OPTIMAL SPATIAL TAXATION
ARE BIG CITIES TOO SMALL?

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Wharton
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Motivation

- Local labor markets (cities):
  1. Urban wage premium
  2. Location choice (size) determines prices (wages, housing)
- Ex ante identical agents $\rightarrow$ ex post heterogeneous
Motivation

- Local labor markets (cities):
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- Ex ante identical agents $\rightarrow$ ex post heterogeneous

- Government needs to raise revenue $G$:
  - Location choice responds to tax rate in local labor market
  - Tax cities differentially? Flat (proportional)? Lump sum?

$\rightarrow$ Propose GE model and estimate optimal income tax schedule
**Motivation**

**Existing Federal Income Taxes**

- Federal Taxes affect workers of *same skill* differentially
  1. Urban Wage Premium
  2. Progressive Taxation

- Average tax rate: 5% points difference *at median* income:
Motivation

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- Due to mobility: no redistribution ⇒ same skills, same utility
  ∴ Focus on taxing ex ante *identical* agents
Motivation

• Taxes affect identical agents differently across cities
  ⇒ In equilibrium: affects location decision
• Policy Question: Optimal Taxation across local labor markets
  • Are big cites too small/too big?
Findings
Representative Agent Economy

- Optimal Ramsey Tax rates in big cities:
  - relatively decreasing in Gvt spending $G$
  - relatively increasing in concentration of housing wealth
- For the US, benchmark economy:
  - Optimal tax higher in big cities (but lower than current)
  - Would lead to big relocation and output gain (6.9%)
  - Moderate welfare gain
Related Work

- Literature:

- Main difference: general equilibrium

- Prices, quantities (housing, consumption, population) are endogenous
Model

\[ \text{Cities, size } l_j \text{ with } L = \sum_j l_j \]

\[ \text{Preferences: } u(c_j, h_j) = a_j l_j \delta_j c_1^{\alpha} h_1^{\alpha} a_j : \text{amenities; } \]

\[ \text{Mobility } \Rightarrow \text{utility equalization: } u(c_j, h_j) = u(c_j', h_j'), \forall j, j' \]

\[ \text{Production: } y_j = A_j l_j^{\gamma_j} \Rightarrow w_j = A_j l_j^{\gamma_j - 1} \]

\[ \text{Market clearing: } \sum_j l_j = L \text{ and } h_j l_j = H_j \]
Model

- $J$ cities, size $l_j$ with $L = \sum_j l_j$
- Preferences:
  \[ u(c, h) = a_j l_j^\delta c^{1-\alpha} h^\alpha \]
  $a_j$: amenities; $l_j^\delta$ are congestion costs
- Mobility $\Rightarrow$ utility equalization:
  \[ u(c_j, h_j) = u(c_{j'}, h_{j'}), \quad \forall j, j' \]
- Production:
  \[ y_j = A_j l_j^\gamma \quad \Rightarrow \quad w_j = A_j l_j^{\gamma-1} \]
- Market clearing: $\sum_j l_j = L$ and $h_j l_j = H_j$
Model
Tax Schedule

- Pre tax income $w$; after tax income $\tilde{w}$
- To estimate US tax schedule (Heathcote-Storesletten-Violante 2012, and Bénabou 2002):

  \[ \tilde{w}_j = \lambda w_j^{1-\tau} \]

  - $\tau = 0$: proportional; $\tau > 0$: progressive; $\tau < 0$: regressive
  - US, estimated $\tau \approx 0.12$

- Taxes are used to finance government spending $G$
  - $T^G = \phi \frac{G}{L}$: fraction $\phi$ is transferred to households
MODEL

Housing Production

- On average: land value 30%, construction 70% of housing
  → land from 25% (small) to 50% (big cities)
- Housing supply in city $j$ (with $K_j$ capital, $L_j$ land)
  \[ H_j = B \left( (1 - \beta)K_j^\rho + \beta L_j^\rho \right)^{1/\rho} , \]
- Representative competitive firm in each city maximizes profits
Model
Ownership of Housing

- Housing value: 24% of output
  - Construction cost (17%): foregone consumption
  - Land value (7%): transfer

