Properties of Property Taxation

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2021 Applied Economics Workshop, IES, Keio University
June 18, 2021

The latest slides will be available on Oshiro's website.

sites.google.com/site/junoshiro5urban/portfolio

- property tax competition attracting labor and capital
  - use Japanese & German city-level data
- tax rate:

  JPN: observed $>$ decentralized $>$ homevoter $>$ centralized

  DEU: decentralized $>$ homevoter $>$ centralized $>$ observed
- welfare:

  both: centralized $>$ homevoter $>$ decentralized $>$ observed

big picture

- **Property tax** = local taxation on land, structure, & depreciating assets
- two different (prima facie) regimes of property taxation:
  1. Centralized regime $\cdots$ Japanese cities adopt a common reference rate offered by a central govt
  2. Decentralized regime $\cdots$ German cities set their tax rate non-cooperatively

  $\longrightarrow$ How different?
- We address how to design the tax system taking spatial issues (labor & capital mobility) into consideration

literature: policies on mobile factors

- Fiscal competition—Decentralization causes distortion in taxation (Wilson 1986; Zodrow & Mieszkowski 1986)
  - tax on mobile capital
  - race to the bottom (too low taxes)
- System of cities—Decentralization causes distortion in population (Henderson 1974; Kanemoto 1980)
  - control mobile worker
  - too large cities due to migration

literature: heterogeneity

- Heterogeous fiscal competition—Bucovetsky 1991; Haufler & Wooton 1999; Ottaviano & van Ypersele 2005; Baldwin & Krugman 2004; Borck & Pflüger 2006
  - heterogeneity in country size matters:
  - small regions often gain under perfect competition
  - large regions often gain under monopolistic competition
- Heterogeneous urban system—Albouy et al. 2019
  - heterogeneity in productivity matters:
  - the marginal social welfare of hosting a worker is higher in a city with higher production advantage $\rightarrow$ such a city can be inefficiently small

what we do

- Fiscal competition in the heterogeneous urban system
- The model:
  - many *small* open cities
  - 2 goods: structure service (fixed properties); final good (numeraire)
  - 3 factors: labor; capital; land
  - 2 agents: mobile workers; immobile landlords
  - heterogeneous regional characteristics: TFPs in production; amenity; mass of landlords; supply of land
  - 3 regimes: decentralized / centralized / homevoters (Fischel 2001)

main results

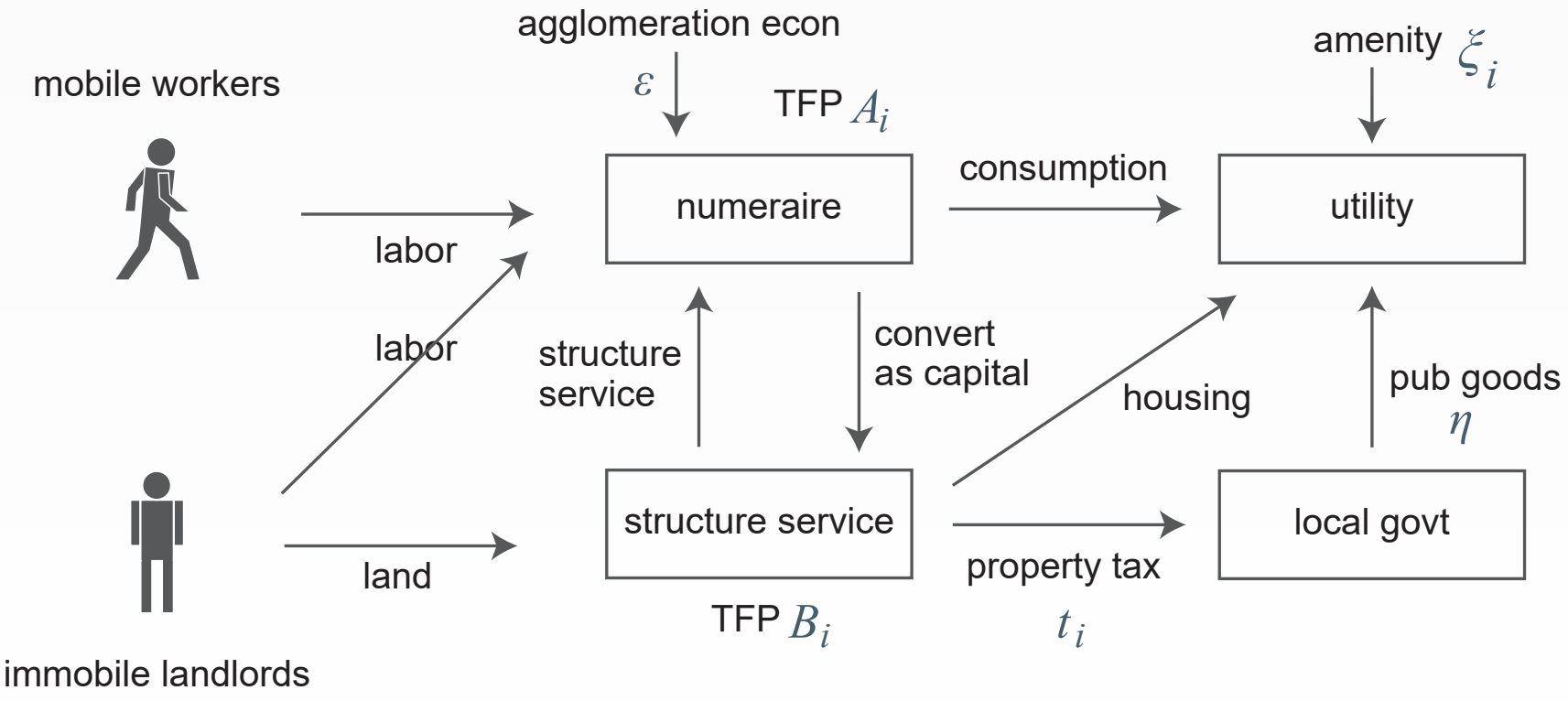
- Decentralized regime $\rightarrow$ too high taxes (race to the top)
  - Positive externality: attract workers $\rightarrow$ raising utility in the other cities via migration
  - Negative externality: attract workers $\rightarrow$ shrinking tax base and public good provision in the other cities
- Decentralization improves welfare in comparison to an observed situation.
  - Social welfare would rise from 0.1–1.9% if the decentralized regime emerged.
- Japanese tax rates are close to decentralized one while German tax rates are close to centralized one.

