International Trade and Macro:
Economic geography

Why geography?

- There is significant variation in economic activity across space
- How much of this can be attributed to space, itself?
- How do railroads, interstates, canals, etc. affect outcomes
- Papers we have covered so far
  - No movement of people across countries/locations
  - No agglomeration forces

Locations

- Continuum of locations $i \in S$ (maybe a line or a circle or the United States)
- At location i
  - Produce a unique differentiated variety
  - Local productivity: $A(i) = \overline{A}(i)L(i)^{\alpha}$
  - Local amenity: $u(i) = \overline{u}(i)L(i)^{\beta}$
- $\overline{A}(i)$ and $\overline{u}(i)$ are exogenous to the region
- $\alpha \geq 0$: more population more productivity (pro agglomeration)
- $\beta \leq 0$: more population more productivity (anti agglomeration)
- Symmetric iceberg trade cost $T(i, j)$ for $i, j \in S$

Households

- Choose where to live/work (no moving costs)
- Preferences

$$W(i) = \left(\int_{s \in S} q(s,i)^{\frac{\sigma-1}{\sigma}} \, ds \right)^{\frac{\sigma}{\sigma-1}} u(i)$$

- $q(s,i)$ per-capita quantity of good produced in s consumed in i
- Local amenities scale utility

Production

- Household in i inelastically supply labor for wage $w(i)$

$$y(i) = A(i)L(i)$$

- Price of good produced in i and sold in j is

$$p(i,j) = \frac{w(i)}{A(i)} T(i,j)$$

- Shipment value ("trade") from i to j

$$X(i,j) = \left(\frac{w(i)T(i,j)}{A(i)} \frac{1}{P(j)} \right)^{1-\sigma} w(j)L(j)$$

- Aggregate price index in j

$$P(j)^{1-\sigma} = \int_{s \in S} T(s,j)^{1-\sigma} A(s)^{\sigma-1} w(s)^{1-\sigma} \, ds$$

Equilibrium

- Given $T(i,j)$, $\overline{A}(i)$, $\overline{u}(i)$
- An equilibrium is $L(i)$, $X(i,j)$, $w(i)$, $p(i)$ such that
  1. Goods markets clear: $w(i)L(i) = \int_S X(i,s)ds$
  2. The labor market clears
  $$\overline{L} = \int_S L(s)\, ds$$
  3. Welfare is equalized
- Welfare is *equalized* when there exits a $W > 0$ s.t.
  - $W(i) \leq W$
  - $W(i) = W$ if $L(i) > 0$
- Everyone living in a populated location is indifferent to moving. Everyone would be worse of moving to an empty location.

Equilibrium

- In general, these equilibrium can be funky
- A *regular* equilibrium has $L(i)$ and $w(i)$ continuous and strictly positive
  - Every location is inhabited
- An equilibrium is *point-wise locally stable* if

$$\frac{dW(i)}{dL(i)} < 0$$

  Cannot make anyone better off by moving an epsilon of folks around

Solving for the equilibrium

- Indirect utility is (from usual CES math...)

$$W(s) = \frac{w(s)}{P(s)} u(s)$$

- Solve above for $P(s)$, then substitute into market clearing. Grind a bit

$$L(i)w(i)^{\sigma} = \int_S W(s)^{1-\sigma} T(i,s)^{1-\sigma} A(i)^{\sigma-1} u(s)^{\sigma-1} L(s) w(s)^{\sigma} ds$$

- Indirect utility substituted into the price index and grind

$$w(i)^{1-\sigma} = \int_S W(s)^{1-\sigma} T(s,i)^{1-\sigma} u(i)^{\sigma-1} A(s)^{\sigma-1} w(s)^{1-\sigma} ds$$

- Looking for $L(i)$ and $w(i)$ that solve these two equations when $W(s) = W$

No spillovers

- If $\alpha = \beta = 0$, we can write this as a matrix equation

$$x = \lambda A x$$
$$y = \lambda A y$$

  - $x(i) = L(i) w(i)^{\sigma}$
  - $y(i) = w(i)^{1-\sigma}$
  - $\lambda = W^{1-\sigma}$
  - $A(i,j) = T(i,j)^{1-\sigma} A(i)^{\sigma-1} u(j)^{\sigma-1}$
- This is an eigenvalue problem with $A(i,j) > 0$. There exits a unique regular equilibrium.