- Ownership distribution of housing is key to results

- Income from land is redistributed to the households:

\[ T_j = (1 - \psi) \frac{\sum_j r_j L_j}{\sum_j l_j} \]

\( \psi \) captures concentration of land wealth

- \( \psi = 0 \): households hold perfectly diversified housing portfolio
- \( \psi = 1 \): all housing is held by zero measure landlords
Model
Ownership of Housing

- Model housing as an asset traded after policy impact
- But only at extreme cases
- Complication for more general setup: heterogeneity
  1. Initial distribution matters
  2. Trading assets $\Rightarrow$ ex post heterogeneity
Equilibrium Allocation

The Household Problem

- Households solve:

  \[
  \max \{ c_j, h_j \} \quad u(c_j, h_j) = a_j l_j^\delta c_j^{1-\alpha} h_j^\alpha \\
  \text{s.t.} \quad c_j + p_j h_j \leq \tilde{w}_j + T_j + T^G
  \]

  \[
  \Rightarrow p_j h_j = \alpha(\tilde{w}_j + T_j + T^G)
  \]

- the indirect utility is:

  \[
  u_j = a_j [(1 - \alpha)^{1-\alpha}](\tilde{w}_j + T_j + T^G)^{1-\alpha} l_j^\delta h_j^\alpha.
  \]
Equilibrium Allocation
Housing Production

- The firm maximizes its profits by choosing $K_j$ and $L_j$

$$\max_{K_j, L_j} p_j B[(1 - \beta)K_j^\rho + \beta L_j^\rho]^{1/\rho} - r_j L_j - r^K K_j$$

($p_j$ housing price, $r_j$ land rental price, $r^K$ capital rental price)

- Set $r^K = 1$. Free entry + FOC’s
  $$\Rightarrow$$ the equilibrium housing supply is

$$h_j = B \left[ (1 - \beta) \left( \frac{1 - \beta}{r_j} \right)^{\frac{\rho}{1-\rho}} + \beta \right]^{1/\rho} L_j$$
Equilibrium Allocation

Worker Mobility

- Workers must be indifferent between locations \( j \) and \( j' \)

\[ u_j = u_{j'} \]

- Normalize \( a_1 = 1 \), so

\[
a_j = \frac{(\tilde{w}_1 + T_1 + T^G)^{1-\alpha} l_j^{\alpha-\delta} \left[ \left(1 - \beta\right) \left(\frac{1-\beta}{\beta} r_1\right)^{\frac{\rho}{1-\rho}} + \beta \right]^{\alpha/\rho} L_1^\alpha}{(\tilde{w}_j + T_j + T^G)^{1-\alpha} l_1^{\alpha-\delta} \left[ \left(1 - \beta\right) \left(\frac{1-\beta}{\beta} r_j\right)^{\frac{\rho}{1-\rho}} + \beta \right]^{\alpha/\rho} L_j^\alpha}
\]

after using indirect utility and equilibrium housing supply.
Quantitative Exercise
Benchmark Economy – Data

- Take $w_j$ and $l_j$ from the data. Set $\gamma = 1$, so $A_j = w_j$
- 2013 CPS. 264 MSAs. Age 16+ in labor force
- The average labor force is 484,373
  max: NY, 9.3 million; min: Bowling Green, KY, 37,000
- Average weekly wages is $645
  max: 70% above mean (Sante Fe, NM); half (Amarillo, TX)
Size distribution (Labor Force)
**Wage Distribution**

![Wage Distribution Graph](image)

The graph illustrates the distribution of log (weekly wages) with bars representing the frequency of different wage levels. The horizontal axis shows the log of weekly wages ranging from 6.2 to 7.2, while the vertical axis represents the fraction of the workforce. The distribution appears to be skewed, with a peak around log wages of 6.6. The curve above the bars represents a normal distribution, indicating a close alignment with the actual data.
Quantitative Exercise
Benchmark Economy – Taxes

• The relation between after and before taxes

\[ \tilde{w}_j = \lambda w_j^{1-\tau} \]

• Use the OECD tax-benefit calculator: \( \lambda = 0.85, \tau = 0.12 \)
  - \( \lambda \): Personal + Soc. Sec.: Robustness, \( \lambda = 0.9 \) and 0.815
  - \( \tau \): Robustness, \( \tau = 0.053 \) and 0.2