mathematical overview

- 4 key variables: p_i, λ_i, t_i, u_a.
- 4 equations:
  1. Structure service market clearing $\rightarrow$ price of structure p_i
  2. Spatial equilibrium $\rightarrow$ population share λ_i
  3. Policy regime $\rightarrow$ tax rates t_i
  4. Total population is fixed $\rightarrow$ reservation utility u_a
- Exact hat algebra: numerically find counterfactual equilibrium in terms of **change**: $\hat{p}_i, \hat{\lambda}_i, \hat{t}_i, \hat{u}_a$.
  - Computable by only a few, publicly available data (value of tax base; tax revenue; population; mass of landlords)

model

- competitive markets in system of cities



population & consumption

- Population n_i = workers + landlords
  - mobile workers have one unit of labor
  - immobile landlords are endowed with F_i units of land and one unit of labor
- Population share $\lambda_i = n_i / \sum_j n_j$, and $\sum_i \lambda_i = 1$.
- Choose consumption of numeraire c_i & housing d_i

$$u_i \propto \xi_i c_i^{1-\mu} d_i^{\mu} g_i^{\eta}.$$

amenity ↑ ↑ public goods

production

- Numeraire $y_i \leftarrow$ labor + structure service

$$y_i = A_i l_i^{\alpha} m_i^{1-\alpha} n_i^{\varepsilon}.$$

$\uparrow$ econ of agglomeration

- Structure service $x_i \leftarrow$ land + capital

$$x_i = B_i h_i^{\gamma} k_i^{1-\gamma}.$$

- Land endowments are H_i (exogenous). Thus $h_i = H_i$.
- Labor in a city is n_i (external for agents). Thus $l_i = n_i$.

structure service market

- market clearing condition of structure service determines $p_i = p_i(\lambda_i, t_i)$

$$x_i = \underbrace{m_i}_{\text{firms}} + \underbrace{\frac{H_i}{F_i} d_{Li}}_{\text{landlords}} + \underbrace{\left(n_i - \frac{H_i}{F_i}\right) d_{Wi}}_{\text{workers}}.$$

- free mobility $\rightarrow$ worker's indirect utility is equalized

$$\underbrace{\left(n_i - \frac{H_i}{F_i}\right)}_{\#\text{ of workers}} \underbrace{(u_{Wi} - u_a)}_{\text{util gap}} = 0, \text{ \& slacks}$$

where u_a is a common utility level.

- Determines population share $\lambda_i = \lambda_i(t_i, u_a)$.

assumptions

- Assumption 1 (stability): we focus on a *stable* equilibrium where $\partial u_{Wi}/\partial \lambda_i < 0$ at an interior eq. This holds iff $(1 - \mu\gamma + \eta)(\alpha + \varepsilon)/(\alpha + \gamma - \alpha\gamma) < 1$.
- Assumption 2 (positive tax effect): An increase in the tax rate increases the utility of workers

$$\frac{\partial u_{Wi}}{\partial t_i} > 0.$$

(+) $t_i \nearrow \rightarrow$ public goods $\nearrow \rightarrow u_{Wi} \nearrow$

(-) $t_i \nearrow \rightarrow$ housing demands $\searrow \rightarrow u_{Wi} \searrow$

(-) $t_i \nearrow \rightarrow$ cost of living $(t_i p_i) \nearrow \rightarrow u_{Wi} \searrow$

governments

- The budget constraint for local governments ▸ Appendix

$$g_i = \text{property tax revenue.}$$

- Benthamite welfare:

$$\begin{aligned} W_i &= (\#\text{ of workers})\, u_{Wi} + (\#\text{ of landlords})\, u_{Li} \\ &= n_i u_{Wi} \left(1 + \gamma \frac{\mu + (1-\alpha)/\alpha}{t_i - \mu\gamma}\right). \end{aligned}$$

- Nation-wide welfare:

$$SW = \sum_i W_i.$$

regimes

1. **Decentralized regime**: City i chooses t_i to maximize Benthamite welfare W_i. Cities take u_a as given and take into consideration market responses.

2. **Centralized regime**: A central planner chooses a uniform tax rate $t_i = t$ for all i to maximize social welfare SW.

