Optimal Spatial Taxation: Are Big Cities Too Small?

Jan Eeckhout and Nezih Guner

University College London, U. Pompeu Fabra and Barcelona GSE

ICREA-MOVE, U. Autònoma de Barcelona and Barcelona GSE

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

	Labor Force	Wage level	Avg. Tax Rate
New York	9.3 million	1.5	19.0%
Asheville, NC	130,000	1	14.0%

Motivation

- Progressive taxes: higher productivity $\longrightarrow$ higher wages $\longrightarrow$ 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)

- Trade-off: more workers in more productive cities $\longrightarrow$ more expensive housing
- Policy Question: what is the optimal tax schedule?
- Wildasin (1980), Glaeser (1998), Kaplow (1995), Knoll-Griffith (2003), Albouy (2009), Albouy-Seegert (2010)

Model

- Cities, characterized by productivity, amenities, and land
- Populated by representative households
  - Utility from consumption and housing
  - Supply labor inelasticly
- 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 $\mathcal{L} = \sum_j l_j$
- 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^{δ} 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
- $TR = \frac{\phi G}{\mathcal{L}}$ is transferred to households

- 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

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

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

- Income from land is redistributed to the households.

- A share ψ 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

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

subject to

$$c_j + p_j h_j \leq \underbrace{\tilde{w}_j + R + TR.}_{\text{income}}$$

- a_j – amenities
- l_j^{δ} – congestion

- 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

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

- Indirect utility

$$u_j = a_j l_j^{\delta} [\alpha^{\alpha}(1-\alpha)^{1-\alpha}] \frac{(\tilde{w}_j + R + TR)}{p_j^{\alpha}}.$$

- Since

$$p_j = \alpha \frac{(\tilde{w}_j + R)}{h_j} \text{ and } \underbrace{h_j l_j}_{\text{demand}} = \underbrace{H_j}_{\text{supply}}$$

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.

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

- As a result,

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

- 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,

$$\underbrace{\frac{B\left[(1-\beta)\left(\frac{1-\beta}{\beta}r_j\right)^{\frac{\rho}{1-\rho}} + \beta\right]^{1/\rho} T_j}{l_j}}_{\text{supply}} = \underbrace{\alpha\frac{(\widetilde{w}_j + R + TR)}{p_j}}_{\text{demand}},$$

Equilibrium – Utility Equalization

- Workers must be indifferent between locations

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

- Let $a_1 = 1$, so

$$\begin{aligned} a_j &= \frac{(\widetilde{w}_1 + R + TR)^{1-\alpha} l_j^{\alpha-\delta} H_1^{\alpha}}{(\widetilde{w}_j + R + TR)^{1-\alpha} l_1^{\alpha-\delta} H_j^{\alpha}} \\ &= \frac{(\widetilde{w}_1 + R + TR)^{1-\alpha} l_j^{\alpha-\delta} \left[(1-\beta)\left(\frac{1-\beta}{\beta} r_1\right)^{\frac{\rho}{1-\rho}} + \beta\right]^{\alpha/\rho} H_1^{\alpha}}{(\widetilde{w}_j + R + TR)^{1-\alpha} l_1^{\alpha-\delta} \left[(1-\beta)\left(\frac{1-\beta}{\beta} r_j\right)^{\frac{\rho}{1-\rho}} + \beta\right]^{\alpha/\rho} H_j^{\alpha}} \end{aligned}$$

- Take w_j, T_j, l_j from the data.
- Set $\gamma = 1$, so $A_j = w_j$.
- Use 2013 Current Population Survey (CPS) March Supplement.
- 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 and 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 ψ to be 35% (67% of 52.2%).

- The relation between after and before taxes

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

- 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.

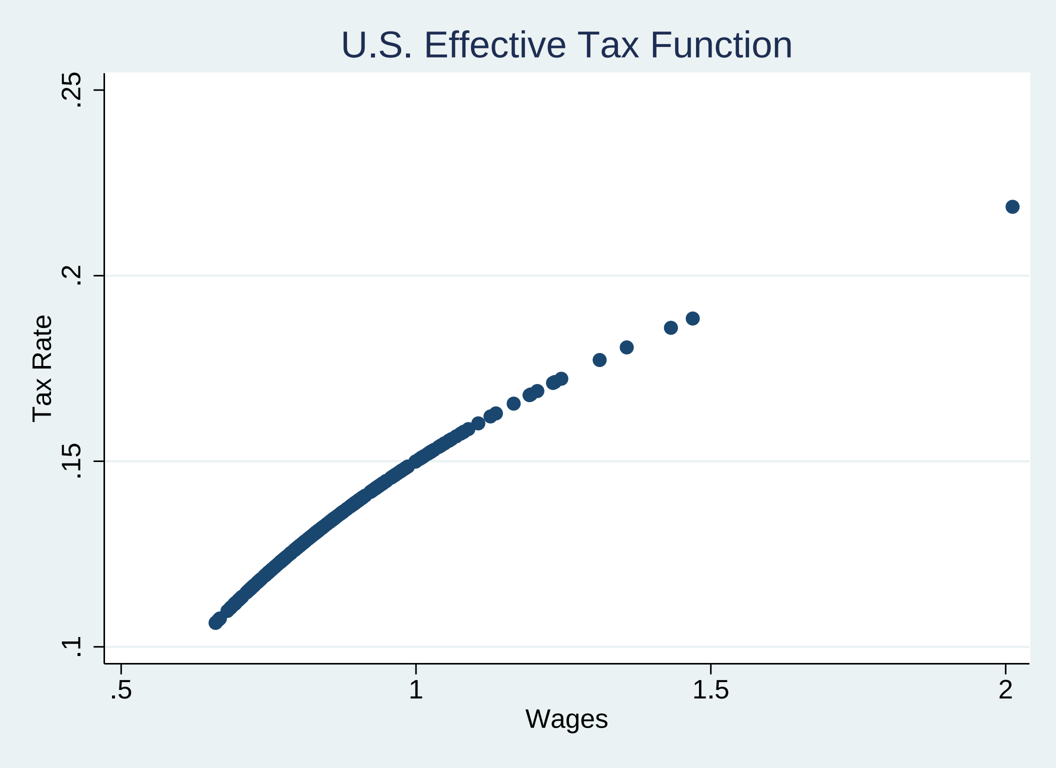
- The calculation takes into account different types of taxes (central government, local and state, social security contributions made by the employee, and so on), as well as many types of deductions and cash benefits (dependent exemptions, deductions for taxes paid, social assistance, housing assistance,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

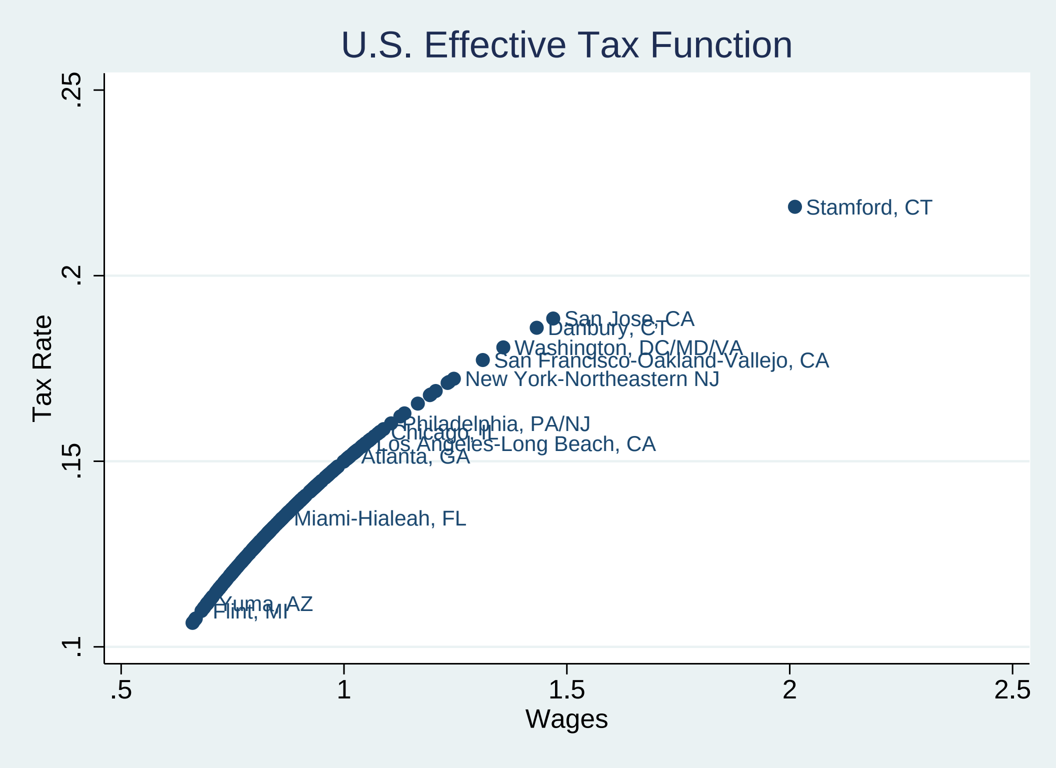
- Get an estimate $\tau = 0.1203$
    - Robustness, $\tau = 0.053$ and $\tau = 0.2$ — Guner, Kaygusuz and Ventura (2014)