<table>
<thead>
<tr>
<th>( w )</th>
<th>0.5</th>
<th>1</th>
<th>2</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>average tax rate</td>
<td>11.4%</td>
<td>15%</td>
<td>25%</td>
<td>32.8%</td>
</tr>
</tbody>
</table>

• We set \( \phi = 0.5 \) (half of tax revenue are transfers)
Quantitative Exercise
Benchmark Economy - Preference Parameters

- Housing Exp. 24% (Davis, Ortalo-Magné) ⇒ \( \alpha = \frac{0.24}{\lambda} = 0.282 \)
- Commuting cost elasticity \( \delta = -0.1 \)
  - Kahn (2010): the joint effect of commuting time (opportunity wage cost) and direct commuting cost (transportation)
- Asset distribution: \( \psi = 0.5 \)
Quantitative Exercise
Benchmark Economy – Calibration

• Need to determine \{\beta, \rho, B, L_j, a_j\}.
• Select \beta and \rho such that:
  1. average share of land in housing cost is 0.3
  2. land share \in [0.15, 0.5] across MSA
     (Davis-Palumbo (2007), Albouy-Ehrlich (2012))
• B such that \( h = 200 \text{ m}^2 \) (average across MSAs)
• Use observed land area \( L_j \) (average across MSAs 5000 km\(^2\))
Quantitative Exercise

Land Areas

![Graph showing distribution of land areas](image)
Quantitative Exercise
Benchmark Economy – Calibration

- Find $a_j$ from utility equalization
- Benchmark Economy. Procedure:
  1. $A_j = w_j$ (FOC) and $l_j$ from data
  2. given $\lambda$ and $\tau$, find \{ $p_j$, $r_j$, $H_j$, $a_j$, $c_j$, $h_j$, $T_j$ \} such that $l_j$'s are equilibrium allocations
Quantitative Exercise
Benchmark Economy – Housing Prices
Quantitative Exercise
Benchmark Economy – Amenities

Initialization:
- New York-Northeastern NJ
- Brownsville-Harlingen-San Benito, TX
- Danbury, CT
- Flint, MI
- Laredo, TX
- Las Cruces, NM
- Muncie, IN
- San Francisco-Oakland-Vallejo, CA
- San Jose, CA
- Stamford, CT
- Sumter, SC
- Washington, DC/MD/VA

Log (Population): .15, .2, .25
Congestion Adjusted Amenities: 11, 12, 13, 14, 15, 16

Chart Description:
- Scatter plot illustrating the relationship between log (population) and congestion-adjusted amenities for various cities.
- Each point represents a city's data, with cities labeled on the chart for clarity.

Analysis:
- The scatter plot shows a general trend where higher congestion-adjusted amenities correspond to higher population values.
- Cities like New York-Northeastern NJ and San Francisco-Oakland-Vallejo, CA tend to have higher congestion-adjusted amenities and larger populations.

Conclusion:
- The data suggests a positive correlation between population size and congestion-adjusted amenities.
- Further analysis could explore the factors contributing to this correlation and the implications for urban planning and resource allocation.

Next Steps:
- Expand the dataset to include more regions and cities.
- Conduct regression analysis to quantify the relationship further.
- Explore policy implications and potential interventions to improve amenities and manage congestion effectively.
Quantitative Exercise

Benchmark Economy – Land Share in the Value of Housing

Figure:
Benchmark Economy, for different observed population levels.
A. Amenities; B. Land Share in the Value of Housing.
Quantitative Exercise
Optimal Taxation

- Given $A_j$ and $a_j$ from the benchmark economy, calculate:
  1. new equilibrium allocation $\{l_j, c_j, h_j, T_j, H_j\}$
  2. prices $\{p_j, r_j\}$

  for different $\lambda, \tau$ ($\lambda$ such that revenue neutral)

- Select $\tau^*$ that maximizes utility
Optimal Tax Schedule $\tau$

![Graph showing the relationship between $\tau$ and Welfare Gain (%)]
TAX SCHEDULES
ACTUAL VS. OPTIMAL

