantity N
   - Land: price r, quantity $L = L^w + L^p$ for workers and production
   - Goods: price $p = 1$, quantity X
3. Agents
   - Workers (homogenous, perfectly mobile)
   - Firm (perfectly competitive, CRS)
4. Indifference Conditions
   - Workers have same indirect utility in all locations
   - Firm has zero profit (i.e., unit costs equal 1)

Workers: Preferences and Budget Constraint

Utility is $u(x, l^c, s)$

- x is consumption of private good
- l^c is consumption of land
- s is amenity

Budget constraint is $x + rl^c - w - I = 0$

- I is non-labor income that is independent of location (e.g., share of national land portfolio)
- w is labor income (note: no hours margin).

Workers: Indirect Utility

- Indirect utility is given

$$V(w, r, s) = \max_{x, l^c} u(x, l^c, s) \text{ s.t. } x + rl^c - w - I = 0$$

- Let $\lambda = \lambda(w, r, s)$ be the marginal utility of a dollar of income, then

$$\begin{aligned} V_w &= \lambda > 0 \\ V_r &= -\lambda l^c < 0 \\ \Rightarrow V_r &= -V_w l^c \end{aligned}$$

Aside: Example of Indirect Utility

Utility is Cobb Douglas over goods and land with an amenity shifter:

$$u(x, l^c, s) = s^{\theta_W} x^{\gamma} (l^c)^{1-\gamma}$$

- Then $x = \gamma\left(\frac{w+I}{1}\right)$ and $l^c = (1-\gamma)\left(\frac{w+I}{r}\right)$
- So indirect utility is:

$$V(w,r,s) = \underbrace{\gamma^{\gamma}(1-\gamma)^{(1-\gamma)}}_{constant} \underbrace{s^{\theta_W}}_{Amenities} \underbrace{1^{-\gamma} r^{-(1-\gamma)}}_{Prices} \underbrace{(w+I)}_{Income}$$

- MU of income is $\lambda(w,r,s)$

$$V_w = \lambda = \gamma^{\gamma}(1-\gamma)^{(1-\gamma)} s^{\theta_W} 1^{-\gamma} r^{-(1-\gamma)}$$

$$V_r = -\lambda l^c = -\gamma^{\gamma}(1-\gamma)^{(1-\gamma)} s^{\theta_W} 1^{-\gamma} r^{-(1-\gamma)} \underbrace{(1-\gamma)\left(\frac{w+I}{r}\right)}_{l^c}$$

$$\Rightarrow V_r = -V_w l^c$$

Firms: Unit Cost Function

CRS production with cost function $C(X, w, r, s)$

- X is output
- Unit cost $c(w, r, s) = \frac{C(X,w,r,s)}{X}$
- L^p is total amount of land used by firms
- N is total employment

From Sheppard's Lemma, we have

$$c_w = N/X > 0$$
$$c_r = L^p/X > 0$$

Aside: Example technology, cost function, factor demand

Suppose $X = f(N, L^p) = s^{\theta_F} N^{\alpha} L^{1-\alpha}$, then cost function is:

$$C(X, w, r, s) = X(s^{\theta_F})^{-1} w^{\alpha} r^{1-\alpha} (\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}) \Rightarrow$$
$$c(w, r, s) = (s^{\theta_F})^{-1} w^{\alpha} r^{1-\alpha} (\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)})$$

Then

$$C_w(X, w, r, s) = \alpha \frac{(X(s^{\theta_F})^{-1} w^{\alpha} r^{1-\alpha} (\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}))}{w} = N$$
$$C_r(X, w, r, s) = (1-\alpha) \frac{(X(s^{\theta_F})^{-1} w^{\alpha} r^{1-\alpha} (\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}))}{r} = L^p$$

Dividing both sides by X gives:

$$c_w = N/X > 0$$
$$c_r = L^p/X > 0$$

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Aside: Components of Models[2]

Three parts of any model

1. Exogenous parameters: model elements that are taken "as given"
2. Endogenous outcomes: model elements that "move around"
3. Equilibrium conditions: the set of rules that tells you what the endogenous model outcomes should be for a given set of exogenous model parameters.

