Optimal Spatial Policies, Geography and Sorting

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Motivation

- **Spatial concentration of economic activity leads to spillovers**
  - Productivity
  - Amenities
  - Different across workers (e.g. by skill)
- **Relevant to explain geographic distribution of economic activity**
  - Wages and city size
  - Sorting by skill (college graduates)
- **Governments routinely shape the spatial distribution through policies**
  - Place-based policies
  - Taxes and transfers
- **Research questions**
  - Is the observed spatial allocation inefficient?
  - What policies (taxes and transfers) would restore efficiency?
  - Are spatial income disparities and sorting too strong?

This Paper

1. **Spatial equilibrium model with various dimensions of heterogeneity**
   - Flexible economy geography, e.g. Allen and Arkolakis (2014)-Redding (2016)
   - Worker sorting and spillovers, e.g. Diamond (2016)
   - Key generalization: transfers across regions and workers
2. **Characterization of optimal spatial transfers and policies**
   - Homogeneous workers and constant elasticities: generically inefficient
   - Additional source of inefficiency due to sorting
3. **Quantification on U.S. data across MSA's using existing spillover estimates**
   - Welfare gains 3%-6% due to inefficient sorting
   - Observed urban premia (wages, sorting, returns to skill) too strong

Literature Background

- **Optimal policies with externalities:** Sandmo (1975), Dixit (1985), Brown and Heal (1983)
- **Optimal city sizes:** Henderson (1974), Helpman (1980), Albouy et al. (2017), Eeckhout and Guner (2017)
- **Quantitative Economic Geography:** Eaton and Kortum (2002), Krugman (1991), **Helpman (1998), Allen and Arkolakis (2014)**, Caliendo et al. (2014), **Redding (2016),** Ahlfeldt et al. (2015), Desmet and Rossi-Hansberg (2014), Monte et al. (2018),...
- **Spatial Sorting:** Combes at al. (2008), Moretti (2013), Baum-Snow and Pavan (2013), De la Roca and Puga (2017), **Diamond (2016)**, Giannone (2017), Behrens et al. (2014), Davis and Dingel (2016), Helsley and Strange (2014), Eeckhout at al. (2014)
- **Spatial Misallocation:**
    - Wedges: Brandt et al. (2013), Desmet and Rossi-Hansberg (2013), Hsieh and Moretti (2015)
    - Policies: Fajgelbaum et al. (2018), Gaubert (2018), Ossa (2015)
- **Place-based Policies:** Glaeser and Gottlieb (2008), Kline and Moretti (2014), Neumark and Simpson (2015), Duranton and Venables (2018),..

Simple Example

- $j \in 1, ..., N$ city sites, homogeneous workers
    - L_j: population in city j
- Utility of a worker in city j: $u_j = a_j \left(z_j + t_j \right)$
    - $a_j = A_j L_j^{\gamma_A}$: amenity
    - $z_j = Z_j L_j^{\gamma_P}$: output per worker
    - t_j: transfer
- Free mobility: $u_j = u$
- Starting from no transfers, reallocate dL from i to j then:

$$\frac{du}{u} \propto \left(\gamma^P + \gamma^A \right) \left(z_i - z_j \right) dL$$

    - Welfare gains from transfers $\longleftrightarrow$ there are compensating differentials
    - Even if elasticities are constant

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Quantitative Model

- Add:
  - **Multiple types θ with asymmetric spillovers**
  - Production of differentiated tradeable goods and non-tradeables
  - Land, labor and intermediate inputs in production
  - City-type specific productivities and amenities
  - Trade frictions
- Characterize transfers that implement global optimum

Preferences and Labor Aggregate

- **Utility of a type-θ worker in city j:**

$$u_j^\theta = U\left(c_j^\theta, h_j^\theta\right) a_j^\theta\left(L_j^1, .., L_j^\Theta\right)$$

  - $U\left(c_j^\theta, h_j^\theta\right)$: traded and non-traded ("housing") consumption
  - $a_j^\theta\left(L_j^1, .., L_j^\Theta\right)$: local amenities of type θ city j