<table>
<thead>
<tr>
<th>Tax Rate</th>
<th>Wages</th>
<th>Benchmark</th>
<th>Optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1.5</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>.25</td>
<td>2</td>
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</tr>
<tr>
<td>.15</td>
<td>2.25</td>
<td>2.25</td>
<td>2.25</td>
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</table>
**Simulation:** \( \tau^* = 0.046 \)

**Change in Labor Force – Productivity**

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<tr>
<th>Location</th>
<th>Change (%)</th>
</tr>
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<tbody>
<tr>
<td>New York-Northeastern NJ</td>
<td>-10</td>
</tr>
<tr>
<td>Brownsville-Harlingen-San Benito, TX</td>
<td>0</td>
</tr>
<tr>
<td>Danbury, CT</td>
<td>0.5</td>
</tr>
<tr>
<td>Flint, MI</td>
<td>1</td>
</tr>
<tr>
<td>Laredo, TX</td>
<td>1.5</td>
</tr>
<tr>
<td>Las Cruces, NM</td>
<td>2</td>
</tr>
<tr>
<td>Muncie, IN</td>
<td>-10</td>
</tr>
<tr>
<td>San Francisco-Oakland-Vallejo, CA</td>
<td>0</td>
</tr>
<tr>
<td>San Jose, CA</td>
<td>0.5</td>
</tr>
<tr>
<td>Stamford, CT</td>
<td>1</td>
</tr>
<tr>
<td>Sumter, SC</td>
<td>1.5</td>
</tr>
<tr>
<td>Washington, DC/MD/VA</td>
<td>2</td>
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**Productivity**

- New York-Northeastern NJ
- Brownsville-Harlingen-San Benito, TX
- Danbury, CT
- Flint, MI
- Laredo, TX
- Las Cruces, NM
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- San Jose, CA
- Stamford, CT
- Sumter, SC
- Washington, DC/MD/VA
- Brownsville-Harlingen-San Benito, TX

The scatter plot shows the change in labor force against amenities for various locations.
SIMULATION: $\tau^* = 0.046$

CHANGE IN AFTER-TAX WAGES
**Simulation:** $\tau^* = 0.046$

**Change in Housing Prices**

- New York-Northeastern NJ
- Brownsville-Harlingen-San Benito, TX
- Danbury, CT
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<td>1.5</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td></td>
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<tr>
<th>MSA</th>
<th>A</th>
<th>a</th>
<th>%Δl</th>
<th>%Δp</th>
<th>%Δc</th>
<th>%Δh</th>
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<tbody>
<tr>
<td><strong>Highest A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stamford, CT</td>
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<td>18.8</td>
<td>12.0</td>
<td>5.1</td>
<td>-6.2</td>
</tr>
<tr>
<td>San Jose, CA</td>
<td>1.47</td>
<td>0.67</td>
<td>10.7</td>
<td>6.1</td>
<td>2.8</td>
<td>-3.2</td>
</tr>
<tr>
<td>Danbury, CT</td>
<td>1.43</td>
<td>0.50</td>
<td>10.6</td>
<td>5.5</td>
<td>2.6</td>
<td>-2.8</td>
</tr>
<tr>
<td><strong>Lowest A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Las Cruces, NM</td>
<td>0.67</td>
<td>0.64</td>
<td>-11.4</td>
<td>-4.0</td>
<td>-2.3</td>
<td>1.8</td>
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<tr>
<td>Laredo, TX</td>
<td>0.66</td>
<td>0.67</td>
<td>-11.4</td>
<td>-4.1</td>
<td>-2.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Brownsville, TX</td>
<td>0.66</td>
<td>0.81</td>
<td>-10.1</td>
<td>-4.6</td>
<td>-2.3</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Highest a</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>1.08</td>
<td>1.15</td>
<td>2.2</td>
<td>1.4</td>
<td>0.6</td>
<td>-0.8</td>
</tr>
<tr>
<td>Los Angeles-Long Beach, CA</td>
<td>1.05</td>
<td>1.13</td>
<td>1.5</td>
<td>0.9</td>
<td>0.4</td>
<td>-0.5</td>
</tr>
<tr>
<td>New York-Northeast NJ</td>
<td>1.25</td>
<td>1.00</td>
<td>5.9</td>
<td>3.6</td>
<td>1.6</td>
<td>-1.9</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>0.50</td>
<td>10.6</td>
<td>5.5</td>
<td>2.6</td>
<td>-2.8</td>
</tr>
<tr>
<td>Grand Junction, CO</td>
<td>0.91</td>
<td>0.49</td>
<td>-2.6</td>
<td>-0.9</td>
<td>-0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Houma-Thibodoux, LA</td>
<td>0.9</td>
<td>0.49</td>
<td>-2.9</td>
<td>-1.0</td>
<td>-0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>
**Simulation:** \( \tau^* = 0.046 \)

