Optimal Spatial Taxation: Are Big Cities Too Small?

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May 2015 - CEPR-ESSIM
Motivation

- How does Federal Income Taxation affect worker location across different labor markets?
- Should labor in large (productive) cities be taxed differently than in small (unproductive) ones?
- Amongst the important policy question in Urban Economics.
- Discussed extensively: policy makers, public debate, academics.
- **Propose a simple general equilibrium model and estimate optimal tax schedule.**
Federal Taxes affect workers of same skill differentially across cities.

- Urban Wage Premium
- Progressive Taxation

<table>
<thead>
<tr>
<th>Labor Force</th>
<th>Wage level</th>
<th>Avg. Tax Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>9.3 million</td>
<td>1.5</td>
</tr>
<tr>
<td>Asheville, NC</td>
<td>130,000</td>
<td>1</td>
</tr>
</tbody>
</table>
Motivation

- Progressive taxes: higher productivity → higher wages → higher taxes in big cities
  - Progressive taxes penalize identical agents in large cities

- In equilibrium: fewer workers locate in large cities
  - spatial misallocation — Desmet and Rossi-Hansberg (2013)
  - misallocation of productive resources — Guner, Ventura and Xi (2008), Restuccia and Rogerson (2008) and Hsieh and Klenow (2009)
Motivation

- **Trade-off:** more workers in more productive cities $\rightarrow$ more expensive housing

- Policy Question: what is the optimal tax schedule?

- **Cities**, characterized by productivity, amenities, and land

- Populated by **representative households**
  - Utility from consumption and housing
  - Supply labor inelastically

- Labor is mobile
  - Utility equalization

- **Competitive builders** use land and capital to build houses
  - Land is owned by household

- **Government** taxes labor income
  - Government spending plus transfers
• $J$ cities. Let $l_j$ be the size of city $j$ with $L = \sum_j l_j$
• Indexed by TFP $A_j$

• Production

\[ y_j = A_j l_j^\gamma \]

• Wages

\[ w_j = \gamma A_j l_j^{\gamma - 1} \]
• $J$ cities. Amenities $a_j$

• Preferences

\[ u(c, h) = a_j l_j^\delta c^{1-\alpha} h^\alpha \]

• $l_j^\delta$ is congestion/commuting costs.
• $c$ consumption
• $h$ housing
• Pre-tax income $w$; after tax income $\tilde{w}$

• Tax schedule (Benabou 2002, Heathcote, Storesletten and Violante 2012, Guner, Kaygusuz, Ventura 2014)

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

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

• Taxes are used to finance government spending $G$

• $TR = \frac{\phi G}{L}$ is transferred to households
Model – Housing Production

- Housing supply in city $j$

\[ H_j = B \left[ (1 - \beta)K_j^\rho + \beta T_j^\rho \right]^{1/\rho}, \]

where $K_j$ is capital and $T_j$ is land.

- There is a representative competitive firm in each city maximizing

\[ \max_{K_j, T_j} p_j B \left[ (1 - \beta)K_j^\rho + \beta T_j^\rho \right]^{1/\rho} - r_j T_j - r^K_j K_j, \]

where $p_j$ is the housing price in city $j$, $r_j$ is the rental price of land and $r^K_j$ is the rental price of capital.

- Income from land is redistributed to the households.
• A share $\psi$ of land is owned by absentee landlords

• The remaining $1 - \psi$ is owned equally by all households.

• Transfers from land income

$$R = (1 - \psi) \frac{\sum_i r_j L_j}{\sum l_j}$$
Choose $c_j$ and $h_j$

$$\max \ u(c_j, h_j) = a_j l_j^\delta c_j^{1-\alpha} h_j^\alpha,$$

subject to

$$c_j + p_j h_j \leq \tilde{\omega}_j + R + TR.$$  

- $a_j$ – amenities
- $l_j^\delta$ – congestion
- income
Choose $c_j$ and $h_j$

$$\max_{\{c_j, h_j\}} u(c_j, h_j) = a_j l_j^\delta c_j^{1-\alpha} h_j^\alpha,$$

subject to

$$c_j + p_j h_j \leq \tilde{w}_j + R + TR.$$

The allocations are

$$c_j = (1 - \alpha)(\tilde{w}_j + R + TR) \text{ and } h_j = \alpha \frac{(\tilde{w}_j + R + TR)}{p_j}.$$
Household Problem