3. **Homevoter regime**: City i chooses t_i to maximize landlords' utility u_{Li}. Cities take u_a as given and take into consideration market responses.

propositions

Proposition 1 (*race to the top*)

Assume all cities are in an interior equilibrium ($u_{Wi} = u_a$). Under decentralized regime, the equilibrium tax rates are **always inefficiently high**.

[sketch of proof] Evaluate social welfare around equilibrium:

$$\frac{t_i}{SW}\frac{\partial SW}{\partial t_i}\Big|_{\text{d-equilibrium}} = \epsilon_{ut}(1+\epsilon_{nu}) < 0,$$

where

$$\epsilon_{ut} = \frac{t_i}{u_a}\frac{\partial u_a}{\partial t_i} = \frac{t_i}{u_a}\frac{\partial u_{Wi}}{\partial t_i}\left[\sum_j \frac{\partial u_{Wi}/\partial \lambda_i}{\partial u_{Wj}/\partial \lambda_j}\right]^{-1} > 0,$$

$$\epsilon_{nu} = \frac{u_a}{\lambda_i}\frac{\partial \lambda_i}{\partial u_a} = -\left[1 - \frac{(\alpha+\varepsilon)(1-\gamma\mu+\eta)}{\alpha+\gamma-\alpha\gamma}\right]^{-1} < -1.$$

intuition for Proposition 1

- Positive externality (1 of $1 + \epsilon_{nu}$):
  - raising taxes attracts workers (Assumption 2).
  - rest of the city face emigration $\rightarrow u_a$ should rise (Assumption 1) but the small city ignores this
- Negative externality (ϵ_{nu} of $1 + \epsilon_{nu}$):
  - Emigration reduces Benthamite sum of utility ($W_j = n_j \times$ per capita utility).
- The latter always dominates the former ($\epsilon_{nu} < -1$) (Assumption 1).

propositions

Proposition 2

Under centralized regime, the equilibrium tax rates are inefficiently high iff

$$\frac{1+\varepsilon}{\varepsilon\lambda_i}\frac{\partial u_a^o}{\partial t_i}+\frac{u_a}{n_i}\frac{\partial n_i^d}{\partial t_i}<\frac{\partial u_a^c}{\partial t}.$$

Proposition 3

Under homevoter regime, the equilibrium tax rates are lower than those under the decentralized regime, and are inefficiently high iff

$$\frac{(1+\varepsilon)/\varepsilon}{\sum_j 1/(\partial u_{Wj}/\partial\lambda_j)}\sum_j n_j\left(1+\gamma\frac{\mu+(1-\alpha)/\alpha}{t_i-\mu\gamma}\right)>u_a.$$

Both are proven in a similar manner to Proposition 1.

exact hat algebra

- Equilibrium (in level) that determines $\{p_i, \lambda_i, t_i, u_a\}$:

$$x_i = m_i + \frac{H_i}{F_i} d_{Li} + \left(n_i - \frac{H_i}{F_i} \right) d_{Wi}. \qquad \text{(structure market)}$$

$$\left(n_i - \frac{H_i}{F_i} \right) (u_{Wi} - u_a) = 0, \text{ \& slacks.} \qquad \text{(spatial eq)}$$

$$t_i = \text{argmax } W_i. \qquad \text{(regime)}$$

$$\sum_i \lambda_i = 1. \qquad \text{(pop constraint)}$$

- Depends on hardly observed heterogeneities: TFPs A_i, B_i, and amenity ξ_i.

exact hat algebra

- Denote the relative change in a variable z as $\hat{z} = z'/z$, where z' is its counterfactual value.
- Equilibrium in *change* that determines $\{\hat{p}_i, \hat{\lambda}_i, \hat{t}_i, \hat{u}_a\}$:

$$\hat{p}_i = \left(t_i^{1-1/\alpha} \frac{t_i - \gamma\mu}{t_i \hat{t}_i - \gamma\mu} \right)^{\frac{\alpha\gamma}{\alpha+\gamma-\alpha\gamma}} \hat{\lambda}_i^{\frac{\gamma(\alpha+\varepsilon)}{\alpha+\gamma-\alpha\gamma}}. \quad \text{(structure market)}$$

$$\left(\hat{\lambda}_i - \frac{H_i}{n_i F_i} \right) (\hat{u}_{Wi} - \hat{u}_a) = 0, \ \& \text{ slacks.} \quad \text{(spatial eq)}$$

$$t_i \hat{t}_i = \text{argmax } \hat{W}_i. \quad \text{(regime)}$$

$$\sum_i \lambda_i \hat{\lambda}_i = 1. \quad \text{(pop constraint)}$$

exact hat algebra

- **Assumption**: Ex ante interior equilibrium (z) = Data.

$$
\begin{aligned}
n_i &= \text{population of a city,} \\
\frac{H_i}{n_i F_i} &= \text{share of immobile landlords in city pop,} \\
t_i &= \text{property tax rate,} \\
p_i x_i &= \text{value of tax base,} \\
p_i m_i &= \text{value of tax base owned by corporations.}
\end{aligned}
$$