**City Size Distribution**

![Graph showing city size distribution with benchmark and optimal lines. The x-axis represents population, ranging from 0 to 1.0e+07, and the y-axis represents a scale from 0 to 1. The graph compares the benchmark and optimal distributions.]
### Aggregate Outcomes

**Optimal \( \tau^* = 0.046 \)**

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal ( \tau )</td>
<td>0.046</td>
</tr>
<tr>
<td>Output gain (%)</td>
<td>6.92</td>
</tr>
<tr>
<td>Population top 5 cities (%)</td>
<td>3.85</td>
</tr>
<tr>
<td>Fraction population that moves (%)</td>
<td>1.67</td>
</tr>
<tr>
<td>Change in average prices (%)</td>
<td>2.55</td>
</tr>
<tr>
<td>Welfare gain (%)</td>
<td>0.026</td>
</tr>
</tbody>
</table>
Optimal Spatial Tax
Optimal Spatial Tax
Constrained Optimal: Ramsey Taxes

- 2 cities, no gvt. transfers, congestion, amenities, housing prod.
- The Ramsey planner’s problem is:

\[
\max_{\{t_j\}} \sum_j u_j l_j \\
\text{s.t. } \sum_j A_j t_j l_j^\gamma = G, \quad u_j = u_j', \quad \sum_j l_j = L
\]
Optimal Spatial Tax
Constrained Optimal: Ramsey Taxes

- 2 cities, no gvt. transfers, congestion, amenities, housing prod.
- The Ramsey planner’s problem is:

\[
\max_{\{t_j\}} \sum_j u_j l_j
\]

s.t. \[\sum_j A_j t_j l_j = G, \quad u_j = u_j', \quad \sum_j l_j = \mathcal{L}\]

- For any \(\psi\), the optimal taxes \(\exists G^*\) such that:
  - for \(G < G^*\): optimal Ramsey tax higher in big city;
  - for \(G > G^*\): optimal Ramsey tax lower in big city
Constrained Optimal: Ramsey Taxes

Role of $G$

- $G$ is source of inefficiency (disappears from the economy)
- $G \uparrow \Rightarrow$ tax more productive city less
- Productive resources to pay $G$: efficient from work in big city
  $\Rightarrow G \uparrow \Rightarrow$ optimal urbanization $\uparrow$
**Constrained Optimal: Ramsey Taxes**

**Equal housing bond: \( \psi = 0 \)**

**Figure:**
- A. Optimal taxes \( t_1, t_2 \);
- B. Population \( l_1, l_2 \);
- C. Output.

\( (A_1 = 1, A_2 = 2, L = 100, \alpha = 0.31, \psi = 0) \)
**Constrained Optimal: Ramsey Taxes**

**Zero measure landlords:** $\psi = 1$

*Figure:* A. Optimal taxes $t_1, t_2$; B. Population $l_1, l_2$; C. Output. ($A_1 = 1, A_2 = 2, L = 100, \alpha = 0.31, \psi = 1$)
Constrained Optimal: Ramsey Taxes

Zero measure landlords

- When land ownership is concentrated
  \[ \rightarrow \text{ No effect on productivity} \]
- More people in big cities \( \implies \) higher value of land (no value to utilitarian planner)
  \[ \rightarrow \psi \uparrow \implies \text{optimal urbanization} \downarrow \]
**Constrained Optimal: Ramsey Taxes**