- **Labor aggregate:**

$$N_j \equiv N\left(z_j^1 L_j^1, .., z_j^\Theta L_j^\Theta\right)$$

  - Imperfect substitution
  - $z_j^\theta = z_j^\theta\left(L_j^1, .., L_j^\Theta\right)$: productivity of type θ in city j

- **Spillover Elasticities:**
  - Productivity: $\gamma_{\theta,\theta'}^{P,j} \equiv \frac{L_j^\theta}{z_j^{\theta'}} \frac{\partial z_j^{\theta'}}{\partial L_j^\theta}$
  - Amenities: $\gamma_{\theta,\theta'}^{A,j} = \frac{L_j^\theta}{a_j^{\theta'}} \frac{\partial a_j^{\theta'}}{\partial L_j^\theta}$

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Sector Level Production and Trade

- Differentiated traded good produced in j: $Y_j = Y_j\left(N_j^Y, I_j^Y\right)$
  - Q_{ji} exported to city i
  - trade cost $d_{ji} \geq 1$
- Bundle of traded goods consumed in j: $Q\left(Q_{1j,..,}Q_{Nj}\right) = C_j + I_j^Y + I_j^H$
- Non Traded good: $H_j = H_j\left(N_j^H, I_j^H\right)$
  - decreasing returns in H_j $\rightarrow$housing supply elasticity

Competitive Equilibrium

- **Type-θ worker:**

$$u^{\theta} = \max_{j,c,h} U\left(c,h\right) a_j^{\theta}$$
$$s.t.\ P_j c + R_j h = x_j^{\theta}$$

  - Expenditure: $x_j^{\theta} = w_j^{\theta} + b^{\theta}\Pi + t_j^{\theta}$

- **Producers**
  - Maximize profits in each sector
  - Wage: $w_j^{\theta} = W_j \frac{\partial N\left(z_j^1 L_j^1, \ldots, z_j^{\Theta} L_j^{\Theta}\right)}{\partial L_j^{\theta}}$.

- **Government budget balance = zero net transfers**

- **+ Market clearing conditions**

Planner's problem

- **Planner chooses** $\{L_j^\theta, c_j^\theta, h_j^\theta, Q_{ji}, I_j^Y, I_j^H\}$ **to solve**

$$\begin{aligned} &\max u^\theta \\ \text{s.t. : } & u^{\theta'} = \underline{u}^{\theta'} \quad \textit{for } \theta' \neq \theta \\ & + \text{feasibility constraints} \\ & + \text{spatial mobility constraint} \end{aligned}$$

  - for arbitrary $\underline{u}^{\theta'}$ (traces out the Pareto frontier)

Optimal Expenditure Distribution

Proposition

If the competitive equilibrium is efficient, then, $\forall j$ with $L_j^\theta > 0$:

$$w_j^\theta + \sum_{\theta'} \frac{L_j^{\theta'}}{L_j^\theta} w_j^{\theta'} \gamma_{\theta,\theta'}^{P,j} + \sum_{\theta'} \frac{L_j^{\theta'}}{L_j^\theta} x_j^{\theta'} \gamma_{\theta,\theta'}^{A,j} = x_j^\theta + E^\theta$$

where E^θ are multipliers of the type-θ labor market clearing constraint.

- Equalization of marginal welfare effect of worker θ across j
  - Marginal output + spillovers
  - Consumes locally
- Extension of familiar "MPL=constant" efficiency condition to a spatial economy
  - Information about x_j^θ needed to assess efficiency, on top of w_j^θ
- Condition is sufficient if planner's problem is concave

First-Best Implementation

Proposition

Assume constant elasticity spillovers:

$$\gamma^{P,j}_{\theta,\theta'} = \gamma^{P}_{\theta,\theta'} \text{ and } \gamma^{A,j}_{\theta,\theta'} = \gamma^{A}_{\theta,\theta'}.$$