"Given a [insert set of exogenous model parameters here], equilibrium is defined by the [insert endogenous model outcomes here] such that [list equilibrium conditions here]."

Exogenous parameters

- Workers Parameters: s, θ_W, γ, I
  - s is level of amenities
  - θ_W governs importance of amenities for utility
  - γ governs importance of goods for utility
  - $1-\gamma$ governs importance of land for utility
  - I is non-labor income
- Firm Parameters: s, θ_F, α
  - s is level of amenities
  - θ_F governs importance of amenities for productivity
  - α is output elasticity of labor
  - $1-\alpha$ is output elasticity of land

Endogenous Model Outcomes

Recall:

- Labor: price w, quantity N
- Land: price r, quantities L^w, L^p for workers and production
- Goods: price $p = 1$, quantity X

so endogenous outcomes are w, r, N, L^w, L^p, X

Equilibrium Concept: Two key indifference conditions

In equilibrium, workers and firms are indifferent across cities with different levels of s and endogenously varying wages $w(s)$ and rents $r(s)$:

$$c(w(s), r(s), s) = 1 \quad (1)$$

$$V(w(s), r(s), s) = V^0 \quad (2)$$

where V^0 is the initial equilibrium level of indirect utility.

Specifically, in our example:
Given $s, \theta_W, \theta_F, \gamma, I, \alpha$, equilibrium is defined by local prices and quantities $\{w, r, N, L^w, L^p, X\}$ such that 1 and 2 hold and land markets clear.

N.B. We will mainly be focusing on prices: $w(s)$ and $r(s)$.

Solving for effect of amenity changes on prices

- Differentiate 1 and 2 with respect to s and rearrange, we have:

$$\begin{bmatrix} c_w & c_r \\ V_w & V_r \end{bmatrix} \begin{bmatrix} w'(s) \\ r'(s) \end{bmatrix} = \begin{bmatrix} -c_s \\ -V_s \end{bmatrix} \tag{3}$$

- Solving for $w'(s), r'(s)$, we have

$$w'(s) = \frac{V_r c_s - c_r V_s}{c_r Vw - c_w V_r}$$
$$r'(s) = \frac{V_s c_w - c_s V_w}{c_r Vw - c_w V_r}$$

- Note we can rewrite

$$c_r Vw - c_w V_r = \lambda L^p / X + \lambda l^c N / X = \lambda L / X = V_w L / X$$

Aside: example values for matrix elements

$$c_w = \alpha \frac{(s^{\theta_F})^{-1} w^{\alpha} r^{1-\alpha} \kappa_0}{w}$$

$$c_r = (1-\alpha) \frac{(s^{\theta_F})^{-1} w^{\alpha} r^{1-\alpha} \kappa_0}{r}$$

$$c_s = \theta_F \frac{(s^{\theta_F})^{-1} w^{\alpha} r^{1-\alpha} \kappa_0}{s}$$

$$V_w = s^{\theta_W} 1^{-\gamma} r^{-(1-\gamma)} \kappa_1$$

$$V_r = -s^{\theta_W} 1^{-\gamma} r^{-(1-\gamma)} \kappa_1 (1-\gamma) \left(\frac{w+I}{r}\right)$$

$$V_s = \theta_W \frac{\left(s^{\theta_W} 1^{-\gamma} r^{-(1-\gamma)} \kappa_1 (w+I)\right)}{s}$$

where $\kappa_0 = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}$ and $\kappa_1 = \gamma^{\gamma}(1-\gamma)^{(1-\gamma)}$ are constants