- λ 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 $\tau = 0.1203$

w	0.5	1	2	5
average tax rate	11.4%	15%	25%	32.8%

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


U.S. Effective Tax Function
Tax Rate
.25
.2
.15
.1
.5
1
1.5
2
Wages

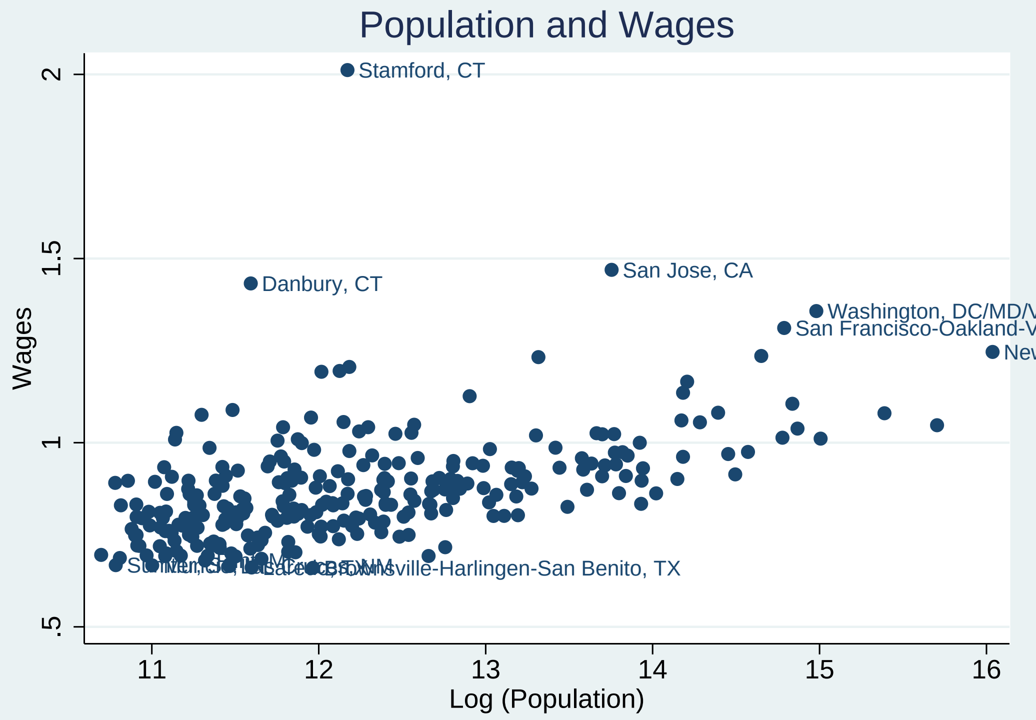

U.S. Effective Tax Function
Tax Rate
Wages
.1
.15
.2
.25
.5
1
1.5
2
2.5
Stamford, CT
San Jose, CA
Danbury, CT
Washington, DC/MD/VA
San Francisco-Oakland-Vallejo, CA
New York-Northeastern NJ
Philadelphia, PA/NJ
Chicago, IL
Los Angeles-Long Beach, CA
Atlanta, GA
Miami-Hialeah, FL
Yuma, AZ
Flint, MI

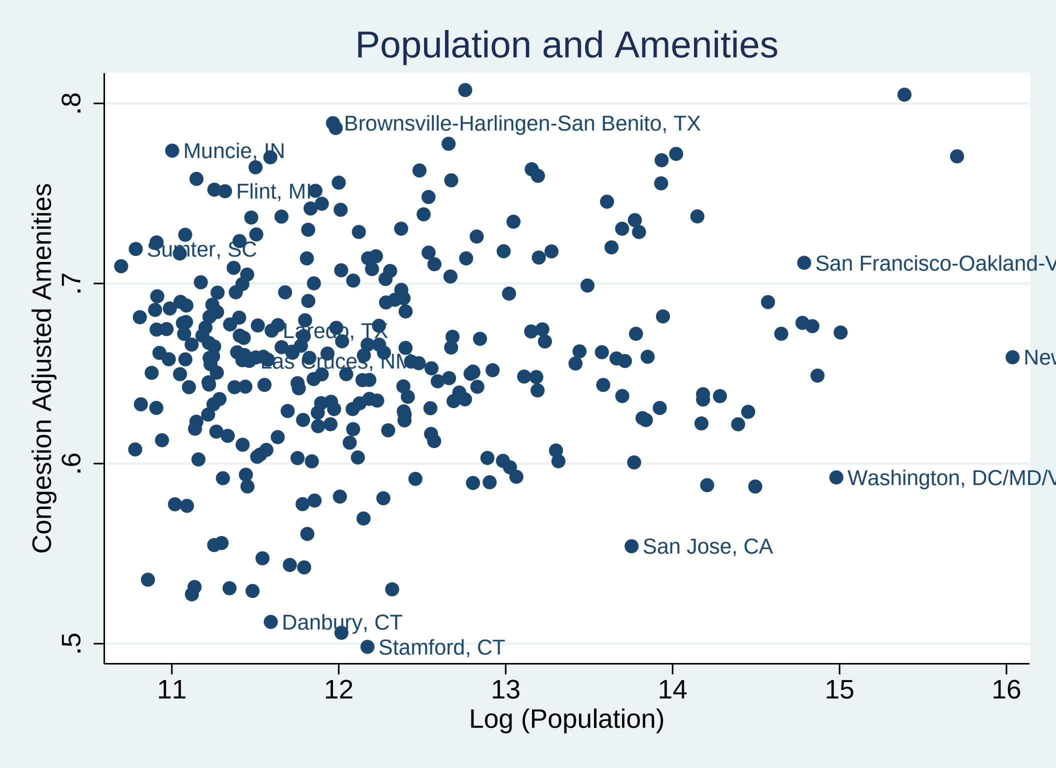
Benchmark Economy - Preference Parameters

- 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*(16$+16$) = 4.16$ a day cost associated with changes in size
  - 4.16$/160$ = 0.026 (2.7% of daily wages)

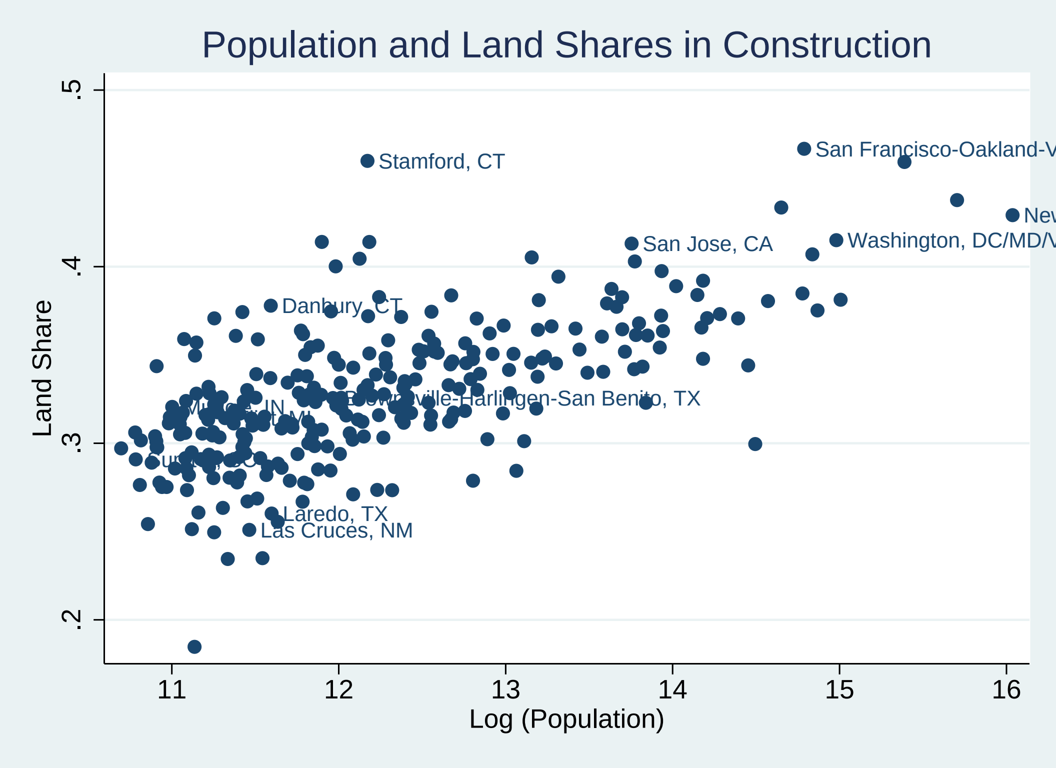
- Need to determined $\{\beta, \rho, B, a_j\}$.
- Select β and ρ such that: i) average share of land in housing cost is 0.3, ii) the share ranges from 0.1 to 0.5 across MSA –Albouy and Ehrlich (2012)
- Select B such that $h = 200$ m^2 (average value across MSAs)
- Find a_j from utility equalization