- Indirect utility

\[ u_j = a_j l_j^\delta [\alpha^\alpha (1 - \alpha)^{1-\alpha}] \left( \tilde{w}_j + R + TR \right) \left( \tilde{w}_j + R + TR \right) \]

- Since

\[ p_j = \alpha \left( \tilde{w}_j + R \right) \]

\[ h_j l_j = H_j \]

where \( H_j \) is the housing stock in city \( j \), we have

\[ u_j = a_j [(1 - \alpha)^{1-\alpha}](\tilde{w}_j + R + TR)^{1-\alpha} l_j^{\delta-\alpha} H_j^\alpha. \]
The firm maximizes its profits by choosing $K_j$ and $T_j$

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

Set $r_j^K = 1$.

The FOCs for this problem are given by

$$p_j B \frac{1}{\rho}[(1 - \beta) K_j^\rho + \beta T_j^\rho]^{\frac{1}{\rho} - 1} (1 - \beta) \rho K_j^{\rho - 1} = 1,$$

and

$$p_j B \frac{1}{\rho}[(1 - \beta) K_j^\rho + \beta T_j^\rho]^{\frac{1}{\rho} - 1} \rho T_j^{\rho - 1} = r_j.$$

Hence

$$K_j = \left(\frac{1 - \beta}{\beta} r_j\right)^{\frac{1}{1-\rho}} T_j.$$
• Due to free entry, firms make zero profits, i.e.

\[
p_j B \left[ (1 - \beta) \left( \frac{1 - \beta}{\beta} r_j \right)^{\frac{\rho}{1-\rho}} T_j^\rho + \beta T_j^\rho \right]^{1/\rho} - r_j T_j - \left( \frac{1 - \beta}{\beta} r_j \right)^{\frac{1}{1-\rho}} T_j = 0.
\]

• As a result,

\[
p_j B \left[ (1 - \beta) \left( \frac{1 - \beta}{\beta} r_j \right)^{\frac{\rho}{1-\rho}} + \beta \right]^{1/\rho} = r_j \left( 1 + \left( \frac{1 - \beta}{\beta} r_j \right)^{\frac{1}{1-\rho}} \right)^{1/\rho} r_j^{\frac{\rho}{1-\rho}}
\]
Equilibrium – Housing Market

- Housing production

\[ H_j = B \left[ (1 - \beta) \left( \frac{1 - \beta}{\beta} r_j \right)^{\frac{\rho}{1-\rho}} + \beta \right]^{1/\rho} T_j, \]

- Housing per person

\[ h_j = \frac{B \left[ (1 - \beta) \left( \frac{1 - \beta}{\beta} r_j \right)^{\frac{\rho}{1-\rho}} + \beta \right]^{1/\rho} T_j}{l_j}. \]

- Therefore,

\[ \frac{B \left[ (1 - \beta) \left( \frac{1 - \beta}{\beta} r_j \right)^{\frac{\rho}{1-\rho}} + \beta \right]^{1/\rho} T_j}{l_j} = \alpha \frac{\left( \tilde{w}_j + R + TR \right)}{p_j}, \]

where \( \alpha \) is the supply and \( \alpha \) is the demand.
Workers must be indifferent between locations

\[ u_j = a_j[(1 - \alpha)^{1-\alpha}](\tilde{w}_j + T + TR)^{1-\alpha} l_j^{\delta - \alpha} H_j^\alpha \]
\[ = a'_j[(1 - \alpha)^{1-\alpha}](\tilde{w}_{j'} + T + TR)^{1-\alpha} l_{j'}^{\delta - \alpha} H_{j'}^\alpha \]
\[ = u_{j'} \]

Let \( a_1 = 1 \), so

\[ a_j = \frac{(\tilde{w}_1 + R + TR)^{1-\alpha} l_j^{\alpha - \delta} H_1^\alpha}{(\tilde{w}_j + R + TR)^{1-\alpha} l_j^{\alpha - \delta} H_j^\alpha} \]
\[ = \frac{(\tilde{w}_1 + R + TR)^{1-\alpha} l_j^{\alpha - \delta} \left[ (1 - \beta) \left( \frac{1-\beta}{\beta} r_1 \right) \frac{\rho}{1-\rho} + \beta \right]^{\alpha/\rho} H_1^\alpha}{(\tilde{w}_j + R + TR)^{1-\alpha} l_j^{\alpha - \delta} \left[ (1 - \beta) \left( \frac{1-\beta}{\beta} r_j \right) \frac{\rho}{1-\rho} + \beta \right]^{\alpha/\rho} H_j^\alpha} \]
• Take $w_j, T_j, l_j$ from the data.