- Once we specify parameters, the equilibrium change ($\hat{z}$) can be calculated without having A_i, B_i, ξ_i and H_i. e.g.,

$$
p_i x_i = \Gamma H_i (B_i p_i)^{1/\gamma}, \quad \hat{(p_i x_i)} = \hat{p}_i^{1/\gamma}.
$$

data

- Source: administrative data publicly available (e.g., Census; summary on property taxation; reports on fiscal balances)
- Time: 2015
- Spatial unit:
  - City, Town, Village for Japan (1719 - outliers = 1712).
  - Community (*Gemeinde*) for Germany (12841 - East - NA = 8353)

tax rate

- Average tax rate $t_i - 1$:

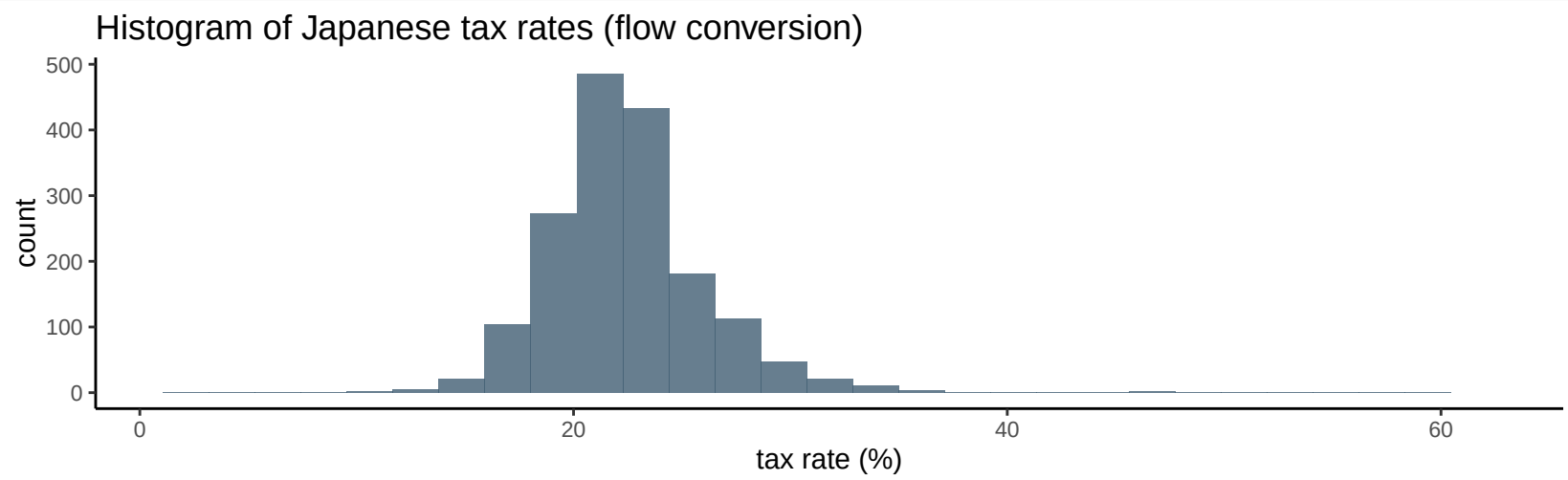
$$\underbrace{(\text{mkt value})}_{p_i x_i} \times \underbrace{(\text{assessment gap}) \times (\text{discount}) \times (\text{statutory rate})}_{\text{average tax rate}} = (\text{tax revenue}).$$

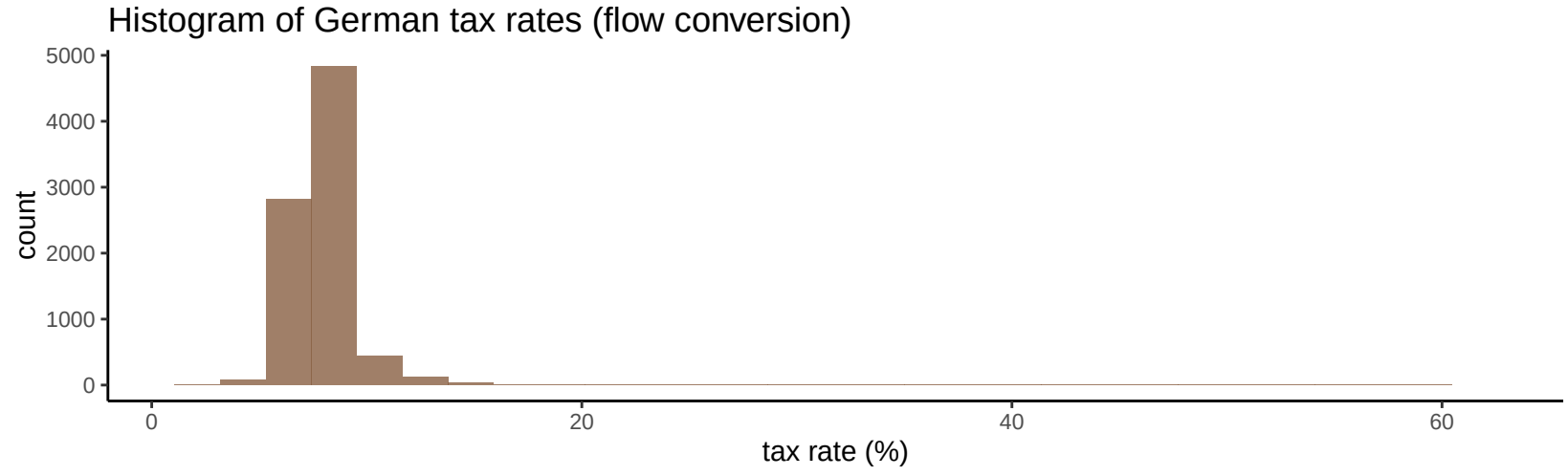
  - 'Tax base' is (assessed price) $\times$ (discount). In estimation we consider nation-wide institutional discounts which are treated as exogenous & equals 67% on average.
  - For German data they are similarly defined (also try a specific-taxation model) ▸ Appendix