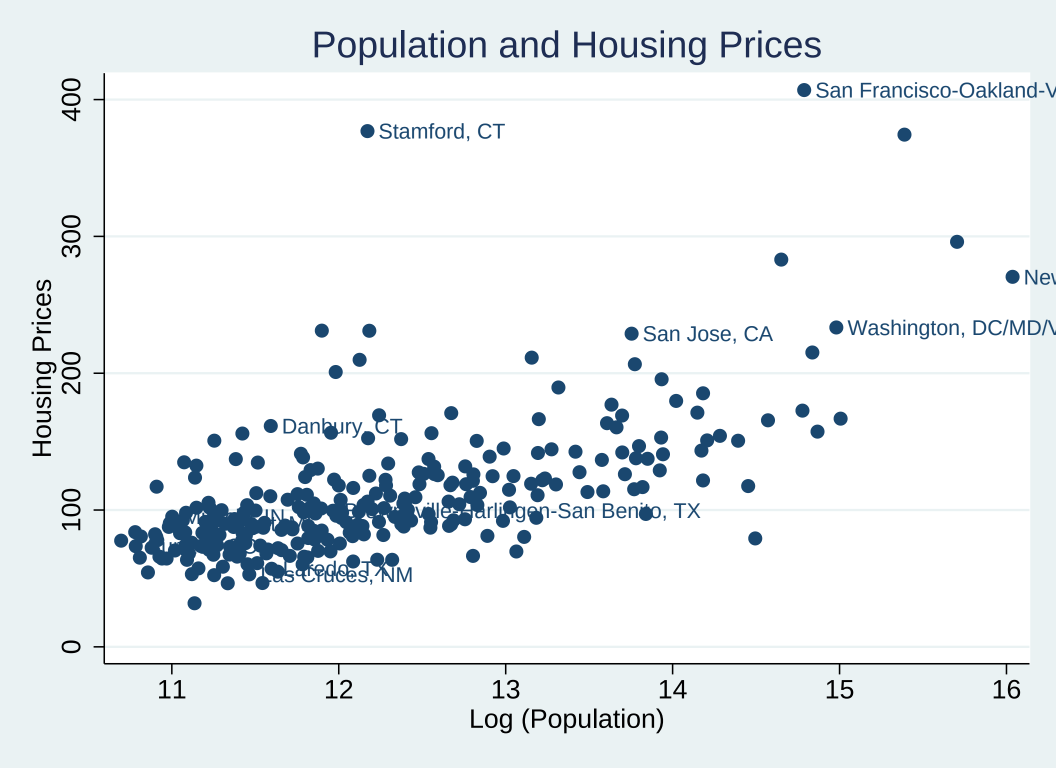
- Procedure: take A_j, T_j and l_j from data, given λ and τ, find $\{p_j, r_j, H_j, a_j, c_j, h_j, R, TR\}$ such that l_j's are *equilibrium allocations*.


Population and Wages
Stamford, CT
San Jose, CA
Danbury, CT
Washington, DC/MD/V
San Francisco-Oakland-V
New
Brownsville-Harlingen-San Benito, TX
Wages
2
1.5
1
.5
11
12
13
14
15
16
Log (Population)

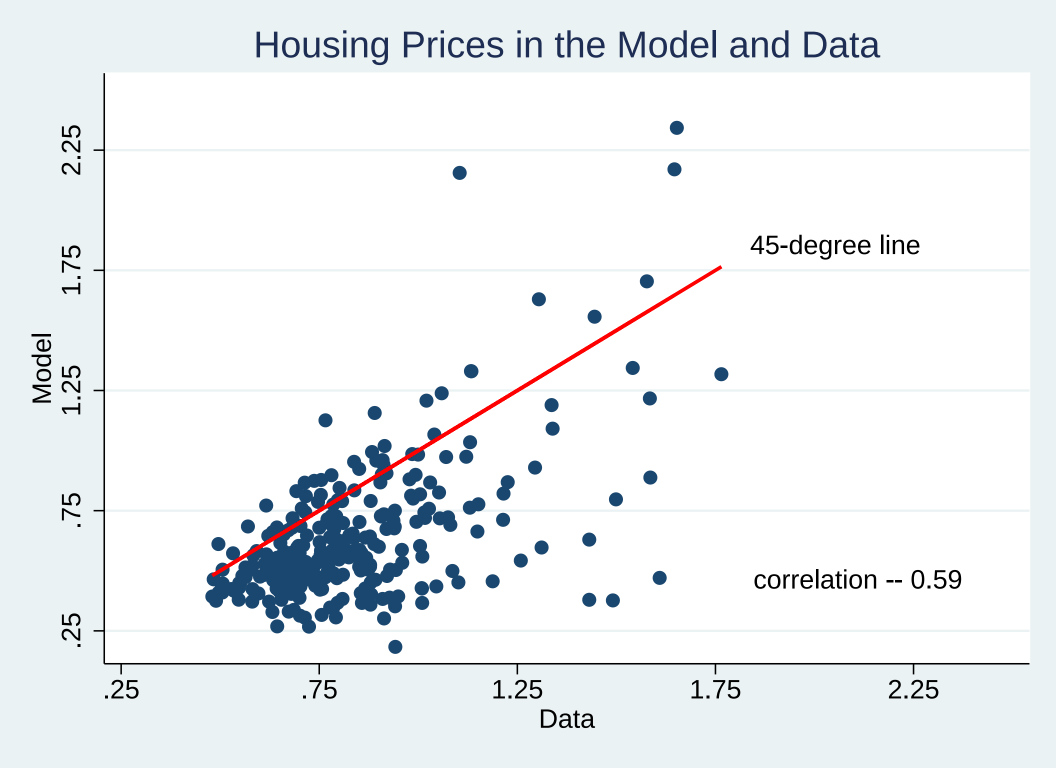


Population and Amenities
Congestion Adjusted Amenities
Log (Population)
.5
.6
.7
.8
11
12
13
14
15
16
Brownsville-Harlingen-San Benito, TX
Muncie, IN
Flint, MI
Sumter, SC
Laredo, TX
Las Cruces, NM
San Francisco-Oakland-V
New
Washington, DC/MD/V
San Jose, CA
Danbury, CT
Stamford, CT


Population and Land Shares in Construction
Stamford, CT
San Francisco-Oakland-V
New
San Jose, CA
Washington, DC/MD/V
Danbury, CT
Brownsville-Harlingen-San Benito, TX
Laredo, TX
Las Cruces, NM
Land Share
.5
.4
.3
.2
11
12
13
14
15
16
Log (Population)



Population and Housing Prices
Housing Prices
Log (Population)
0
100
200
300
400
11
12
13
14
15
16
San Francisco-Oakland-V
Stamford, CT
New
San Jose, CA
Washington, DC/MD/V
Danbury, CT
Laredo, TX
Las Cruces, NM



Housing Prices in the Model and Data
45-degree line
correlation -- 0.59
Model
Data
.25
.75
1.25
1.75
2.25

- Given A_j, T_j, a_j, find τ^* (and the associated prices and quantities) to maximize welfare
- Find the new allocations using

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

or

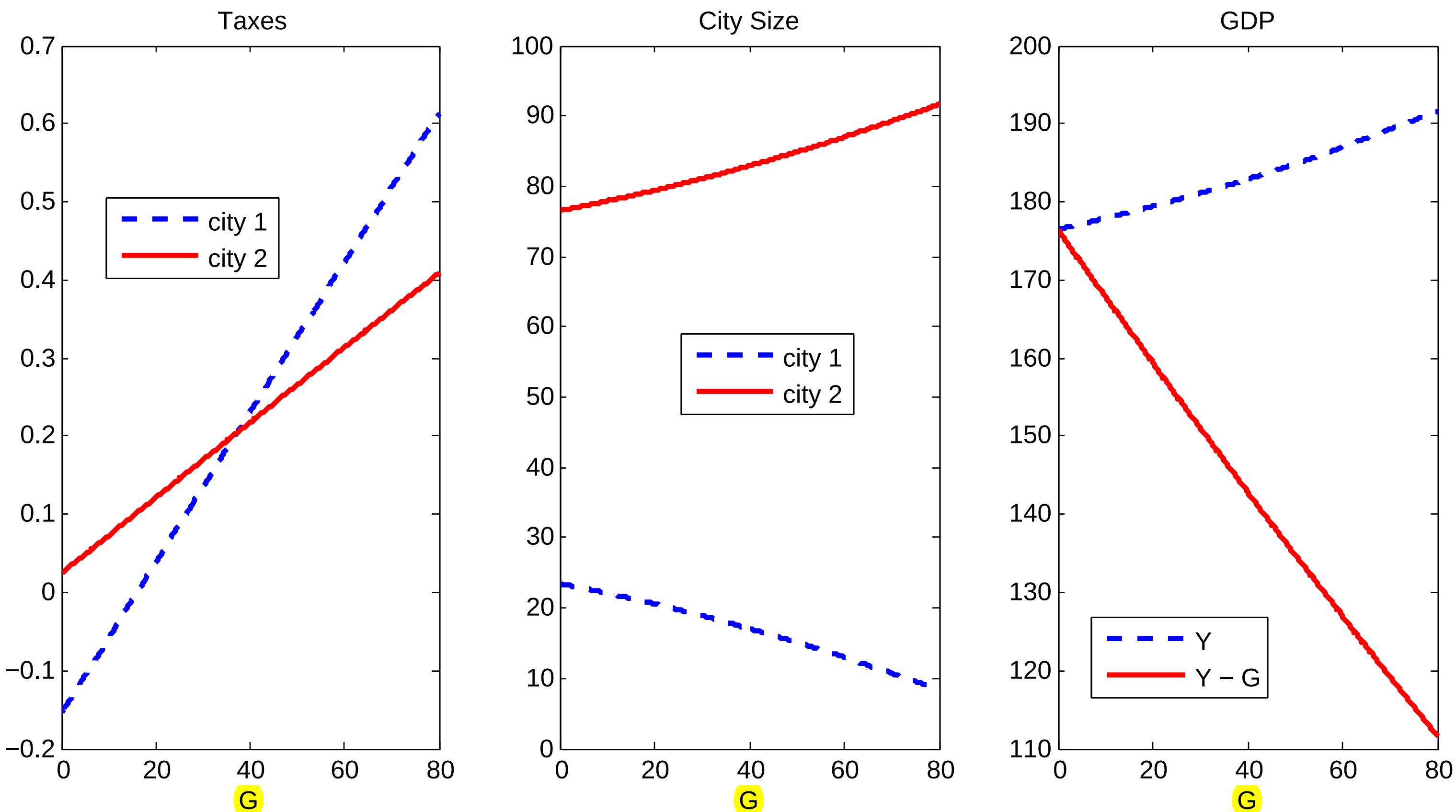
$$l_j = l_1 [(\frac{H_j}{H_1})^{\frac{\alpha}{\alpha-\delta}} a_j^{\frac{1}{\alpha-\delta}} (\frac{\lambda w_j^{1-\tau} + R + TR}{\lambda w_1^{1-\tau} + R + TR})^{\frac{1-\alpha}{\alpha-\delta}} (\frac{(1-\beta)(\frac{1-\beta}{\beta} r_j)^{\frac{\rho}{1-\rho}} + \beta}{(1-\beta)(\frac{1-\beta}{\beta}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