Then the optimal allocation can be implemented by the transfers

$$t^{\theta}_{j} = s^{\theta}_{j} w^{\theta}_{j} + T^{\theta}$$

where

$$s^{\theta}_{j} = \frac{\gamma^{P}_{\theta,\theta} + \gamma^{A}_{\theta,\theta}}{1-\gamma^{A}_{\theta,\theta}} + \sum_{\theta' \neq \theta} \frac{\gamma^{P}_{\theta,\theta'} w^{\theta'}_{j} + \gamma^{A}_{\theta,\theta'} x^{\theta'}_{j}}{1-\gamma^{A}_{\theta,\theta}} \frac{L^{\theta'}_{j}}{w^{\theta}_{j} L^{\theta}_{j}}$$

and $T^{\theta} = b^{\theta}\Pi + \frac{E^{\theta}}{1-\gamma^{A}_{\theta,\theta}}$ *targets the planner's Pareto weights.*

- Global optimum implemented by city-type specific subsidy: $s^{\theta}_{j}(\mathbf{w}, \mathbf{x}, \mathbf{L}; \gamma)$
    - Regardless of micro details (e.g. production functions, fundamentals, trade elasticity,..)

Special cases

- **Single worker type:** $t_j^* = s w_j^* + T$ where

$$s = \frac{\gamma^P + \gamma^A}{1 - \gamma^A}$$

  - If $-\gamma^A > \gamma^P$: $s < 0$, redistribution to low-wage cities
  - tax policy (s, T) constant over space

- **Two worker types, only cross-productivity spillovers:**

$$s_j^\theta = \gamma^P_{\theta,\theta'} \left(\frac{w_j^{\theta'} L_j^{\theta'}}{w_j^\theta L_j^\theta} \right)$$

  - If $\gamma^P_{\theta,\theta'} > 0$, type θ subsidized more where "scarce"
  - Gains from transfers even without compensating differentials

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Other Applications

- Monopolistic competition and economic geography models ◂ more
- Commuting ◂ more
- Spillovers across cities ◂ more
- Idiosyncratic preference draws within types ◂ more

Quantitative Implementation

Data Requirements

- Impose constant elasticity (CES or CD) functional forms for all functions
  - Derive condition to ensure sufficiency of optimality condition functions

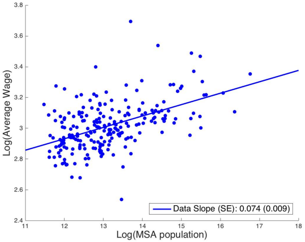
- Solving for optimal allocation requires:
  1. Elasticities (production, preferences, spillovers)
  2. City-type distributions of: wages, employment, expenditures + trade flows

- Calibrate city-type specific shifters of utility and output to match observed distributions (Dekle et al, 2008)

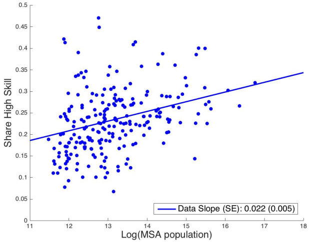
Data and Calibration

- U.S. data across MSA's in 2007
  - 2 worker types: college and non-college workers
- By MSA: BEA Regional Economic Accounts
  - Labor Income, Capital Income, Taxes, Transfers $\rightarrow$ Disposable Income
  - Construct expenditure as disposable income
- Breakdown by skill: IPUMS-ACS (income and transfers) and March CPS (taxes)
  - Control for observable characteristics (age, education, sector, race)
- Use spillover elasticities $(\gamma^A_{\theta',\theta}, \gamma^P_{\theta',\theta})$ from Diamond (2016) and Ciccone and Hall (1996) details
  - High skill: $\gamma^P_{S,\theta} > 0$, $\gamma^A_{S,\theta} > 0$
  - Low skill: $\gamma^P_{U,\theta} \approx 0$, $\gamma^A_{U,\theta} << 0$