• Set $\gamma = 1$, so $A_j = w_j$.


• For each of 264 Metropolitan Statistical Areas (MSA), compute $l_j$ as the population above age 16 who are in the labor force.

• Calculate $w_j$ as weekly wages, i.e. as total annual earnings divided by total number of weeks worked.
The average labor force is 484,373, with a maximum (New York-Northern New Jersey-Long Island) of more than 9.3 million and a minimum (Bowling Green, KY) of about 37,000.

The population distribution is highly skewed, close to log-normal, where the top 5 MSAs account for 21.7% of total labor force.

Average weekly wages is 645$. The highest weekly wage is 100% above the mean level (Stamford, CT) and the lowest is about 60% of the mean level (Brownsville-Harlingen-San Benito, TX).
The data on land areas of cities (MSAs), $T_j$, is taken from the Census Bureau.

Average land area of MSAs is about 5254 km$^2$.

The largest MSA in terms of land areas is huge with 70630 km$^2$ (Riverside-San Bernardino, CA), the smallest one has an area of only 312 km$^2$ (Stamford, CT).
We set $\psi = 0.65$, i.e. only 35% of land is owned by the households.

- 12.6% of the housing equity is owned by the top 1%.
  - Assume that only 88.4% of land is owned by the households on our economy.

The homeowner equity as a share of total home values is about 60%.

- Assume that remaining 40%, i.e. debt, is also owned by the agent outside of the economy.

About 52% of total housing value, 60% of 88.4%, remains in the economy.
- Only 67% of households own a house in the US between 2000 and 2010.
- Set $\psi$ to be 35% (67% of 52.2%).
The relation between after and before taxes

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

Use the OECD tax-benefit calculator that gives the gross and net (after taxes and benefits) labor income at every percentage of average labor income on a range between 50% and 200% of average labor income, by year and family type.

The calculation takes into account different types of taxes (central government, local and state, social security contributions made by the employee, and so on), as well as many types of deductions and cash benefits (dependent exemptions, deductions for taxes paid, social assistance, housing assistance, in-work benefits, etc.).

Get an estimate \( \tau = 0.1203 \)

- Robustness, \( \tau = 0.053 \) and \( \tau = 0.2 \) — Guner, Kaygusuz and Ventura (2014)
Benchmark Economy – Taxes

- $\lambda$ determines average taxes
- $\lambda = 0.85$, i.e. taxes are about 15% of GDP – sum of personal taxes and social security contributions
  - Robustness, $\lambda = 0.9$ and $\lambda = 0.815$
- With $\lambda = 0.85$ and $\tau = 0.1203$

<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>

- Finally, we set $\phi = 0.82$.
  - Defense spending is 18% of the Federal Budget.
Benchmark Economy - Preference Parameters

- Housing Exp. 24% (Davis, Ortalo-Magné, 2009)
  \[ \Rightarrow \alpha = \frac{0.24}{\lambda} = 0.282 \]

- Commuting costs \( \delta = -0.026 \)
  
  - Elasticity of commuting time w.r.t. city size is 0.13 – Gordon and Lee (2011)
  
  - Average commuting time is 50 minutes – US Census Bureau, about 16$
  
  - Plus households spend about 10% of their income on commuting, about 16$
  
  - \( 0.13 \times (16$ + 16$) = 4.16$ a day cost associated with changes in size \)
  
  - \( 4.16$/160$ = 0.026 (2.7% of daily wages) \)
Benchmark Economy – Calibration

- Need to determine \( \{\beta, \rho, B, a_j\} \).