- The stock variables are converted into 'flow' values by using (stock) = (flow) / (user cost) where user cost is net capital price (=3%). ▸ Appendix

tax rate

- Average tax rates:

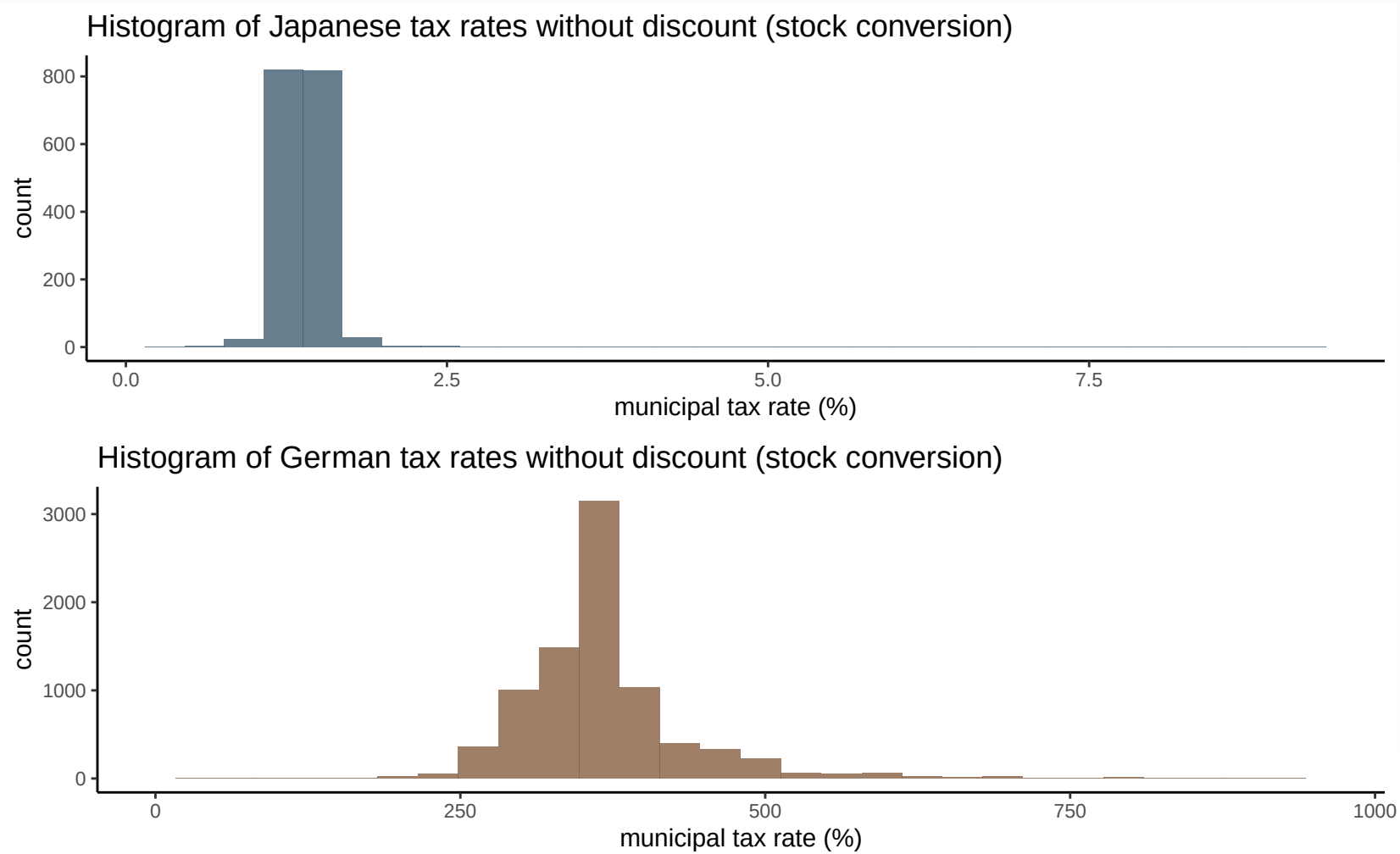




tax rate

- City-level statutory rates give a different impression...

(mkt value) × (assessment gap) × (discount) × (statutory rate) = (tax revenue).



parametrization

variables	description	value
α	Labor share in numeraire production	0.60
ε	Elasticity of agglomeration econ in numeraire production	0.00 or 0.02 or 0.04
γ	Land share in producing structures	0.25
μ	Housing preference	0.251 (JPN) or 0.235 (DEU)
η	Taste for local public goods in Japan	0.086 or 0.132
η	Taste for local public goods in Germany	0.093 or 0.137
N	Total population in Japan	127.1×10^6
N	Total population in Germany	64.1×10^6

- γ comes from Ahlfeldt et al. (2015). μ is from OECD
- ε is zero for our benchmark. Introducing economies of agglomeration ($\varepsilon = .02$ or $.04$) doesn't change a lot.
- η is calibrated to match Haughwout (2002): land price elasticity to public infrastructure $=$ .11 or .23.