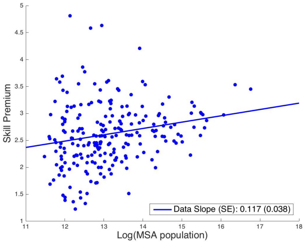
Data: Correlations with City Size



(a) Wage

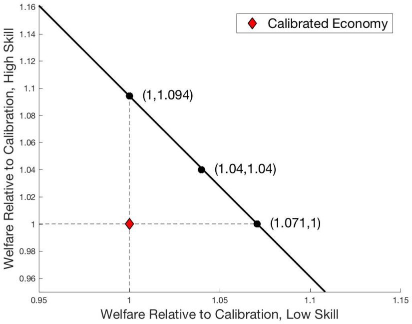


(b) High Skill Share



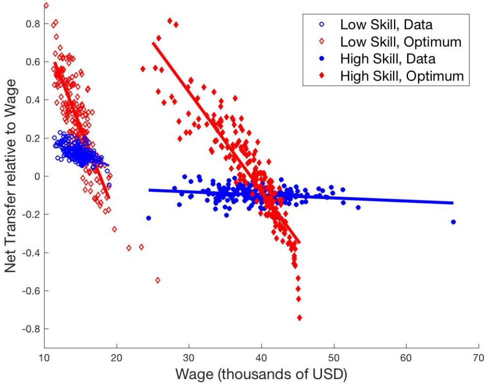
(c) Skill Wage Premium

Utility Frontier



- Gains of 4%
  - 3% - 6% across a range of spillovers and specifications
  - other gammas other specs
- **Driven by inefficient sorting**:
  - With homogeneous workers: 0.06%
  - With heterogeneous workers but without sorting: 0.25%

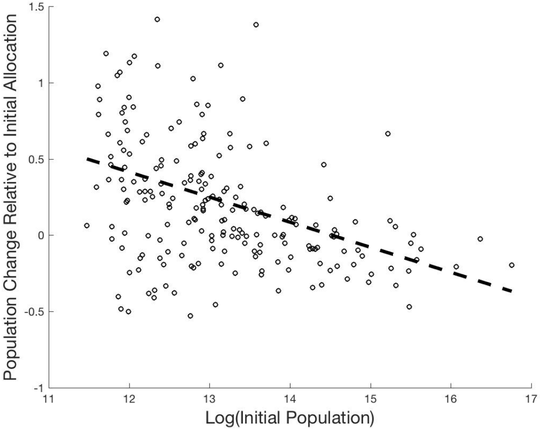
Actual vs. Optimal Transfers



- Optimal redistribution is stronger than in the data
  - Low skill: $\gamma^A_{U,U}, \gamma^A_{U,S} < 0 \rightarrow$tax in high-wage (bigger) cities
  - High skill: $\gamma^A_{S,S}, \gamma^P_{S,S} > 0 \rightarrow$*subsidy* in high-wage cities,
    - offset by $\gamma^A_{S,U}, \gamma^P_{S,U} > 0$

Reallocation away From Large Cities

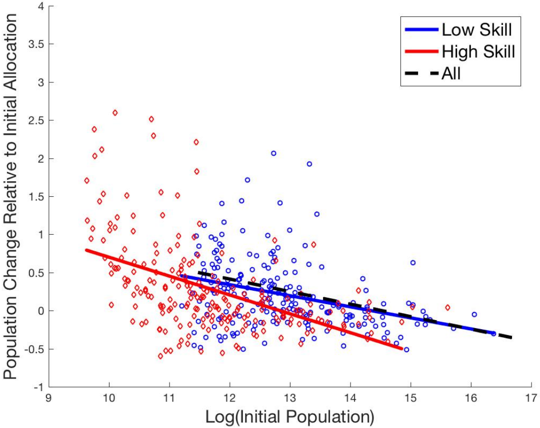
On average, smaller cities grow more...



Slope (SE): -0.16 (0.03)

Stronger Reallocation for High Skill Workers

...in particular through reallocation of high skill workers...