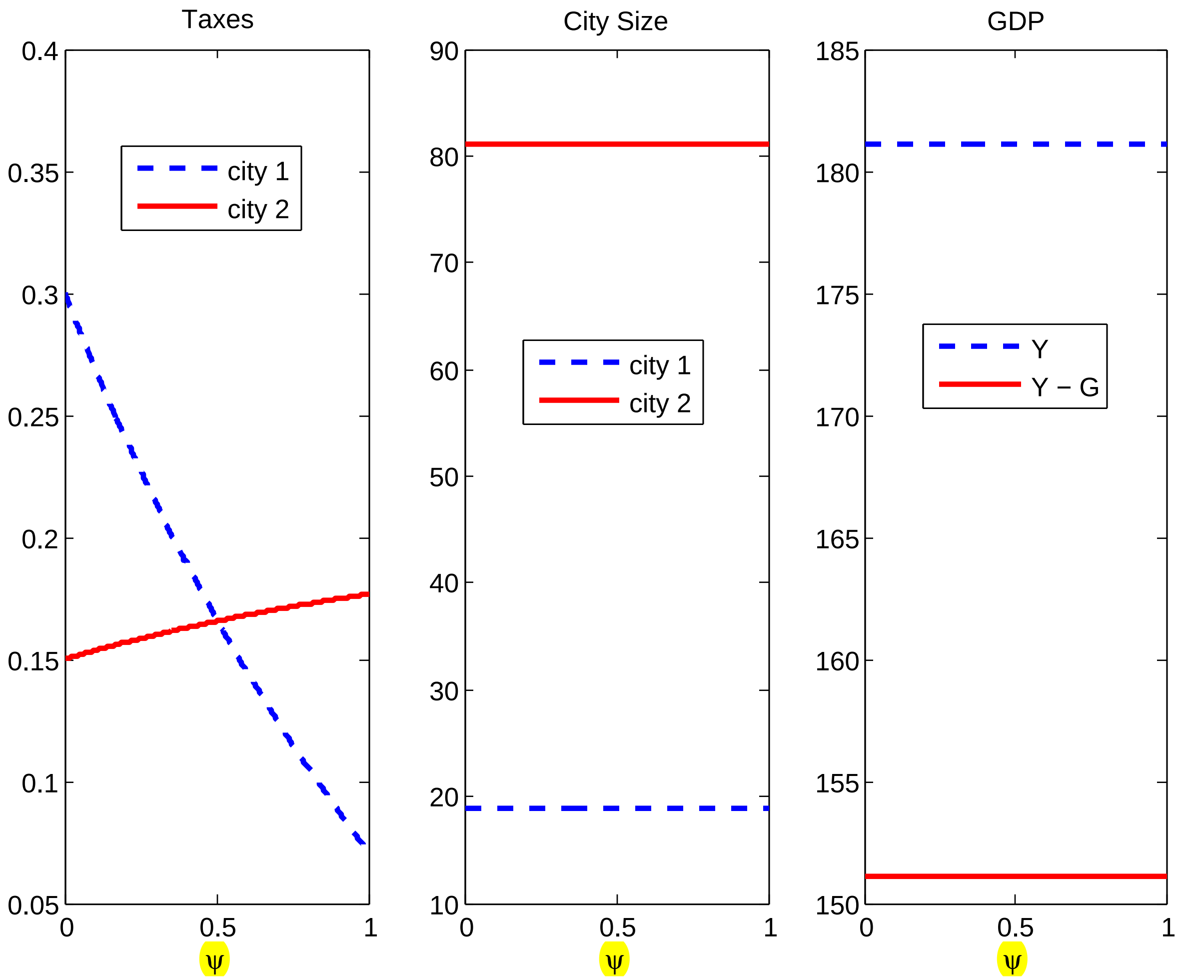
- Given A_j, T_j, a_j, find τ^* (and the associated prices and quantities) to maximize welfare
- Adjust λ to assure revenue neutrality

$$\sum_j l_j(\tau) w_j(\tau)(1 - \lambda w_j^{-\tau}) = \sum_j l_j w_j (1 - \lambda^{US} w_j^{-\tau^{US}}).$$

Optimal Taxes – Two City Example

- 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.

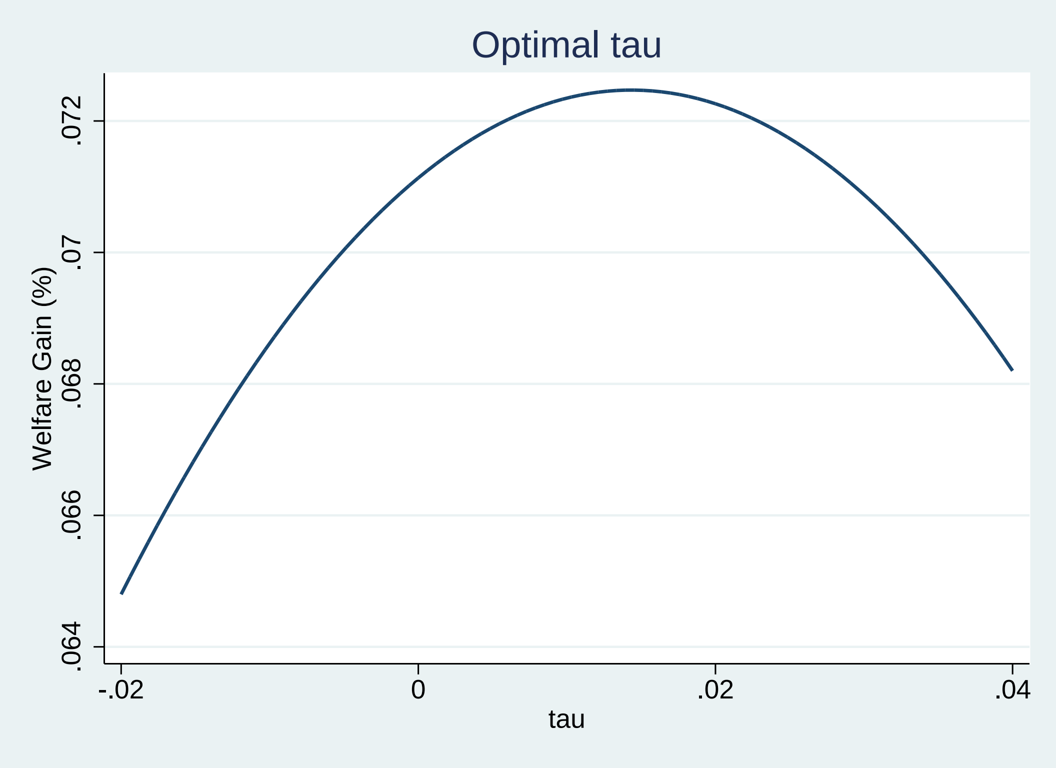

Taxes
city 1
city 2
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
0
20
40
60
80
G
City Size
100
90
80
70
60
50
40
30
20
10
0
G
GDP
200
190
180
170
160
150
140
130
120
110
Y
Y − G
G



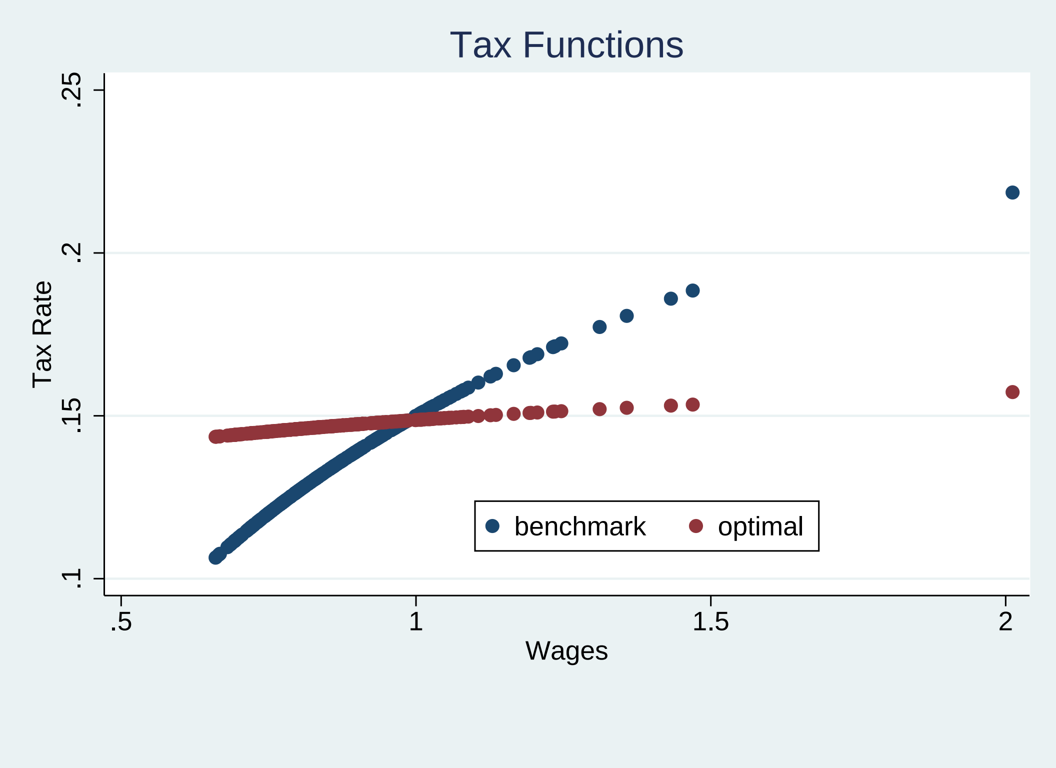
Taxes
city 1
city 2
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.5
1
ψ
City Size
city 1
city 2
90
80
70
60
50
40
30
20
10
0
0.5
1
ψ
GDP
Y
Y − G
185
180
175
170
165
160
155
150
0
0.5
1
ψ