- Select \( \beta \) and \( \rho \) such that: i) average share of land in housing cost is 0.3, ii) the share ranges from 0.1 to 0.5 across MSA – Albouy and Ehrlich (2012)

- Select \( B \) such that \( h = 200 \text{ m}^2 \) (average value across MSAs)

- Find \( a_j \) from utility equalization
• Procedure: take \( A_j, T_j \) and \( l_j \) from data, given \( \lambda \) and \( \tau \), find \( \{p_j, r_j, H_j, a_j, c_j, h_j, R, TR\} \) such that \( l_j' \)s are equilibrium allocations.
Population and Housing Prices

Housing Prices vs. Log (Population)

Cities: 
- 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
Housing Prices in the Model and Data

- **45-degree line**
- **correlation -- 0.59**
Given $A_j$, $T_j$, $a_j$, find $\tau^*$ (and the associated prices and quantities) to maximize welfare

Find the new allocations using

$$ a_j = \frac{(\lambda w_1^{1-\tau} + R + TR)^{1-\alpha} l_j^{\alpha-\delta} \left[ (1 - \beta) \left( \frac{1-\beta}{\beta} r_1 \right)^{\frac{\rho}{1-\rho}} + \beta \right]^{\alpha/\rho}}{(\lambda w_j^{1-\tau} + R + TR)^{1-\alpha} l_1^{\alpha-\delta} \left[ (1 - \beta) \left( \frac{1-\beta}{\beta} r_j \right)^{\frac{\rho}{1-\rho}} + \beta \right]^{\alpha/\rho}} H_1^\alpha H_j^\alpha. $$

or

$$ l_j = l_1 \left[ \left( \frac{H_j}{H_1} \right)^{\frac{\alpha}{\alpha-\delta}} a_j^{\frac{1}{\alpha-\delta}} \left( \frac{\lambda w_j^{1-\tau} + R + TR}{\lambda w_1^{1-\tau} + R + TR} \right)^{\frac{1-\alpha}{\alpha-\delta}} \left( \frac{(1 - \beta) \left( \frac{1-\beta}{\beta} r_j \right)^{\frac{\rho}{1-\rho}} + \beta}{(1 - \beta) \left( \frac{1-\beta}{\beta} r_1 \right)^{\frac{\rho}{1-\rho}} + \beta} \right) \right]. $$
Given $A_j, T_j, a_j$, find $\tau^*$ (and the associated prices and quantities) to maximize welfare.

Adjust $\lambda$ to assure revenue neutrality.

$$\sum_j l_j(\tau) w_j(\tau)(1 - \lambda w_j^{-\tau}) = \sum_j l_j w_j(1 - \lambda^{US} w_j^{-\tau^{US}}).$$
Consider a simple representative agent economy with two cities.

Let $\gamma = 1$, $\beta = 1$ (only land), $\delta = 0$ (no congestion), $\phi = 0$ (no tax rebate), $a_j = 1$ (no amenities), and $T_j = T$ (equal land).

$\psi = 0.35$ (65% of land is owned by absentee landlords).

City 2 is twice as productive as city 1.
• Given $A_j$, $T_j$, $a_j$, find $\tau^*$ (and the associated prices and quantities) to maximize welfare

• Adjust $\lambda$ to assure revenue neutrality

$$\sum_j l_j(\tau)w_j(\tau)(1 - \lambda w_j^{-\tau}) = \sum_j l_j w_j(1 - \lambda^{US} w_j^{-\tau^{US}}).$$
Welfare Gain (%)\[
\begin{array}{c}
-0.02 \\
0 \\
0.02 \\
0.04
\end{array}
\]
\[
\begin{array}{c}
0.04 \\
0.06 \\
0.08 \\
0.10
\end{array}
\]

Optimal tau
Optimal Taxes – Quantitative Analysis

- Given $A_j$, $T_j$, and $a_j$, find $\tau^*$ (and the associated prices and quantities) to maximize welfare
- Adjust $\lambda$ to assure revenue neutrality
- The optimal $\tau^* = 0.0145$

Benchmark Economy, move from $\tau$ to $\tau^*$

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<tr>
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<th></th>
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<td>Output gain (%)</td>
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<td>Consumption (%)</td>
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<td>Housing Consumption (%)</td>
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<td>Population change top 5 cities (%)</td>
<td>7.95</td>
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<td>Fraction of Population that Moves (%)</td>
<td>3.47</td>
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## Optimal Taxes – Select Cities