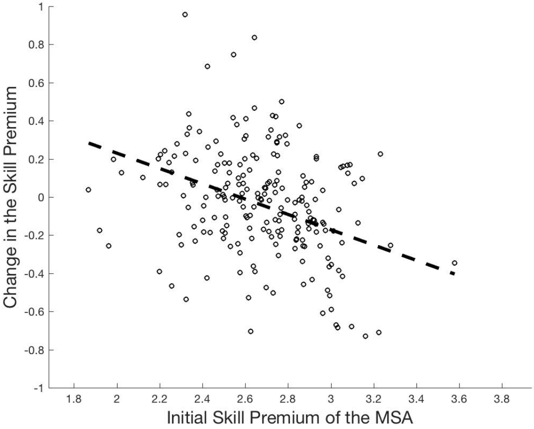


High skill: -0.25 (0.03)

Low Skill: -0.15 (0.03)

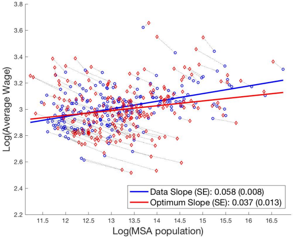
Reduction in Skill Premium

...leading to a reduction of the skill premium in more unequal cities.

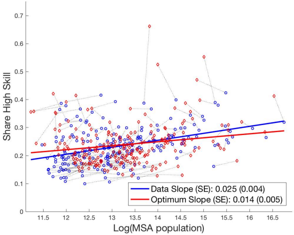


Slope (SE): -0.4 (0.07)

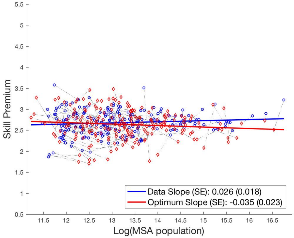
Weakening of Urban Premia



(d) Wage



(e) High Skill Share



(f) Skill Wage Premium

Which Elasticities Matter?

- Calibrated vs "revealed-optimal" elasticities
- Optimal transfer rule from planner:

$$t_j^\theta = a_0^\theta + a_1^\theta w_j^\theta + a_2^\theta \frac{w_j^{\theta'} L_j^{\theta'}}{L_j^\theta} + a_3^\theta \frac{x_j^{\theta'} L_j^{\theta'}}{L_j^\theta} + \varepsilon_j^\theta$$

for $\theta = U, S$

- If data is efficient: $\gamma_{\theta,\theta}^A = \frac{a_1^\theta - \gamma_{\theta,\theta}^P}{1 + a_1^\theta}$, $\gamma_{\theta,\theta'}^P = a_2^\theta \left(1 - \gamma_{\theta,\theta}^A\right)$, $\gamma_{\theta,\theta'}^A = a_3^\theta \left(1 - \gamma_{\theta,\theta}^A\right)$

- Efficient elasticities vs. calibration
  - Similar order of magnitude
  - But calibrated has $\gamma_{S,\theta}^A > 0$, "revealed-optimal" $\gamma_{S,\theta}^A < 0$

Conclusion

- **Quantitative framework combining flexible economic geography, heterogeneous workers, and spillovers**
- **Characterization of first best allocation and optimal transfers**
  - Scope for welfare-enhancing transfers even with common spillovers
  - Additional source of inefficiency from sorting
- **Quantification**
  - Optimal spatial transfers feature stronger redistribution to low-income cities
  - Weaker patterns of urban premia
  - Losses from inefficient sorting
- **Caveats**
  - Static model, invariant worker types
  - First best policies, no fiscal competition

Parametrization of Spillover Elasticities

- **Spillovers set to match Diamond (2016) estimates**
  - Productivities:
$$\begin{bmatrix} \gamma^P_{UU} & \gamma^P_{US} \\ \gamma^P_{SU} & \gamma^P_{SS} \end{bmatrix} = \begin{bmatrix} 0.003 & 0.02 \\ 0.044 & 0.053 \end{bmatrix}$$
    - Level matches elasticity of 0.06 (Ciccone and Hall, 1996)
    - Also multiply by 2
  - Amenities:
$$\begin{bmatrix} \gamma^A_{UU} & \gamma^A_{US} \\ \gamma^A_{SU} & \gamma^A_{SS} \end{bmatrix} = \begin{bmatrix} -0.43 & -1.24 \\ 0.18 & 0.77 \end{bmatrix}$$

    Also:
    - Divide all by 2
    - Scale $\gamma_{\theta,\theta'}$ by +/- 1 SD around Diamond (2016) estimates