With spillovers

- More complicated, but can get to

$$A(i)^{\sigma-1}w(i)^{1-\sigma} = \phi L(i)w(i)^{\sigma}u(i)^{\sigma-1} \tag{1}$$

$$L(i)^{\tilde{\sigma}\gamma_1} = K_1(i)W^{1-\sigma}\int_S T(s,i)^{1-\sigma}K_2(s)\left(L(s)^{\tilde{\sigma}\gamma_1}\right)^{\frac{\gamma_2}{\gamma_1}} ds \tag{2}$$

- $\gamma_1 = 1 - \alpha(\sigma - 1) - \beta\sigma$
- $\gamma_2 = 1 + \alpha\sigma + (\sigma - 1)\beta$
- $\tilde{\sigma} = \frac{\sigma-1}{2\sigma-1}$

- The second equation is a Hammerstein non-linear integral equation.

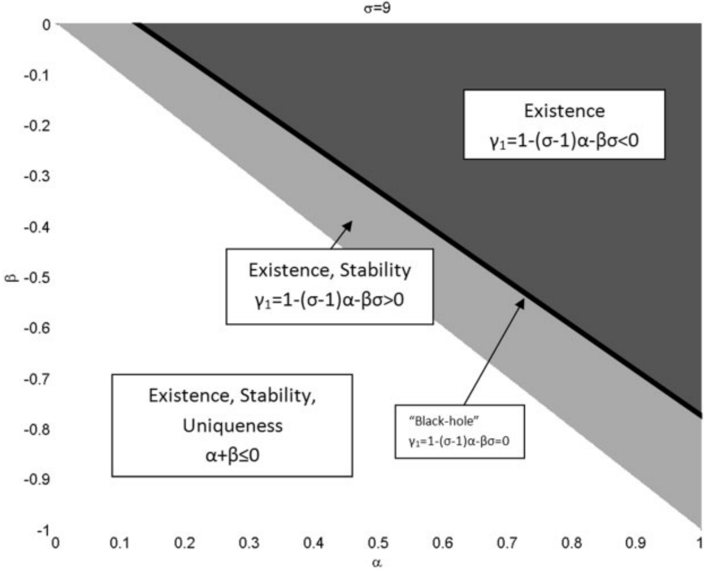
With spillovers

- Theorem
  - A regular equilibrium exits
  - If $\gamma_1 < 0$ none are point-wise stable
  - If $\gamma_1 > 0$ all are point-wise stable
  - If $\gamma_2/\gamma_1 \in [-1, 1]$ the equilibrium is unique
- Market clearing implies

$$W(i) = \left(\int_S T(i,s)^{1-\sigma} P(s)^{\sigma-1} w(s) L(s)\, ds \right)^{\frac{1}{\sigma}} P(i)^{-1} \overline{A}(i)^{\frac{\sigma-1}{\sigma}} \overline{u}(i) L(i)^{-\frac{\gamma_1}{\sigma}}$$

- Only get uniqueness when congestion offsets productivity spillovers

$$\alpha + \beta \leq 0$$


σ=9
Existence
γ1=1-(σ-1)α-βσ<0
Existence, Stability
γ1=1-(σ-1)α-βσ>0
Existence, Stability,
Uniqueness
α+β≤0
"Black-hole"
γ1=1-(σ-1)α-βσ=0
β
α

Some examples

- Consider a line
- Trade costs $\tau(i) = \tau$; border b
- If i, j on same side of border, $T(i, j) = \exp(\tau|i - s|)$
- If i, j on different sides of border, $T(i, j) = \exp(b + \tau|i - s|)$