- Given A_j, T_j, a_j, find τ^* (and the associated prices and quantities) to maximize welfare
- Adjust λ to assure revenue neutrality

$$\sum_j l_j(\tau) w_j(\tau)(1 - \lambda w_j^{-\tau}) = \sum_j l_j w_j (1 - \lambda^{US} w_j^{-\tau^{US}}).$$



Optimal tau
Welfare Gain (%)
.064
.066
.068
.07
.072
-.02
0
.02
.04
tau



Tax Functions
Tax Rate
.1
.15
.2
.25
.5
1
1.5
2
Wages
benchmark
optimal

Optimal Taxes – Quantitative Analysis

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

Benchmark Economy, move from τ to τ^*

Outcomes	
Welfare gain (%)	0.0725
Output gain (%)	1.57
Consumption (%)	1.53
Housing Consumption (%)	-1.75
Population change top 5 cities (%)	7.95
Fraction of Population that Moves (%)	3.47
Change in average prices (%)	5.32

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

Benchmark Economy, move from τ to τ^*

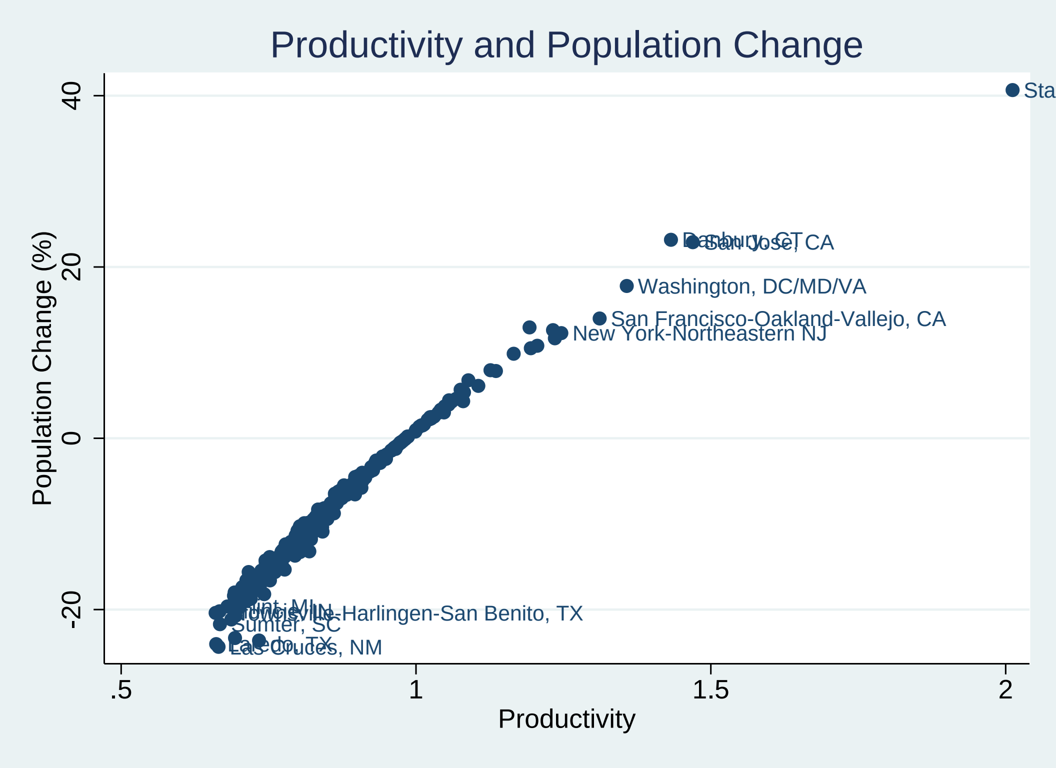
Outcomes	
Welfare gain (%)	0.0725
Output gain (%)	1.57
Consumption (%)	1.53
Housing Consumption (%)	-1.75
Population change top 5 cities (%)	7.95
Fraction of Population that Moves (%)	3.47
Change in average prices (%)	5.32

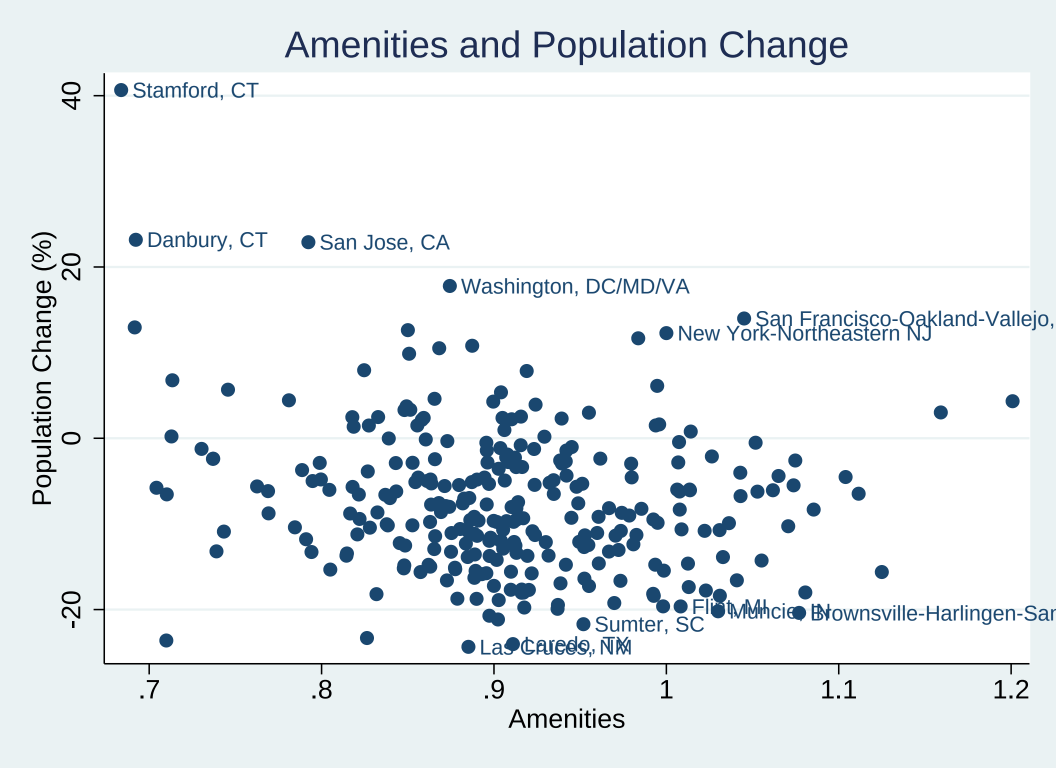
Optimal Taxes – Select Cities

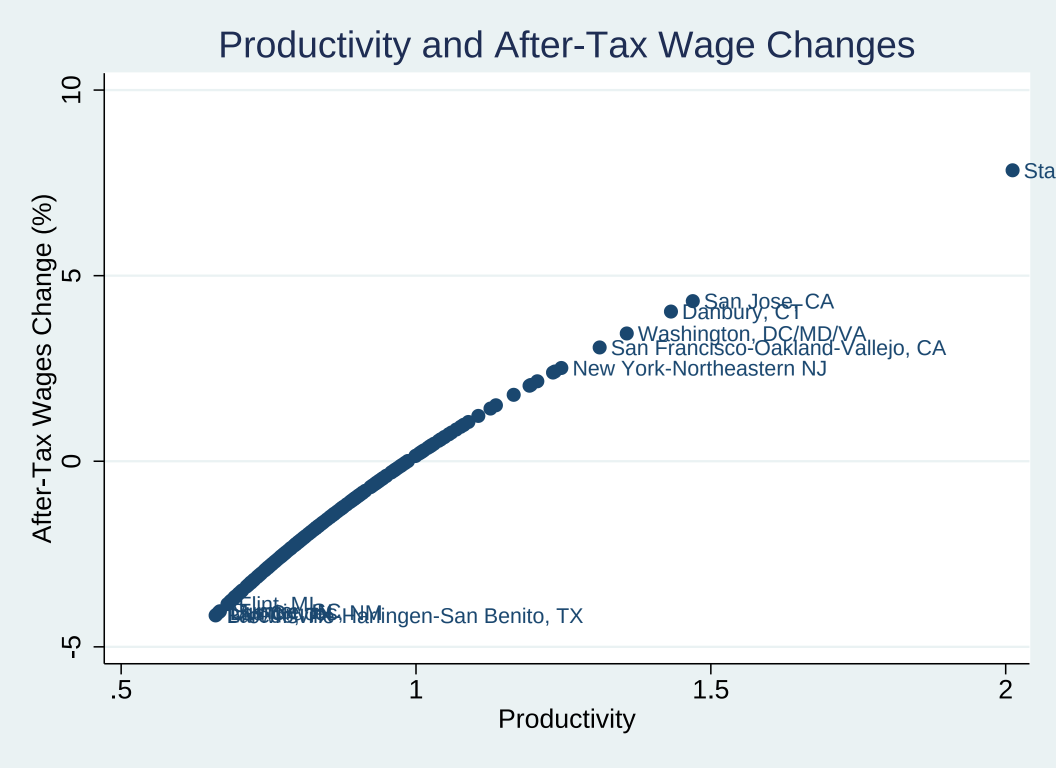
MSA	A	a	$\%\Delta l$	$\%\Delta p$	$\%\Delta c$	$\%\Delta h$
Highest A						
Stamford, CT	2.01	0.68	40.65	23.52	7.17	-13.34
San Jose, CA	1.47	0.79	22.09	11.98	3.88	-7.24
Danbury, CT	1.43	0.69	23.18	10.99	3.62	-6.64
Lowest A						
Las Cruces, NM	0.67	0.89	-24.35	-8.34	-3.06	5.76
Laredo, TX	0.66	0.91	-24.03	-8.52	-3.11	5.92
Brownsville-...., TX	0.66	1.08	-20.39	-8.95	-3.12	6.41