**Benchmark:** $\psi = 0.5$

**Figure:**

A. Optimal taxes $t_1, t_2$; B. Population $l_1, l_2$; C. Output.

($A_1 = 1, A_2 = 2, L = 100, \alpha = 0.31, \psi = 0.5$)
The planner chooses the bundles $l_j, c_j, h_j$ to maximize Utilitarian welfare:

$$\max_{l_j, c_j, h_j} \sum_j c_j^{1-\alpha} h_j^\alpha l_j$$

s.t. $\sum_j c_j l_j + \sum_j K_j + G = \sum_j A_j l_j, \quad h_j l_j = H_j, \quad \sum_j l_j = L.$

Solution:

- Equate $MU_j$ and $MP_j$ (Ramsey: $MU, MP \neq$ across cities)
  $\Rightarrow$ Few in small city: unproductive, large consumption
**Optimal Spatial Tax**

**Unconstrained Optimal**

**Figure:**

- \( A_1 = 1, A_2 = 2, \mathcal{L} = 100, \alpha = 0.31, u = c^{0.8}. \)
Optimal Spatial Tax
Lotteries

- Constrained optimal: utility equal. \( \neq \) marginal utility equal. With mobility (Ramsey): tradeoff productivity–utility (low \( G \)):
  - too little consumption in small cities
  - too little production in large cities

- Can we implement first best in this economy?
- Yes, with lotteries (as in labor supply - Rogerson)
- Maybe not in a static world, but over life cycle
- But:
  - What with those who live in NY MSA for their whole life?
  - Lottery with zero probability if \( \gamma = 1 \)...
Optimal Spatial Tax
Sensitivity: Equal Taxes
## Sensitivity Analysis

### Land Ownership I

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Benchmark $\psi = 0.5$</th>
<th>All bond $\psi = 0$</th>
<th>All landlord $\psi = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal $\tau$</td>
<td>0.046</td>
<td>-0.067</td>
<td>0.134</td>
</tr>
<tr>
<td>Output gain (%)</td>
<td>6.92</td>
<td>16.93</td>
<td>-1.31</td>
</tr>
<tr>
<td>Population top 5 cities (%)</td>
<td>3.85</td>
<td>9.04</td>
<td>-0.75</td>
</tr>
<tr>
<td>Fraction population that moves (%)</td>
<td>1.67</td>
<td>3.90</td>
<td>0.33</td>
</tr>
<tr>
<td>Change in average prices (%)</td>
<td>2.55</td>
<td>6.34</td>
<td>-0.47</td>
</tr>
<tr>
<td>Welfare gain (%)</td>
<td>0.026</td>
<td>0.14</td>
<td>0.001</td>
</tr>
</tbody>
</table>
• Asset distribution to reflect owner occupied housing rate 67%
• Generates ex post heterogeneity
• Short cut (but land is not correctly priced!):
  \[ T_j = \theta \frac{r_j L_j}{l_j} + (1 - \theta) \frac{\sum_j r_j L_j}{\sum_j l_j} \]
  instead of landlords: get equal share of land value in the city
• “as if” within city redistribution
## Sensitivity Analysis
### Land Ownership II

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Benchmark $\psi = 0.5$</th>
<th>owner occupied $\theta = 0.67$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal $\tau$</td>
<td>0.046</td>
<td>0.061</td>
</tr>
<tr>
<td>Output gain (%)</td>
<td>6.92</td>
<td>5.78</td>
</tr>
<tr>
<td>Population top 5 cities (%)</td>
<td>3.85</td>
<td>3.23</td>
</tr>
<tr>
<td>Fraction population that moves (%)</td>
<td>1.67</td>
<td>1.40</td>
</tr>
<tr>
<td>Change in average prices (%)</td>
<td>2.55</td>
<td>2.16</td>
</tr>
<tr>
<td>Welfare gain (%)</td>
<td>0.026</td>
<td>0.018</td>
</tr>
</tbody>
</table>
## Sensitivity Analysis