Trade costs

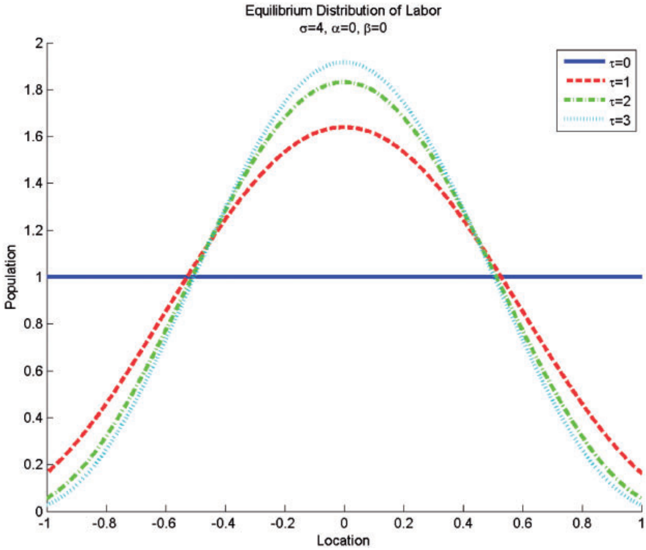


FIGURE III

Economic Activity on a Line: Trade Costs

A border

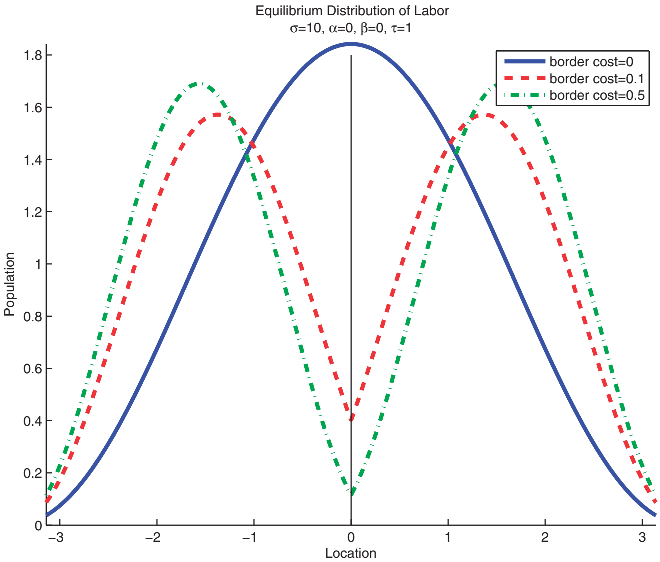


FIGURE IV

Economic Activity on a Line: Border Costs

$\overline{A}(i)$ is heterogeneous

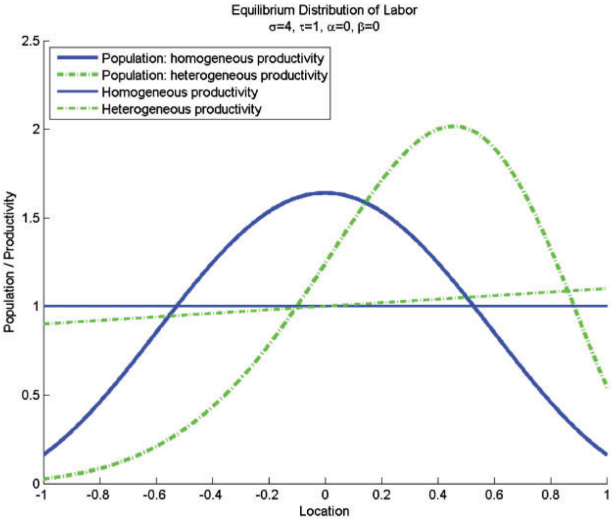


FIGURE V

Economic Activity on a Line: Exogenous Productivity Differences

Strength of productivity spillovers

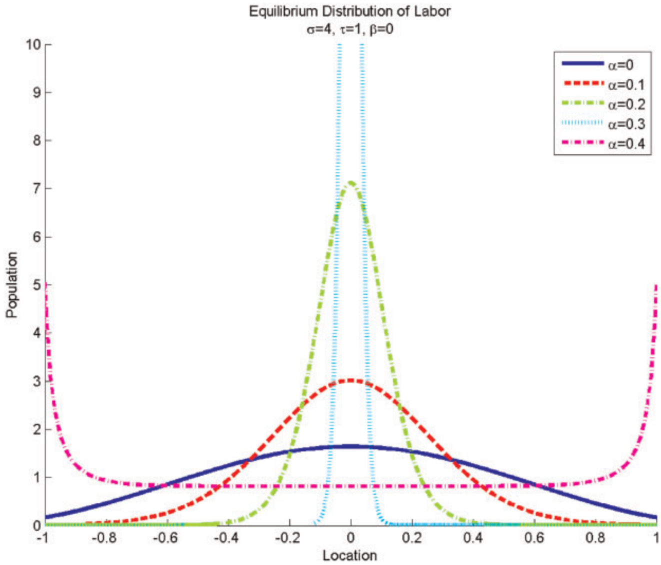


FIGURE VI

Economic Activity on a Line: Productivity Spillovers

Asymmetric trade costs

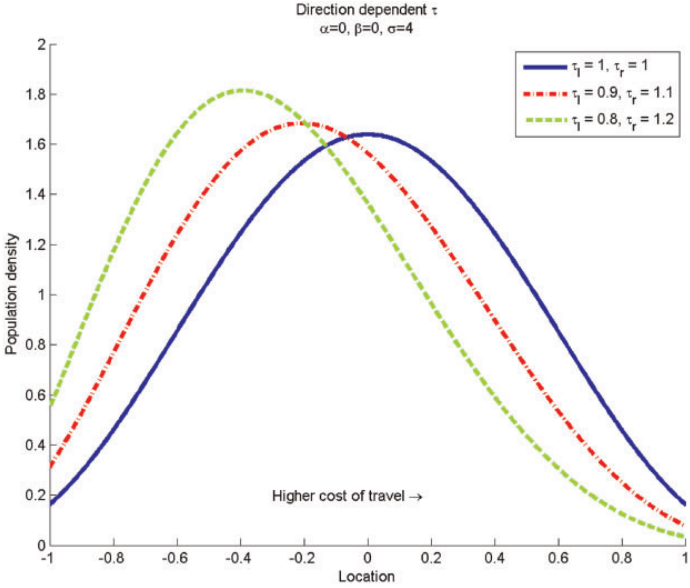
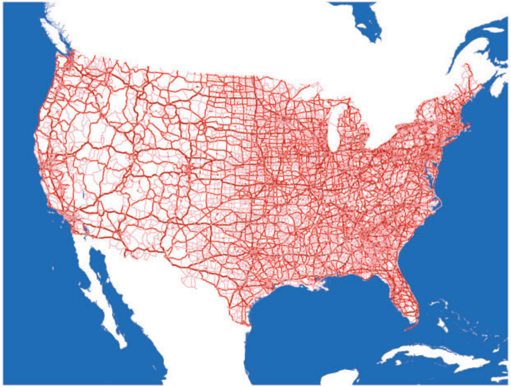


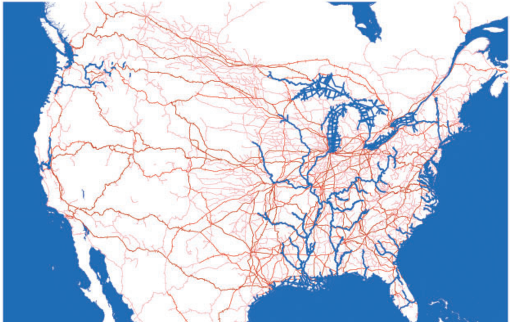
FIGURE VII

Economic Activity on a Line: Direction of Travel

To the data: The US transport network

- Break up the US into counties
- Data at each point: wages and population
- Trade flows across points, by mode (Commodity Flow Survey)
- Map the highway, rail, and navigable waterways





Estimate trade costs

- Cost from i to j by mode m

$$c(i,j) = \exp(\tau_m d_m(i,j) + f_m + \nu_{tm})$$

- If shocks are Gumbell, share by mode is