Optimal Taxes – Select Cities

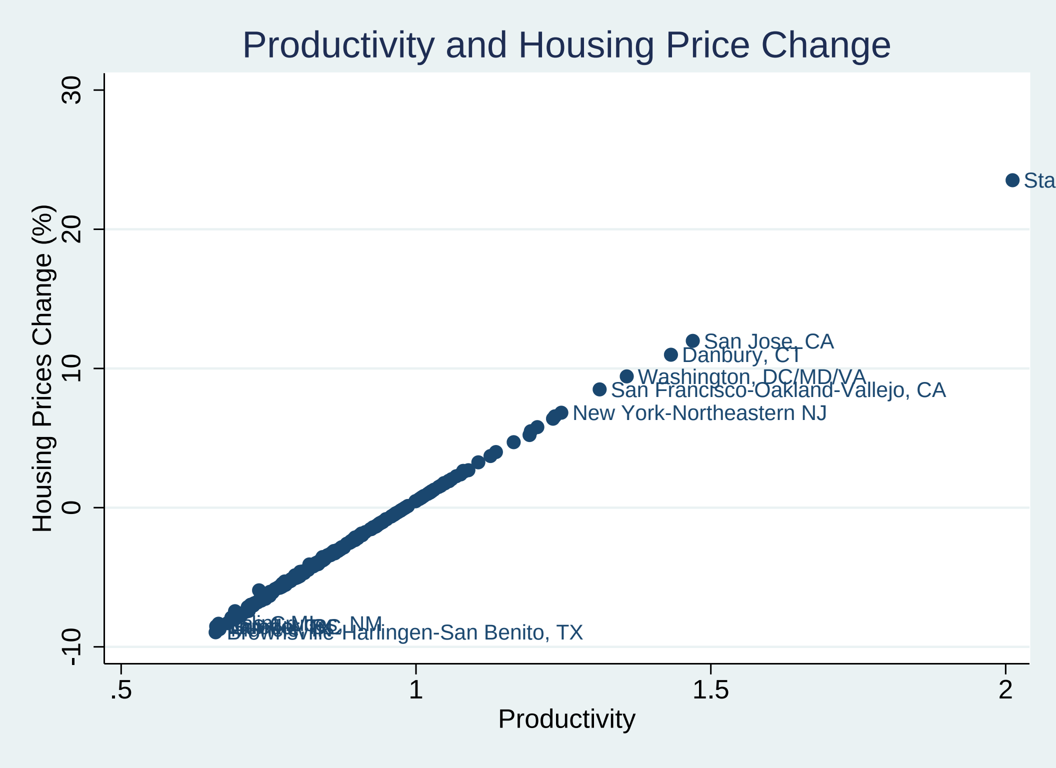
MSA	A	a	$\%\Delta l$	$\%\Delta p$	$\%\Delta c$	$\%\Delta h$
Highest a						
Chicago, IL	1.08	1.20	4.33	2.64	0.92	-1.67
LA-Long Beach, CA	1.05	1.16	3.02	1.76	0.65	-1.10
El Paso, TX	0.72	1.12	-15.62	-7.42	-2.51	5.30
Lowest a						
Danbury, CT	1.43	0.69	23.18	10.95	3.62	-6.64
Anchorage, AK	1.19	0.69	12.94	5.22	1.84	-3.21
Stamford, CT	2.01	0.68	40.65	23.22	7.17	-13.24


Productivity and Population Change
Population Change (%)
40
20
0
-20
Productivity
.5
1
1.5
2
Sta
Danbury, CT
San Jose, CA
Washington, DC/MD/VA
San Francisco-Oakland-Vallejo, CA
New York-Northeastern NJ
Harlingen-San Benito, TX
Sumter, SC
Laredo, TX
Las Cruces, NM

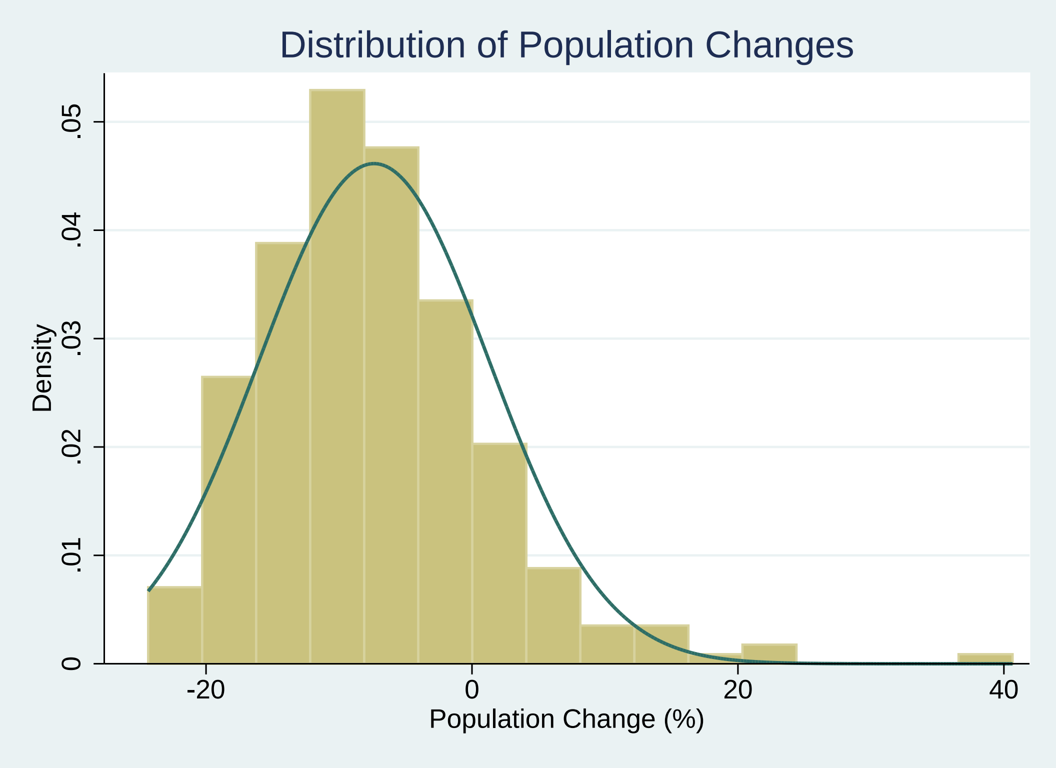

Amenities and Population Change
Population Change (%)
40
20
0
-20
.7
.8
.9
1
1.1
1.2
Amenities
Stamford, CT
Danbury, CT
San Jose, CA
Washington, DC/MD/VA
San Francisco-Oakland-Vallejo,
New York-Northeastern NJ
Flint, MI
Muncie, IN
Brownsville-Harlingen-San
Sumter, SC
Laredo, TX
Las Cruces, NM



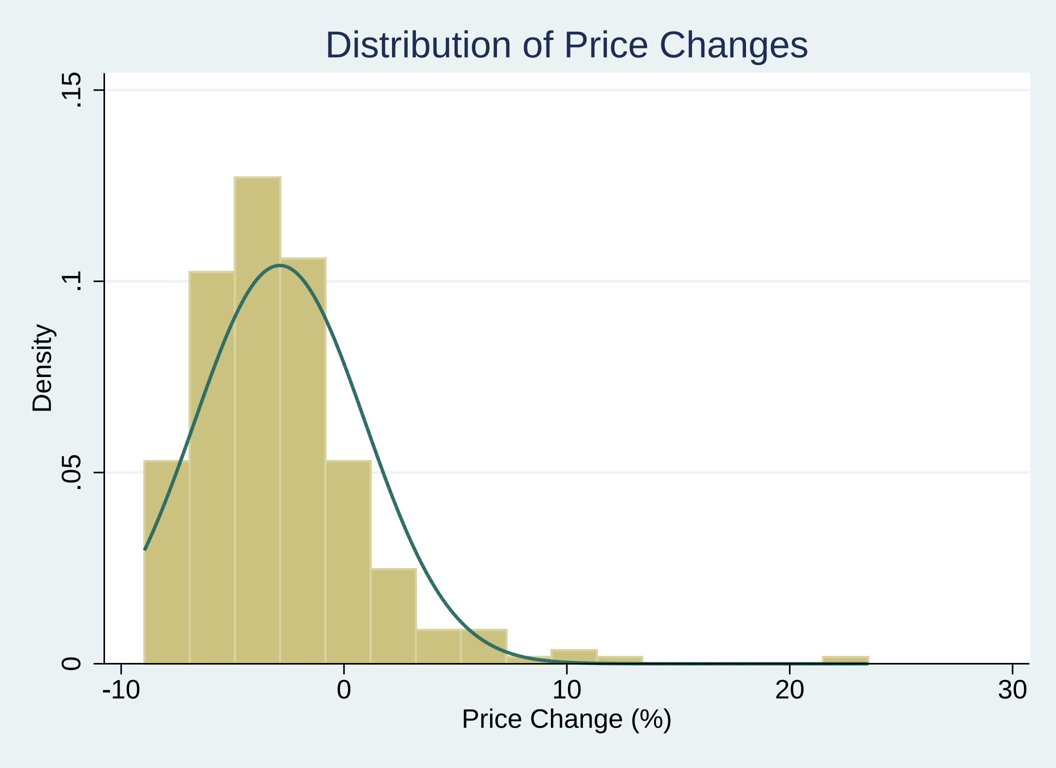
Productivity and After-Tax Wage Changes
After-Tax Wages Change (%)
10
5
0
-5
Productivity
.5
1
1.5
2
San Jose, CA
Danbury, CT
Washington, DC/MD/VA
San Francisco-Oakland-Vallejo, CA
New York-Northeastern NJ
Flint, MI