<table>
<thead>
<tr>
<th>MSA</th>
<th>A</th>
<th>a</th>
<th>%Δl</th>
<th>%Δp</th>
<th>%Δc</th>
<th>%Δh</th>
</tr>
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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>
<td>2.01</td>
<td>0.68</td>
<td>40.65</td>
<td>23.52</td>
<td>7.17</td>
<td>-13.34</td>
</tr>
<tr>
<td>San Jose, CA</td>
<td>1.47</td>
<td>0.79</td>
<td>22.09</td>
<td>11.98</td>
<td>3.88</td>
<td>-7.24</td>
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<tr>
<td>Danbury, CT</td>
<td>1.43</td>
<td>0.69</td>
<td>23.18</td>
<td>10.99</td>
<td>3.62</td>
<td>-6.64</td>
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<tr>
<td><strong>Lowest A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Las Cruces, NM</td>
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<td>-8.34</td>
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<td>Laredo, TX</td>
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<td>-8.95</td>
<td>-3.12</td>
<td>6.41</td>
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<td></td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>1.08</td>
<td>1.20</td>
<td>4.33</td>
<td>2.64</td>
<td>0.92</td>
<td>-1.67</td>
</tr>
<tr>
<td>LA-Long Beach, CA</td>
<td>1.05</td>
<td>1.16</td>
<td>3.02</td>
<td>1.76</td>
<td>0.65</td>
<td>-1.10</td>
</tr>
<tr>
<td>El Paso, TX</td>
<td>0.72</td>
<td>1.12</td>
<td>-15.62</td>
<td>-7.42</td>
<td>-2.51</td>
<td>5.30</td>
</tr>
<tr>
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<td>-6.64</td>
</tr>
<tr>
<td>Anchorage, AK</td>
<td>1.19</td>
<td>0.69</td>
<td>12.94</td>
<td>5.22</td>
<td>1.84</td>
<td>-3.21</td>
</tr>
<tr>
<td>Stamford, CT</td>
<td>2.01</td>
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Productivity and Population Change

- Florida: Miami-Hialeah-FT Lauderdale, FL
- Texas: Houston, TX; San Antonio, TX
- California: Los Angeles, CA; San Diego, CA, San Jose, CA
- New York: New York-Northeastern NJ
- Washington, DC/MD/VA

Population Change (%)

Los Angeles-Long Beach-Anaheim, CA
San Francisco-Oakland-Vallejo, CA
San Jose, CA
San Antonio, TX
Houston, TX
New York-Northeastern NJ
Stamford, CT
Fairfield, CT
Danbury, CT
Sumter, SC
Washington, DC/MD/VA
Las Cruces, NM
Laredo, TX
Brownsville-Harlingen-San Benito, TX
San Antonio, TX
New York-Northeastern NJ
Stamford, CT
San Francisco-Oakland-Vallejo, CA
San Jose, CA
San Antonio, TX
Houston, TX
New York-Northeastern NJ
Stamford, CT
San Francisco-Oakland-Vallejo, CA
San Jose, CA
San Antonio, TX
Houston, TX
New York-Northeastern NJ
Stamford, CT
Amenities and Population Change

- 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

Population Change vs. Amenities
Productivity and After-Tax Wage Changes

After-Tax Wages Change (%) vs. Productivity

- San Jose, CA
- Danbury, CT
- Washington, DC/MD/VA
- San Francisco-Oakland-Vallejo, CA
- 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
- New York-Northeastern NJ
Change in Consumption and Housing Across Cities

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

<table>
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<tr>
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<td>Output gain (%)</td>
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<td>2.21</td>
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<td>Avg. prices (%)</td>
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### Optimal Taxes – Size of Government

#### Size of Government

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Optimal Taxes – Size of Government

Size of Government

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## Optimal Taxes – Land Ownership

### Different Values of $\psi$

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<th>Outcomes</th>
<th>Benchmark $\psi = 0.35$</th>
<th>All Bond $\psi = 0$</th>
<th>All Landlords $\psi = 1$</th>
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<td>Change in average prices (%)</td>
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<td><strong>0.0130</strong></td>
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</table>
• Federal Taxation leads to spatial misallocation
• Optimal tax not flat
• Optimal tax: lower progressiveness
• Trade-off: productivity vs. cost of living
• Evidence of Spatial Misallocation due to Federal Taxation
  • Large effects on output and population
  • Small effects on welfare
• To do: city-specific taxes
Land

Log (Land, sq km)

Fraction

6 7 8 9 10 11
# Sensitivity – Equal Land Size

<table>
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<tr>
<th>Outcomes</th>
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<td>Fraction of Population that Moves (%)</td>
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## Sensitivity – No Tax Rebate

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<td>Population change top 5 cities (%)</td>
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<td>9.83</td>
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