Effect of amenity changes on prices

- Price changes

$$w'(s) = \frac{(V_r c_s - c_r V_s)X}{\lambda L} \tag{4}$$

$$r'(s) = \frac{(V_s c_w - c_s V_w)X}{\lambda L} \tag{5}$$

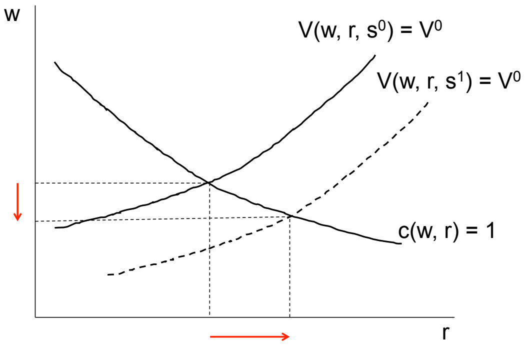
- Special cases of interest:

1. Amenity only valued by consumers: $\theta_F = 0 \Rightarrow c_s = 0$
2. Amenity only has productivity effect: $\theta_W = 0 \Rightarrow V_s = 0$
3. Firms use no land $1 - \gamma = 0$ and amenity is non-productive $\theta_F = 0$: $c(w(s)) = 1,\ c_r = c_s = 0$

Outline

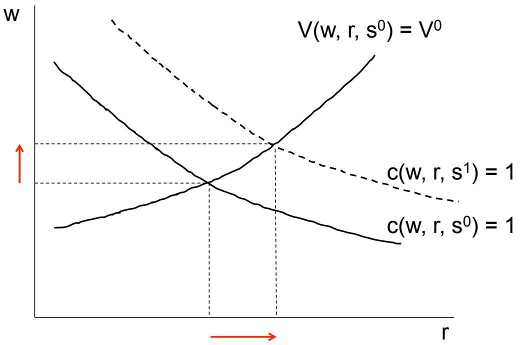
1. Amenity only valued by consumers: $\theta_F = 0 \Rightarrow c_s = 0$

- When $c_s = 0$, higher $s \Rightarrow$ higher r, lower w
- Workers are willing to pay more in land rents and receive less in pay to have access to higher levels of amenities



2. Amenity only has productivity effect: $\theta_W = 0 \Rightarrow V_s = 0$

- When $V_s = 0$, higher $s \Rightarrow$ higher r and higher w
- Firms are willing to pay more in land rents and wages to access higher productivity due to amenities



3. Firms use no land $\gamma = 1$, amenity not productive $\theta_F = 0$

- Only production input is labor and firms are indifferent across locations, so wages must be the same across cities: $c(w(s)) = 1$

- Since $c_r = c_s = 0$,

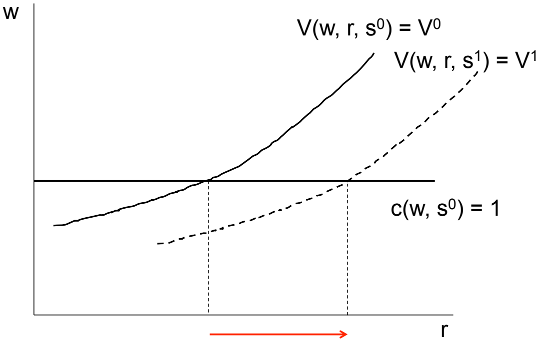
$$w'(s) = 0$$
$$r'(s) = \frac{V_s c_w}{-c_w V_r} = \frac{V_s}{l^c V_w}, \text{ since } V_r = -l^c V_w$$

- So the rise in total cost of land for a worker living in a city with higher s is

$$l^c r'(s) = \frac{V_s}{V_w}$$

3. Firms use no land $\gamma = 1$, amenity not productive $\theta_F = 0$

- $\frac{V_s}{V_w}$ = marginal WTP for a change in s so the marginal value of a change in the amenity is "fully capitalized" in rents



$\frac{V_s}{V_w} = \theta_W \frac{(w+I)}{s}$ is increasing in income, decreasing in level of amenities

Inferring the Value of Amenities

How do we infer the value of amenities in the more general case?