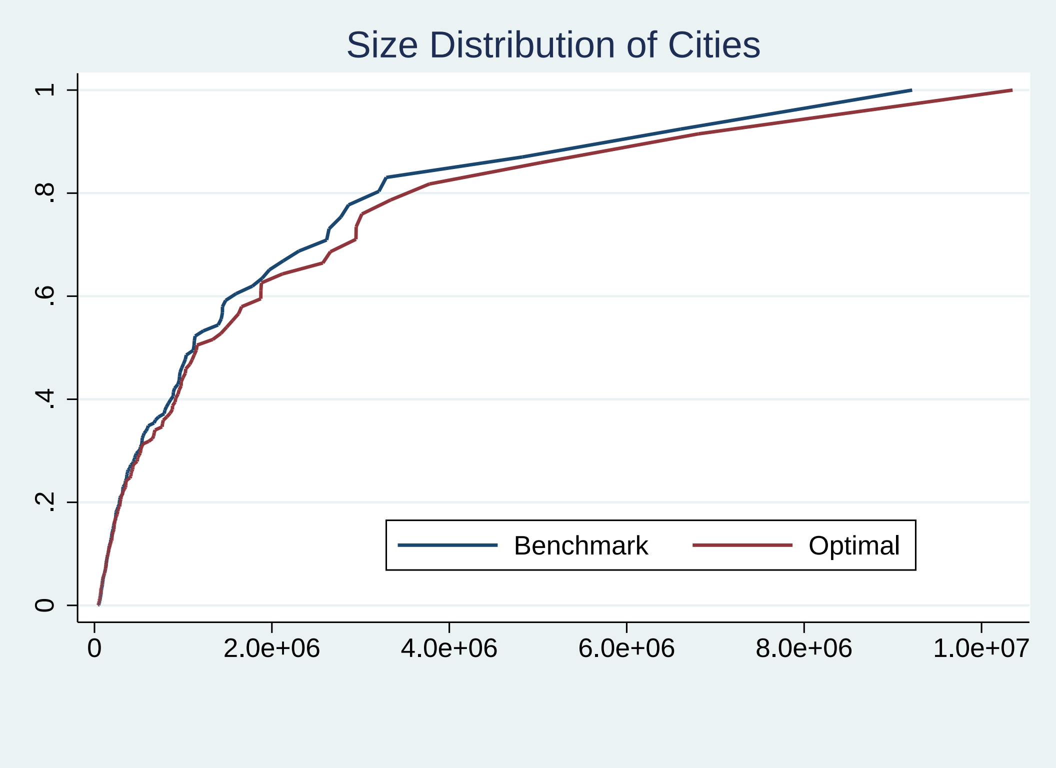
Productivity and Housing Price Change
Housing Prices Change (%)
30
20
10
0
-10
.5
1
1.5
2
Productivity
Sta
San Jose, CA
Danbury, CT
Washington, DC/MD/VA
San Francisco-Oakland-Vallejo, CA
New York-Northeastern NJ
Brownsville-Harlingen-San Benito, TX



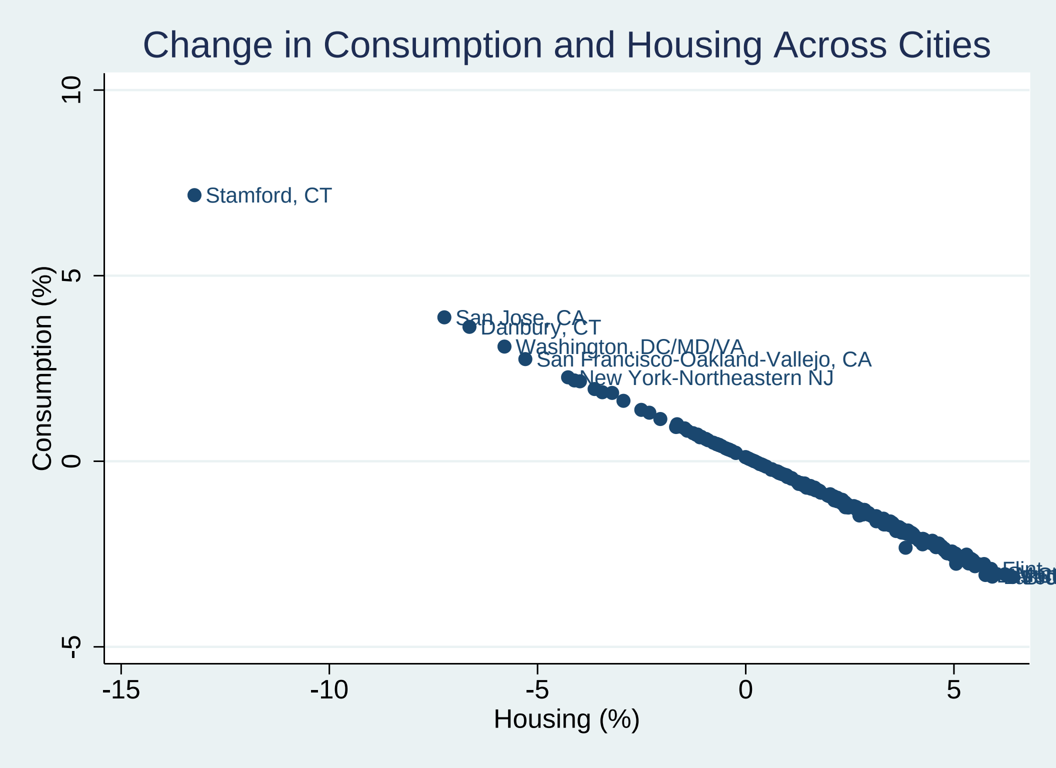
Distribution of Population Changes
Density
0
.01
.02
.03
.04
.05
-20
0
20
40
Population Change (%)



Distribution of Price Changes
Density
0
.05
.1
.15
-10
0
10
20
30
Price Change (%)



Size Distribution of Cities
1
.8
.6
.4
.2
0
0
2.0e+06
4.0e+06
6.0e+06
8.0e+06
1.0e+07
Benchmark
Optimal


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
10
5
0
-5
Consumption (%)
-15
-10
-5
0
5
Housing (%)

Size of Government

	$\lambda = 0.9$			$\lambda = 0.85$		
τ	0.053	0.120	0.2	0.053	0.120	0.2
Optimal τ	0.0606	0.0646	0.0697	0.0095	0.0145	0.0189
Output gain (%)	-0.13	0.93	2.21	0.64	1.57	2.72
Pop. in 5 cit. (%)	-0.64	4.76	11.21	3.25	7.95	13.69
Pop. move. (%)	0.28	2.08	4.88	1.42	3.47	5.95
Avg. prices (%)	-0.40	3.07	7.58	2.10	5.32	9.56
Welfare gain (%)	0.0004	0.0237	0.1315	0.0119	0.0725	0.2105

Size of Government

	$\lambda = 0.9$			$\lambda = 0.85$		
τ	0.053	0.120	0.2	0.053	0.120	0.2
Optimal τ	0.0606	0.0646	0.0697	0.0095	0.0145	0.0189
Output gain (%)	-0.13	0.93	2.21	0.64	1.57	2.72
Pop. in 5 cit. (%)	-0.64	4.76	11.21	3.25	7.95	13.69
Pop. move. (%)	0.28	2.08	4.88	1.42	3.47	5.95
Avg. prices (%)	-0.40	3.07	7.58	2.10	5.32	9.56
Welfare gain (%)	0.0004	0.0237	0.1315	0.0119	0.0725	0.2105

Size of Government

	$\lambda = 0.85$			$\lambda = 0.815$		
τ	0.053	0.120	0.2	0.053	0.120	0.2
Optimal τ	0.0095	0.0145	0.0189	-0.0212	-0.0167	-0.0116
Output gain (%)	0.64	1.57	2.72	1.02	1.89	2.96
Pop. in 5 cit. (%)	3.25	7.95	13.69	5.13	9.53	14.77
Pop. move. (%)	1.42	3.47	5.95	2.24	4.14	6.41
Avg. prices (%)	2.10	5.32	9.56	3.38	6.49	10.48
Welfare gain (%)	0.0119	0.0725	0.2105	0.0319	0.1086	0.2585