descriptive statistics

- For Japan,

variable	description	mean	S.D.	median
τ_i	average property tax rate	22.6%	4.1%	22.1%
	average property tax rate (stock measure)	0.89%	0.28%	0.85%
$\tau_i^{*\prime}$	Municipal-level property tax rate (stock measure)	1.42%	0.33%	1.38%
$p_i x_i / n_i$	value of housing services per capita	308.1	253.1	265.5
$p_i d_i$	value of housing services HHs own per capita	176.8	82.4	161.8
$p_i m_i / n_i$	value of housing services firms own per capita	131.3	219.5	94.7
$p_i m_i / (p_i x_i)$	share of corporates' housing	38.8%	12.1%	36.1%
n_i	city population	74237	288599	24033
w_i	wage rate	325.8	565.7	231.0
g_i	tax revenues	5.83×10^6	37.3×10^6	1.44×10^6
$r_i H_i / n_i$	land rent income per capita	77.0	63.3	66.4
$H_i / (n_i F_i)$	share of immobile landlords in population	80.1%	10.3%	81.5%

Note: Unit of housing values is thousands of yen per capita. Unit of population is person.

- For Germany, ▸ Appendix

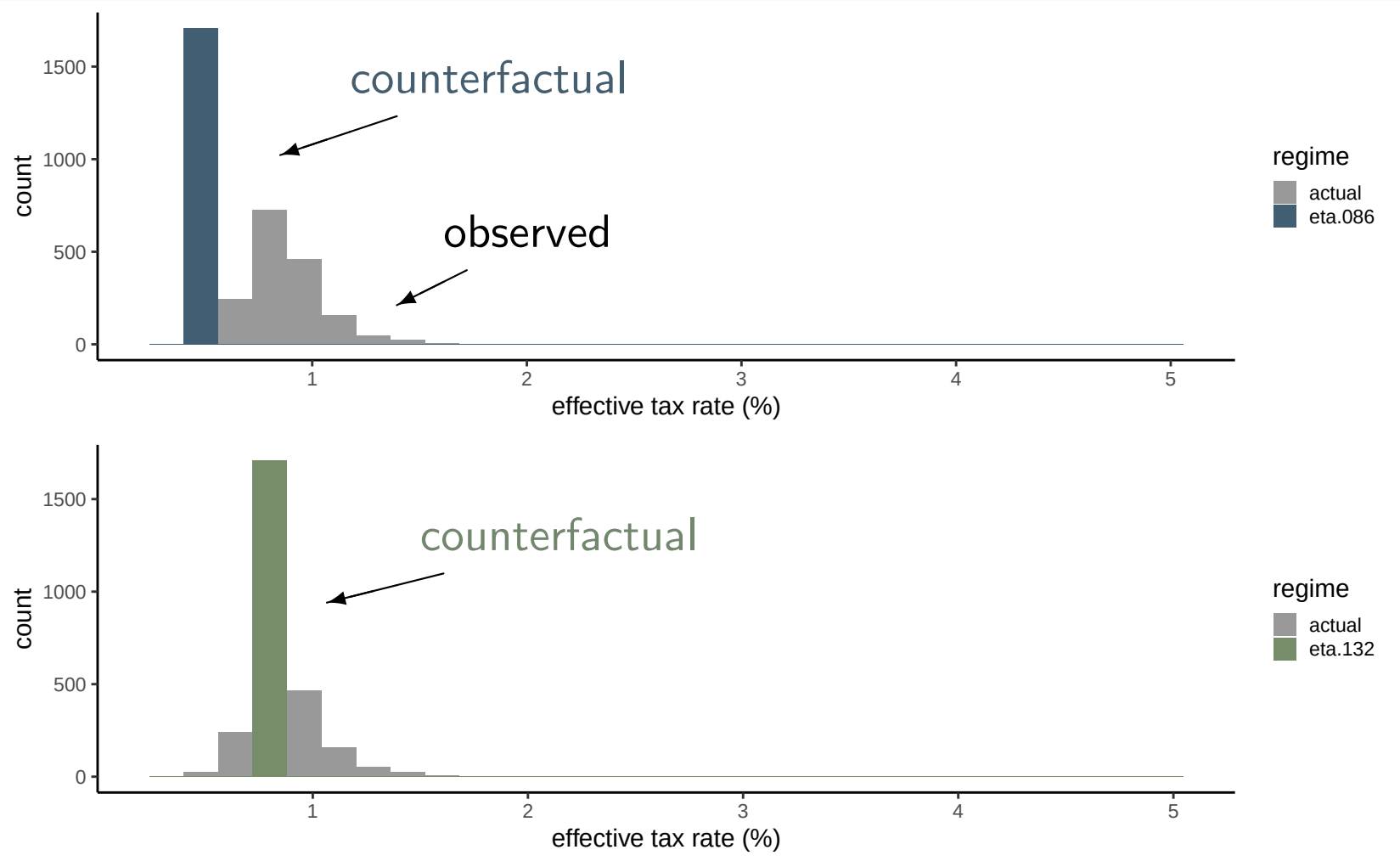
summary of results

	Japan $\eta = .086$	Japan $\eta = .132$	Germany $\eta = .093$	Germany $\eta = .137$
decentralized				
statutory tax rate	0.77%	1.25%	736.7%	1149.0%
social welfare change $S\hat{W}$	+1.8%	+0.1%	+0.2%	+1.9%
centralized				
optimal tax rate	0.59%	0.91%	567.4%	871.7%
social welfare change $S\hat{W}$	+2.0%	+0.4%	+0.4%	+2.2%
homevoter				
statutory tax rate	0.65%	1.10%	622.9%	1017.4%
social welfare change $S\hat{W}$	+1.8%	+0.3%	+0.4%	+2.1%
observed				
statutory tax rate		1.42%		367.1%

Tax rates are measured in stock and exclude $\bar{\tau}_i$ which is (assessment gap) $\times$ (discount).