- **Other Parameters**
  - $(\alpha_C, \rho) = (0.38, 0.39)$
  - $\{d_{H,j}\} = 0.13$ (average)
  - $\sigma = 5$ (Head and Mayer, 2014)

back

Optimal Imbalances in Quantitative Spatial Models

- **Standard quantitative geography models are a special case**
  - Single worker type, no intermediate inputs, fixed housing supply
  - Cobb-Douglas utility: $U(c,h) = c^{\alpha_C} h^{1-\alpha_C}$
  - Constant spillover elasticities $\left(\gamma^P, \gamma^A\right)$
- **Optimal Expenditures:**

$$x_j = w_j(1-\eta) + \eta \bar{w}$$

  - Composite elasticity $\eta \equiv 1 - \frac{\alpha_C\left(1+\gamma^P\right)}{1-\gamma^A}$
  - Efficiency→Optimal imbalances:

$$t_j = \eta\left(\bar{w} - w_j\right)$$

    - Uniqueness region ($\eta > 0$): net transfers to
- **Optimal Policies across models given η**
  - Helpman (1998): transfers from **low to high income** cities
  - Allen and Arkolakis (2014), Redding (2016): transfers from **high to low income** cities

back

Commuting

- Homogeneous workers with commuting (Ahlfeldt et al. 2015; Monte et al. 2018):
  - Allocation determines commuters L_{ji} from residence j to workplace i
- Utility and output:

$$u_{ji} = a_j\left(L_j^R\right)U_{ji}\left(c_{ji}, h_{ji}\right)$$
$$z_i = z_i\left(L_i^W\right)$$

- Optimal transfers separable into a residence-based and a workplace-based tax:

$$t_{ji}^* = t_i^W + t_j^R - T$$

where

$$t_i^W = \gamma_i^P w_i^*$$
$$t_j^R = \gamma_j^A \sum_{i'} \frac{L_{ji'}^* x_{ji'}^*}{L_j^R}$$

back

Spillovers Across Locations

- Homogeneous workers with spillovers across locations (Rossi-Hansberg, 2005; Ahlfeldt et al. 2015):

$$\gamma^{P,j,j'} = \frac{\partial z_{j'}}{\partial L_j} \frac{L_j}{z_{j'}}$$

- Optimal transfers:

$$t_j = \frac{\gamma^{P,j,j} + \gamma^A}{1-\gamma^A} w_j + \sum_{j' \neq j} \frac{\gamma^{P,j,j'}}{1-\gamma^A} \frac{L_{j'} w_{j'}}{L_j} + T$$

back

Spillovers Across Locations

- Idiosyncratic draws. Utility of worker l of type θ in j: $u_j^\theta \epsilon_j^l$
  - Extreme value (Fréchet) draws: $\Pr\left(\epsilon_j^l < x\right) = e^{-x^{-1/\sigma_\theta}}$
  - Higher $\sigma_\theta \rightarrow$ lower labor supply elasticity
- Optimal transfers exactly as before with $\gamma_{\theta,\theta}^{A,j} - \sigma_\theta$ instead of $\gamma_{\theta,\theta}^{A,j}$
  - σ_θ isomorphic to congestion
- Without spillovers, optimal subsidy: $s^\theta = -\frac{\sigma_\theta}{1+\sigma_\theta}$
  - Tackle distributional concerns (rather than inefficiencies)

back

- Preferences: $U(c,h) = c^{\alpha_C} h^{1-\alpha_C}$
- Varieties: $Q = \left(\sum_i Q_{ji}^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)}$
- Labor: $N_j = \left(\sum_\theta \left(z_j^\theta L_j^\theta\right)^\rho\right)^{1/\rho}$
- Output in Y: $z_j^Y \left(N_j^Y\right)^{1-b_{Y,j}^I} \left(I_j^Y\right)^{b_{Y,j}^I}$,
- Output H: $z_j^H \left(\left(N_j^H\right)^{1-b_{H,j}^I} \left(I_j^H\right)^{b_{H,j}^I}\right)^{1/\left(1+d_{H,j}\right)}$
- Spillovers: $a_j^\theta = A_j^\theta \prod_{\theta'} \left(L_j^{\theta'}\right)^{\gamma_{\theta',\theta}^A}$ and $z_j^\theta = Z_j^\theta \prod_{\theta'} \left(L_j^{\theta'}\right)^{\gamma_{\theta',\theta}^P}$

Proposition

The planning problem is concave if

$$\min_\theta \left\{-\sum_{\theta'} \gamma_{\theta',\theta}^A\right\} > \max\left\{\max_\theta \left\{\sum_{\theta'} \gamma_{\theta',\theta}^P\right\}, 0\right\}$$

and $\gamma_{\theta,\theta'}^A > 0$ *for* $\theta \neq \theta'$.