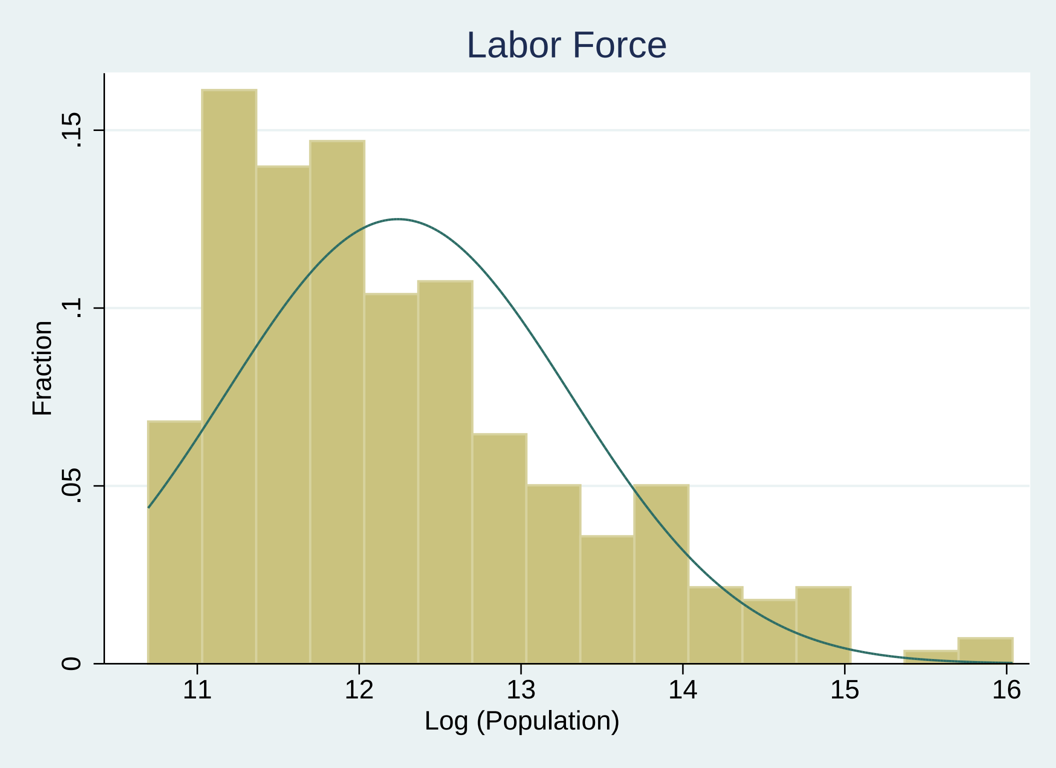
Optimal Taxes – Land Ownership

Different Values of ψ

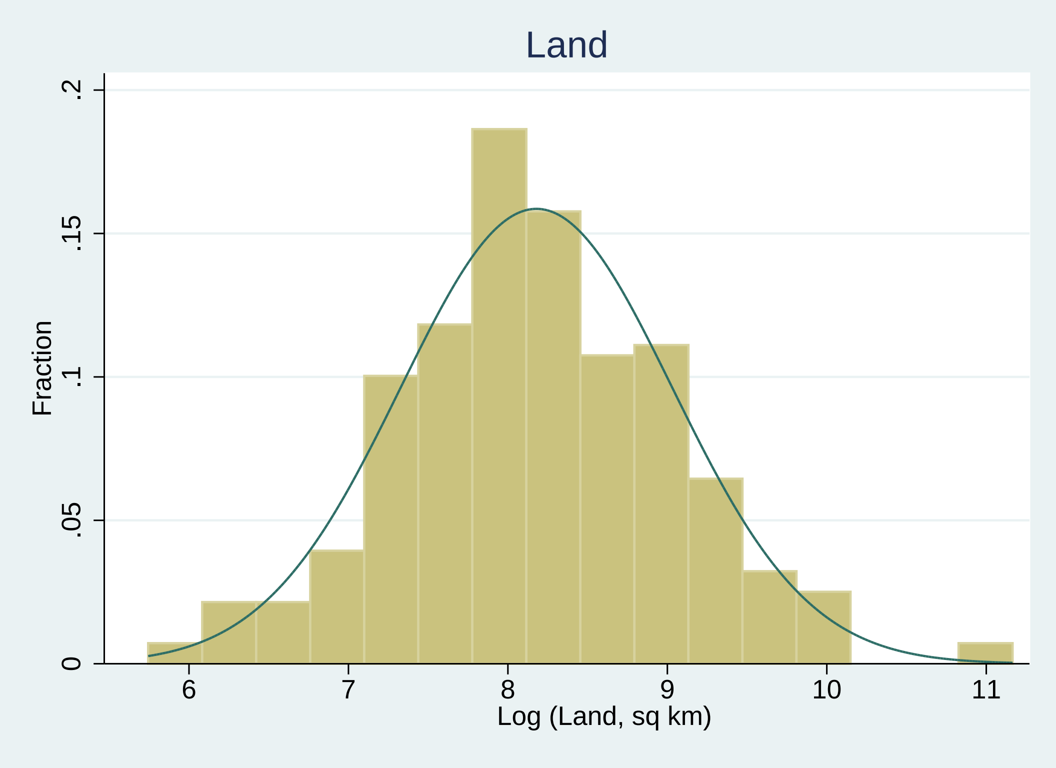
Outcomes	Benchmark $\psi = 0.35$	All Bond $\psi = 0$	All Landlords $\psi = 1$
Optimal τ	0.0145	-0.1394	0.0783
Output gain (%)	1.57	3.60	0.65
Consumption (%)	1.53	3.69	0.61
Housing Consumption (%)	-1.75	-4.04	-0.71
Pop. change top 5 cities (%)	7.95	18.24	3.31
Frac. of Pop. that Moves (%)	3.47	7.65	1.45
Change in average prices (%)	5.32	13.09	2.11
Welfare gain (%)	0.0725	0.3445	0.0130

Conclusions

- 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

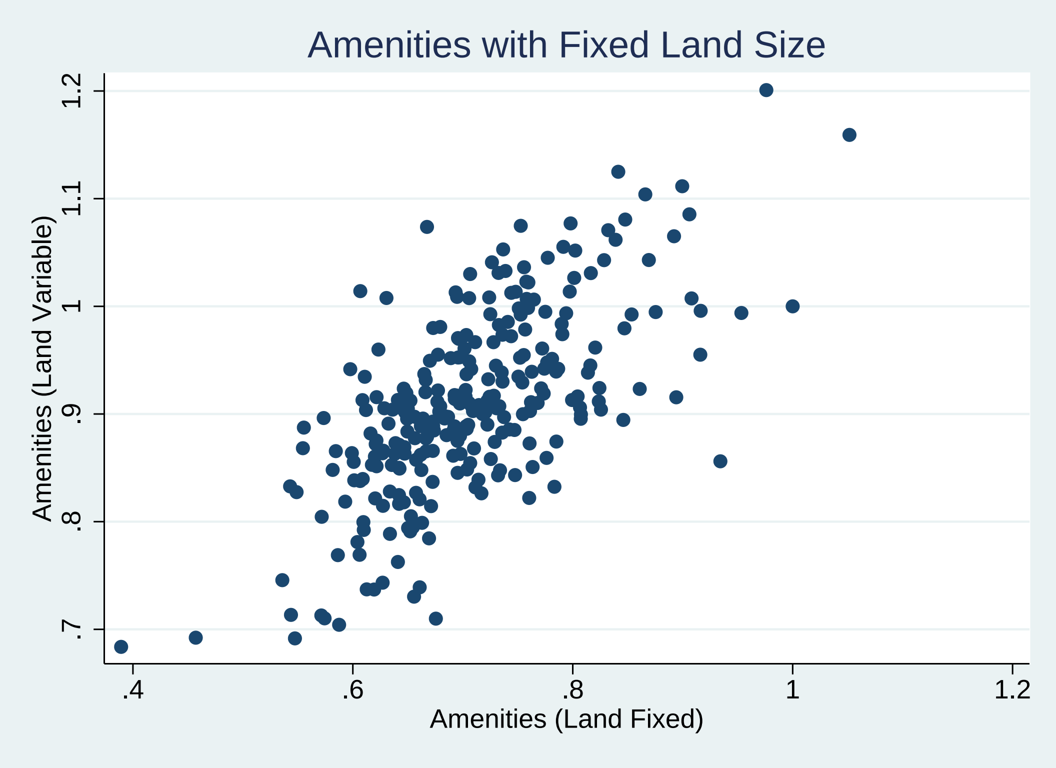

Labor Force
Fraction
0
.05
.1
.15
11
12
13
14
15
16
Log (Population)


Wages
Fraction
0
.05
.1
.15
.2
6.2
6.4
6.6
6.8
7
7.2
Log (Weekly Wages)


Land
Fraction
0
.05
.1
.15
.2
6
7
8
9
10
11
Log (Land, sq km)

Sensitivity – Equal Land Size

Outcomes	Benchmark	Fixed Land
Optimal τ	0.0145	0.0303
Output gain (%)	1.57	1.30
Population change top 5 cities (%)	7.95	6.00
Fraction of Population that Moves (%)	3.47	2.77
Change in average prices (%)	5.32	5.34
Welfare gain (%)	0.0725	0.0485



Amenities with Fixed Land Size
Amenities (Land Variable)
1.2
1.1
1
.9
.8
.7
.4
.6
.8
1
1.2
Amenities (Land Fixed)

Sensitivity – No Tax Rebate

Outcomes	Benchmark	No Tax Rebate
Optimal τ	0.0145	0.0073
Output gain (%)	1.57	1.95
Population change top 5 cities (%)	7.95	9.83
Fraction of Population that Moves (%)	3.47	4.30
Change in average prices (%)	5.32	6.69
Welfare gain (%)	0.0725	0.109