$$\pi_m(i,j) = \frac{\exp(-a_m d_m(i,j) - b_m}{\sum(\exp(-a_k d_k(i,j) - b_k))}$$

  - $a_m = \theta\tau_m$ and $b_m = \theta f_m$

- Using the estimated a_m, b_m the gravity equation from the model is

$$\log X_{ij} = \frac{\sigma - 1}{\theta} \log \sum(\exp(-a_m d_{mij} - b_m)) + (1-\sigma)\beta' \log C_{ij} + \delta_i + \delta_j$$

  - This gets us θ and we can recover τ_m, f_m

	All CFS areas			
	Road	Rail	Water	Air
Geographic trade costs				
Variable cost	0.5636***	0.1434***	0.0779***	0.0026
	(0.0120)	(0.0063)	(0.0199)	(0.0085)
Fixed cost	0	0.4219***	0.5407***	0.5734***
	N/A	(0.0097)	(0.0236)	(0.0129)
Estimated shape parameter (θ)		14.225***		
		(0.3375)		
Nongeographic trade costs				
Similar ethnicity		−0.0888***		
		(0.0153)		
Similar language		0.063***		
		(0.0223)		
Similar migrants		−0.0191		
		(0.0119)		
Same state		−0.2984***		
		(0.0101)		
R-squared (within)		0.4487		
R-squared (overall)		0.6456		
Observations with positive bilateral flows	9,601	9,601	9,601	9,601
Observations with positive mode-specific bilateral flows	9,311	1,499	78	1,016