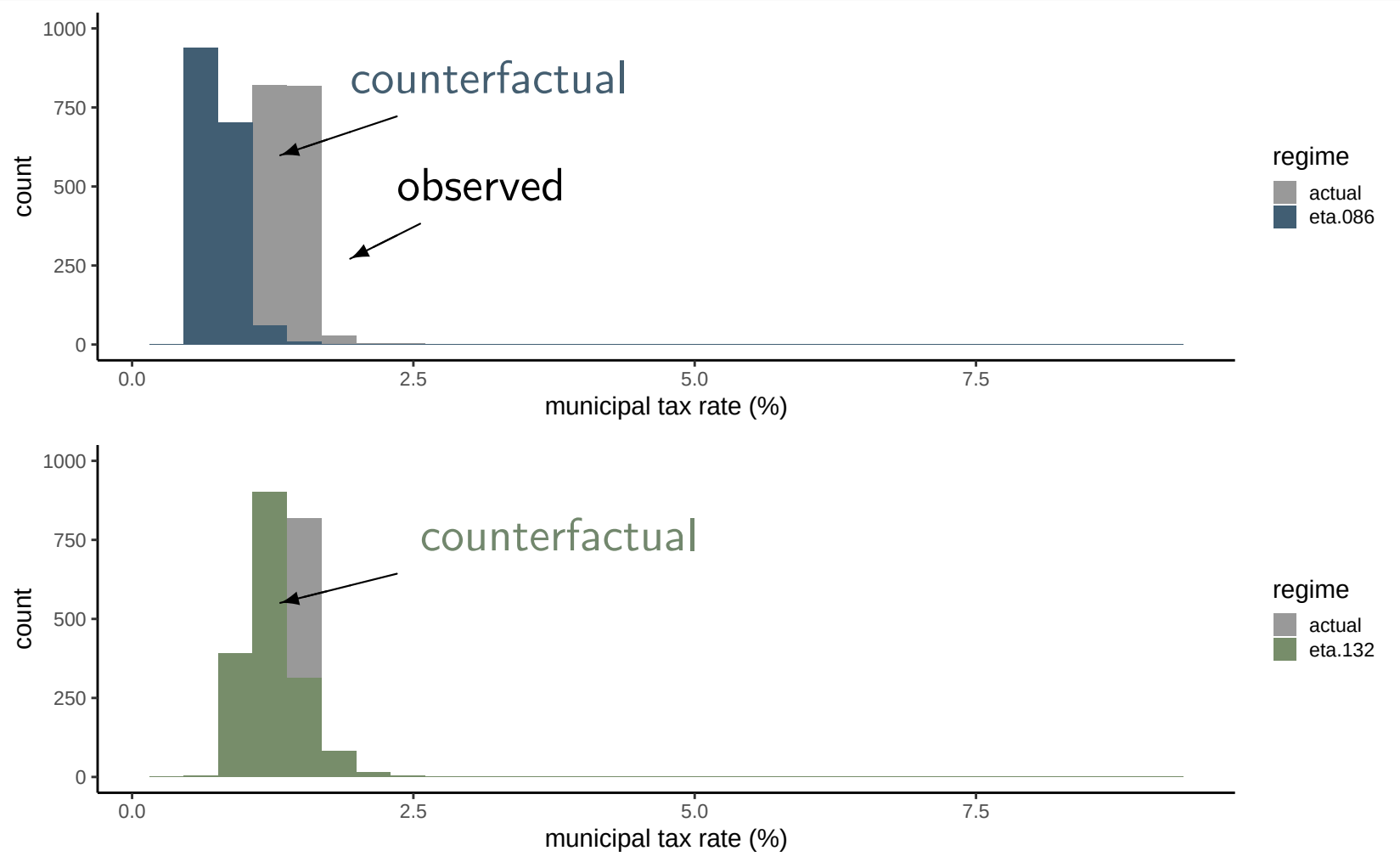
Decentralized regime in Japan

- Decentralized regime lowers tax rates



Decentralized regime in Japan

- tax rates without discounts also have little variation



Decentralized regime in Japan

- Decentralized regime lowers tax rates

Table: Japan, $\eta = .086$ and $\varepsilon = 0$.