- $\Omega(s) = V(w(s), r(s), s)$ represents total utility of living in city s

- If all cities have equal utility, then

$$\begin{aligned}
\Omega'(s) &= V_w w'(s) + V_r r'(s) + V_s = 0 \text{ in equilibrium} \\
V_s &= -V_w w'(s) - V_r r'(s) \\
V_s &= -V_w w'(s) + l^c V_w r'(s) \\
\Rightarrow \frac{V_s}{V_w} &= l^c r'(s) - w'(s) \qquad (6)
\end{aligned}$$

- So WTP for the amenity is extra land cost for consumers less lower wages in a higher-amenity city

Inferring the Value of Amenities

We can get more insight from looking at firms:

- Firms face $c(w(s), r(s), s) = 1$ across cities, so

$$c_w w'(s) + c_r r'(s) + c_s = 0 \tag{7}$$

- Consider 2 cases

1. $c_s = 0$ (no productivity effects of higher amenity levels)
2. $c_s \neq 0$

Inferring the Value of Amenities, $c_s = 0$

- In the case when $c_s = 0$,

$$w'(s) = \frac{-c_r}{c_w} r'(s) = \frac{-L^p}{N} r'(s) \quad (8)$$

- Combine 6 and 7 to get the WTP of the N people in a given city:

$$N \frac{V_s}{V_w} = Nl^c r'(s) + L^p r'(s) = Lr'(s) \quad (9)$$

Thus, in this case, aggregate WTP can be derived from looking at how the total value of all land changes as s changes

Inferring the Value of Amenities, $c_s \neq 0$

- Define "social value" SV as the sum of aggregate worker WTP and cost-induced savings. Then the change in SV given changes s is

$$
\begin{aligned}
dSV &= N\frac{V_s}{V_w} - Xc_s \\
&= N(l^c r'(s) - w'(s)) - X(-c_w w'(s) - c_r r'(s)) \\
&= Nl^c r'(s) - Nw'(s)) + X\frac{N}{X}w'(s) + X\frac{L^p}{X}r'(s) \\
&\Rightarrow dSV = Lr'(s) \qquad (10)
\end{aligned}
$$

- So the change in social value is the change in total value of land

Extension: Albouy (JPE, 2009)

- Introduces a non-traded good y sold at city-specific price p
- Worker's Problem: indirect utility is given by

$$V(w, r, s) = \max_{x,y} u(x, y, s) \text{ s.t. } x + py - w - I = 0 \tag{11}$$

- Unit cost function for tradable good:

$$c(w, r, s) = 1 \tag{12}$$

- Unit cost function for non-tradable good:

$$g(w, r, s) = p \tag{13}$$

- Albouy model has 3 endogenous variables, w, r and p, but can follow Rosen-Roback analysis

Extension: Albouy (JPE, 2009)

- Studies the unequal geographic burden of federal taxation
- Progressive fed tax schedule $\Rightarrow$ higher taxes in higher w places
- "Federal taxes act like an arbitrary head tax for living in a city with wage improving attributes, whatever those attributes may be"
- Simulation: a worker moving from a typical low-wage city to a high-wage city would experience a 27% increase in federal taxes, which is equivalent to a $269 billion transfer from workers in high-wage, high-productivity areas to low-wage, low-productivity cities.

N.B. Could use approach to study an amenity s (e.g., inefficiency in the local construction sector) that raises the cost of the local good and has no inherent value for consumers or productivity effects on the traded sector (i.e., $\theta_F = \theta_W = 0$).