### Initial Tax Policy

<table>
<thead>
<tr>
<th></th>
<th>$\lambda = 0.9$</th>
<th>$\lambda = 0.85$</th>
<th>$\lambda = 0.815$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau$</td>
<td>0.053 0.12 0.2</td>
<td>0.053 0.12 0.2</td>
<td>0.053 0.12 0.2</td>
</tr>
<tr>
<td>Optimal $\tau^*$</td>
<td>0.0092 0.0133 0.0153 0.0429</td>
<td>0.0457 0.0490 0.0969 0.0990 0.1010</td>
<td>0.0092 0.0133 0.0153 0.0429</td>
</tr>
<tr>
<td>Output gain (%)</td>
<td>3.78 9.50 16.98</td>
<td>0.91 6.92 14.53</td>
<td>-4.21 2.11 10.22</td>
</tr>
<tr>
<td>Pop top 5 (%)</td>
<td>2.13 5.23 9.07</td>
<td>0.52 3.85 7.83</td>
<td>-2.46 1.20 5.61</td>
</tr>
<tr>
<td>Pop moves (%)</td>
<td>0.93 2.26 3.91</td>
<td>0.23 1.67 3.38</td>
<td>1.07 0.52 2.43</td>
</tr>
<tr>
<td>Avg. prices (%)</td>
<td>1.40 3.53 6.30</td>
<td>0.33 2.55 5.34</td>
<td>-1.53 0.77 3.71</td>
</tr>
<tr>
<td>Welfare gain (%)</td>
<td>0.0082 0.0512 0.1499</td>
<td>0.0004 0.0264 0.1090</td>
<td>0.0103 0.0024 0.0520</td>
</tr>
</tbody>
</table>
Sensitivity Analysis

Fixed Land Area (5000km²)

Amenities (Land Variable)

Amenities (Land Fixed)
## Sensitivity Analysis

### Fixed Land Area (5000km²)

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Benchmark</th>
<th>Fixed Land Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal $\tau$</td>
<td>0.046</td>
<td>0.059</td>
</tr>
<tr>
<td>Output gain (%)</td>
<td>6.92</td>
<td>5.17</td>
</tr>
<tr>
<td>Population change top 5 cities (%)</td>
<td>3.85</td>
<td>2.88</td>
</tr>
<tr>
<td>Fraction Population that Moves (%)</td>
<td>1.67</td>
<td>1.30</td>
</tr>
<tr>
<td>Change in average prices (%)</td>
<td>2.55</td>
<td>2.56</td>
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<tr>
<td>Welfare gain (%)</td>
<td>0.026</td>
<td>0.016</td>
</tr>
</tbody>
</table>
# Sensitivity Analysis

## No Rebate of Tax Revenue ($\phi = 0$)

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Benchmark</th>
<th>No Tax Rebate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal $\tau$</td>
<td>0.046</td>
<td>0.045</td>
</tr>
<tr>
<td>Output gain (%)</td>
<td>6.92</td>
<td>7.43</td>
</tr>
<tr>
<td>Population change top 5 cities (%)</td>
<td>3.85</td>
<td>4.12</td>
</tr>
<tr>
<td>Fraction population that moves (%)</td>
<td>1.67</td>
<td>1.79</td>
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<tr>
<td>Change in average prices (%)</td>
<td>2.55</td>
<td>2.89</td>
</tr>
<tr>
<td>Welfare gain (%)</td>
<td>0.026</td>
<td>0.030</td>
</tr>
</tbody>
</table>
The Role of Heterogeneity

Heterogeneity in:

1. Housing asset holdings
2. Skills: $\tau^{US} = 0.12$? Redistribution heterogeneous agents
   ⇒ Role of a city-specific tax
Concluding Remarks

• Federal Taxation can lead to spatial misallocation
• Taxes location specific ⇒ optimal Ramsey tax not flat
  • Gvt. spending $G \uparrow \Rightarrow$ tax big city $\downarrow$
  • Asset concentration $\uparrow \Rightarrow$ tax big city $\uparrow$
• US benchmark economy, optimal tax:
  1. Tax big cities more: $\tau^* \sim 0.04$ (less than current)
  2. Large effects on output (6.9%) and population (1.67%)
  3. Small effects on welfare
⇒ Big GE effects from gvt. spending and ownership structure
Optimal Spatial Taxation
Are Big Cities Too Small?

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&ICREA-MOVE, Autonoma, and Barcelona GSE

Wharton
November 4, 2014