Finding productivity and amenities

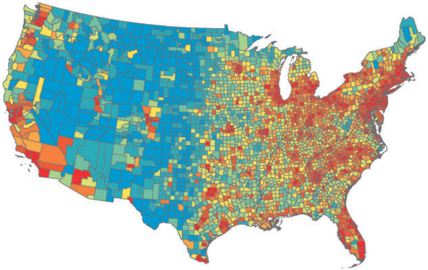
- Substitute (1) into the indirect utility function and substitute out the price index

$$u(i)^{1-\sigma} = \frac{W(i)^{1-\sigma}}{\phi} \int_S T(s,i)^{1-\sigma} w(i)^{\sigma-1} w(s)^{\sigma} L(s) u(s)^{\sigma-1}\, ds$$

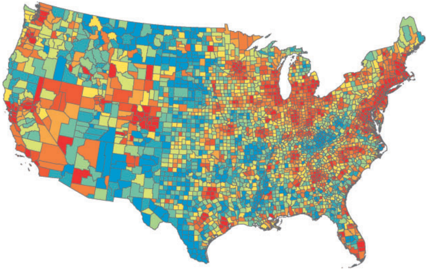
- We know $T(i,j)$, $w(i)$, $L(i)$. Can solve for $u(i)$
- Given $u(i)$ use (1) to recover $A(i)$
- For a value of α and β we can recover $\overline{A}(i)$ and $\overline{u}(i)$

How do things look?

- Places with dense populations tend to have high wages
- So we find these places have high productivity, but low amenities



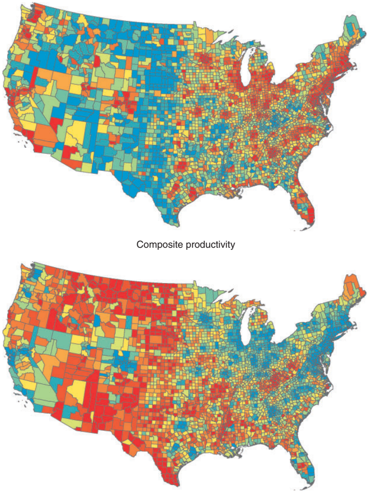
Population density



Wages

FIGURE XII

U.S. Population Density and Wages in 2000



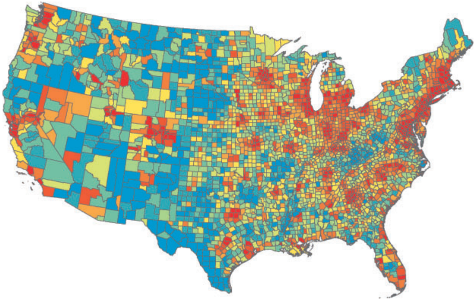
Composite productivity

Composite amenity

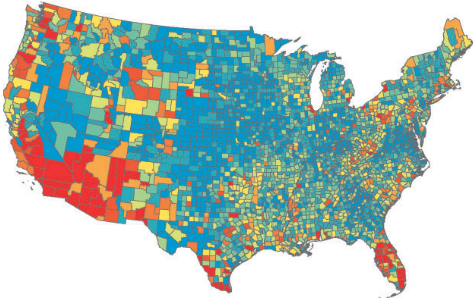
FIGURE XIII

Estimated Composite Productivity and Amenity

This figure shows the estimated composite productivity (top) and amenity (bottom) by decile. The data are reported at the county level; darker shading indicates higher deciles.

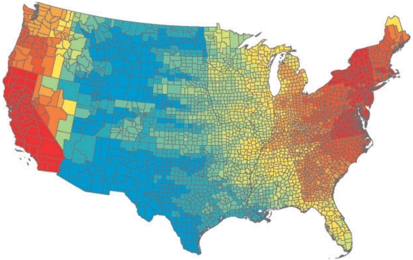


Exogenous productivity

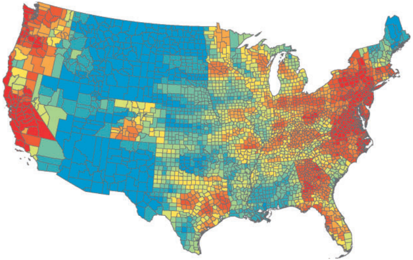


Exogenous amenity

No highways



$\alpha = 0,\ \beta = 0$



$\alpha = 0.1,\ \beta = -0.3$

FIGURE XVIII

Estimated Change in the Population from Removing the Interstate Highway System