Leaving Chicago for Nashville

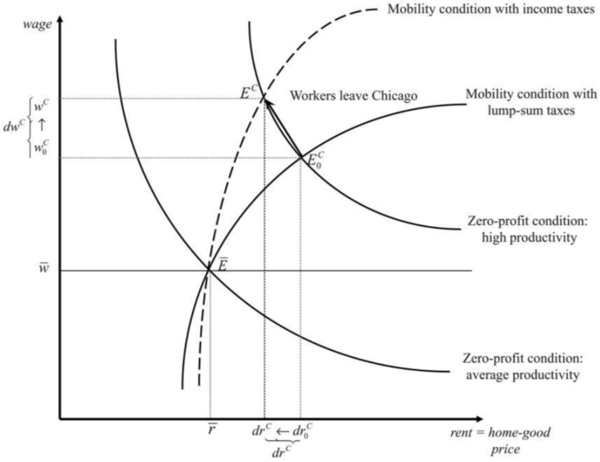


FIG. 1.—Effect of federal taxes on a high trade-productivity city. In a simplified model ($r^j = p^j$, $Q^j = A_Y^j = 1$ for all j), replacing a lump-sum tax, T, with a utility-equivalent federal income tax, τ, raises wages, w, and lowers rents, r, and employment in Chicago, labeled "C," a city with high trade productivity ($A_X^C > 1$), changing the equilibrium from E_0^C to E^C.

Explaining Albouy (JPE, 2009) Figure 1 in words

Initial Equilibrium

- Zero profit condition is higher for Chicago due to higher TFP there
- without taxes, wages w_0^C are higher in Chicago to pay for higher rents (note amenities are set equal in this example)

With progressive income taxes

- Workers in costlier cities like chicago now need to be paid more to be willing to live there
- Relative to initial equilibrium, fewer workers in Chicago which lowers the demand for land in both production and consumption $\Rightarrow$ rents fall by dr^C
- This also raises the labor-to-land ratio, causing wages to rise dw^C
- Firms are no better off since cost savings on land are passed off to workers in higher wages

Moving to Miami: the higher quality of life case

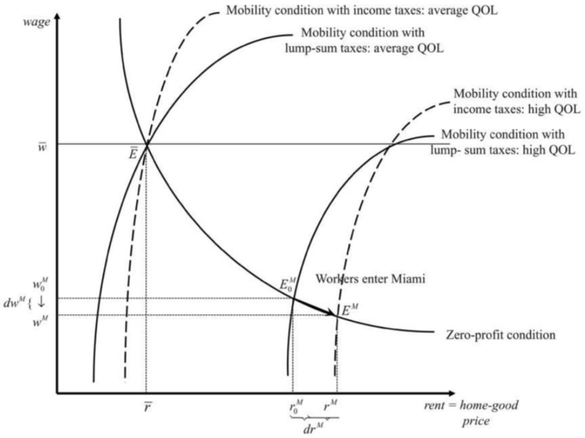


FIG. 2.—Effect of federal taxes on a high-quality-of-life city. In a simplified model ($r^j = p^j$, $A_X^j = A_Y^j = 1$ for all j), replacing a lump-sum tax, T, with a utility-equivalent federal income tax, τ, lowers wages, w, and raises rents, r, and employment in Miami, labeled "M," a city with high quality of life ($Q^M > 1$), changing the equilibrium from E_0^M to E^M.

Source: Albouy (JPE, 2009)

Explaining Albouy (JPE, 2009) Figure 2 in words

Initial Equilibrium

- Like Chicago, Miami is relatively crowded and has high rents, but as compensation, workers get a nicer environment rather than higher wages
- Labor demand is downward sloping (due to fixed land supply) and a larger supply of workers means a lower equilibrium wage
- Both cities have same TFP so on same zero-profit condition
- The mobility condition is lower and to the right in Miami because of higher quality of life

With progressive income taxes

- A worker is now more willing to bid down wage to live in Miami since a \$1 wage cut implies only a $\$(1-\tau)$ reduction in consumption
- Relative to initial equilibrium, more workers in Miami which raises the demand for land in both production and consumption $\Rightarrow$ rents increase by dr^M
- This also lowers the labor-to-land ratio, causing wages to fall dw^M