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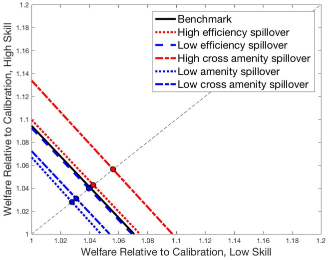
Utility Frontiers under Alternative Parametrizations



Spillovers	Welfare Gain (%)
Benchmark	4.0
High efficiency spillover	4.3
Low amenity spillover	2.8
High cross-amenity spillover	5.6
Low cross-amenity spillover	3.1

return

Welfare Gains Under Other Specifications

	Welfare Gain (%)
Benchmark	4.0
Land Regulations, keeping distortions	3.7
Land Regulations, removing distortions	8.6
Three skill groups	3.9
Imperfect Mobility	4.3
Expenditures = Income	6.3
Local land rents distribution	4.9

return

Model With Land Regulations

- Benchmark: housing supply elasticity is a technological constraint
- Introduce tax in problem of housing producers:

$$\Pi_j^H = \max_{N_j^H, I_j^H} (1 - t_{H,j}) R_j H_j \left(N_j^H, I_j^H\right) - W_j N_j^H - P_j I_j^H, \tag{1}$$

where $t_{H,j} = 1 - \frac{1}{1-\tau_{H,j}} (R_j H_j)^{-\tau_{H,j}}$

- Housing supply elasticity:

$$\frac{\partial \ln H_j}{\partial \ln R_j} = \frac{1 - \tau_{H,j}}{d_{H,j} + \tau_{H,j}}$$

  - Define $\tau_{H,j}$ as land-use regulations

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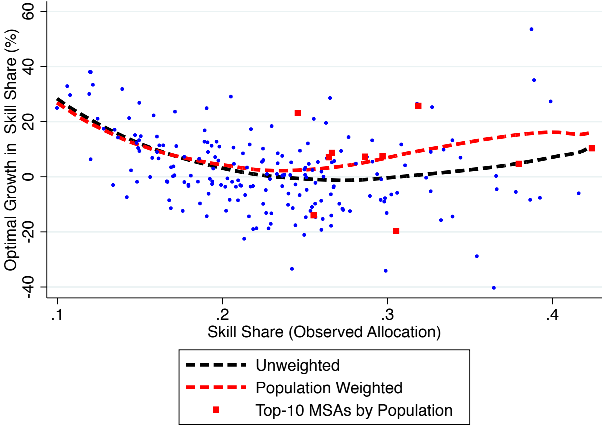
Growth in Skill Share vs. Initial Skill Share



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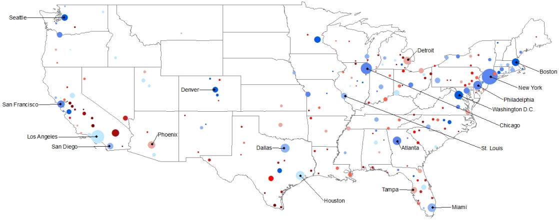
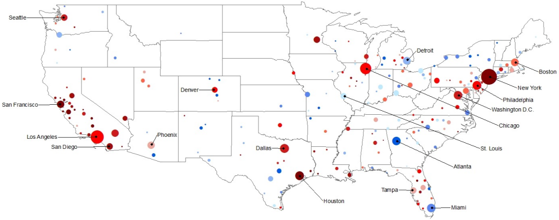
Regional Patterns



(g) Population



(h) High Skill Share

Red = (+) change, Blue = (-) change; Size = Initial Population

return