variable	description	mean	S.D.	median
τ_i'	Property tax rate	**13.4%**	0.8%	13.4%
	Property tax rate (stock conversion)	0.47%	0.04%	0.46%
$\tau_i^{*\prime}$	Municipal-level property tax rate (stock conversion)	0.77%	0.16%	0.75%
n_i'	City population	74237.0	282523	24770.8
$\hat{n}_i$	Change of city population	103.5%	8.5%	101.8%
$\hat{p}_i$	Change of housing price	103.6%	2.8%	103.1%
$\hat{w}_i$	Change of wage rate	102.8%	0.5%	102.9%
$\hat{g}_i$	Change of public goods	69.6%	5.5%	68.7%
$\hat{r}_i$	Change of land rent	115.8%	14.1%	113.2%
$\hat{u}_a$	Change of reservation utility	100.7%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	103.2%	2.5%	102.7%
$\hat{W}_i$	City's welfare change	105.7%	9.3%	103.8%
EV_{Wi}/I_{Wi}	Worker's equivalent variation / income	0.7%	0.0	0.7%
EV_{Li}/I_{Li}	Landlord's equivalent variation / income	4.2%	0.0	4.2%
$S\hat{W}$	Change of social welfare	101.8%	—	—

For other cases with a different parameter set, ▸ Appendix

Decentralized regime in Japan

- A higher η raises taxes but lowers welfare gains.

Table: Japan, $\eta = .132$ and $\varepsilon = 0$.

variable	description	mean	S.D.	median
τ_i'	Property tax rate	**20.1%**	0.4%	20.1%
	Property tax rate (stock conversion)	0.76%	0.02%	0.75%
$\tau_i^{*\prime}$	Municipal-level property tax rate (stock conversion)	1.25%	0.25%	1.22%
n_i'	City population	74237.3	288444	24214
$\hat{n}_i$	Change of city population	101.6%	8.4%	99.9%
$\hat{p}_i$	Change of housing price	101.1%	2.4%	100.5%
$\hat{w}_i$	Change of wage rate	100.6%	1.0%	100.8%
$\hat{g}_i$	Change of public goods	94.7%	10.4%	92.9%
$\hat{r}_i$	Change of land rent	104.7%	12.8%	101.9%
$\hat{u}_a$	Change of reservation utility	100.1%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	100.8%	2.1%	100.3%
$\hat{W}_i$	City's welfare change	102.1%	8.9%	100.2%
EV_{Wi}/I_{Wi}	Worker's equivalent variation / income	0.1%	0.0	0.1%
EV_{Li}/I_{Li}	Landlord's equivalent variation / income	1.0%	0.0	1.0%
$S\hat{W}$	Change of social welfare	100.1%	—	—

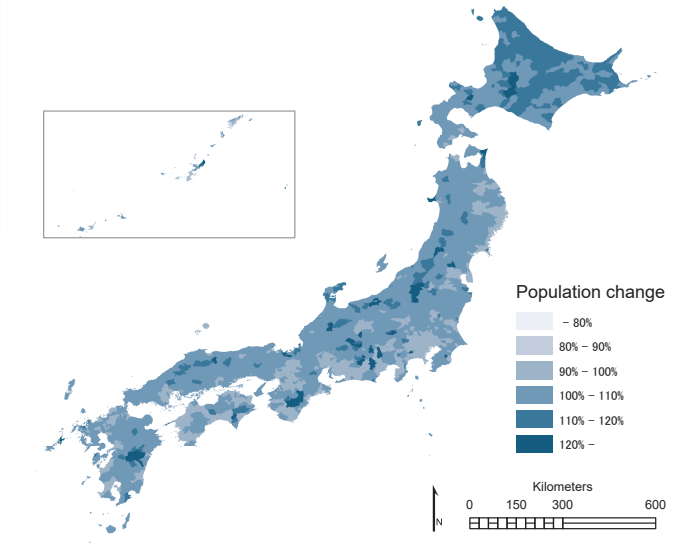
Decentralized regime in Japan

- Decentralized regime lowers tax rates.
  - Price of structure service p_i rises
  - Public good provision g_i decreases
  - Workers disperse more (SD$(n_i) \searrow$)
  - Both workers and landlords are better off (especially for landlords)
  - Social welfare SW modestly increases
    - But some cities lose without transfers
  - Cities with a high level of ex ante tax rate are likely to gain ($\hat{W}_i$ increases with t_i)
  - Unclear whether large cities are likely to gain (slightly negative correl btw $\hat{W}_i$ & n_i)

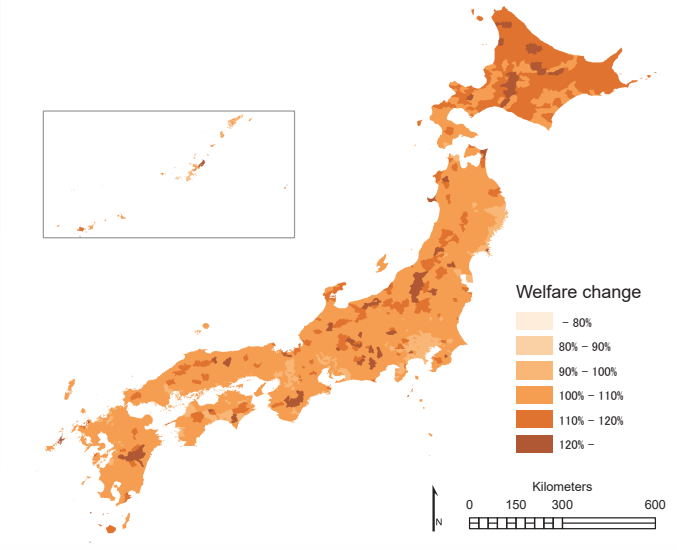
Decentralized regime in Japan

- peripheral areas often gain from decentralization

population change



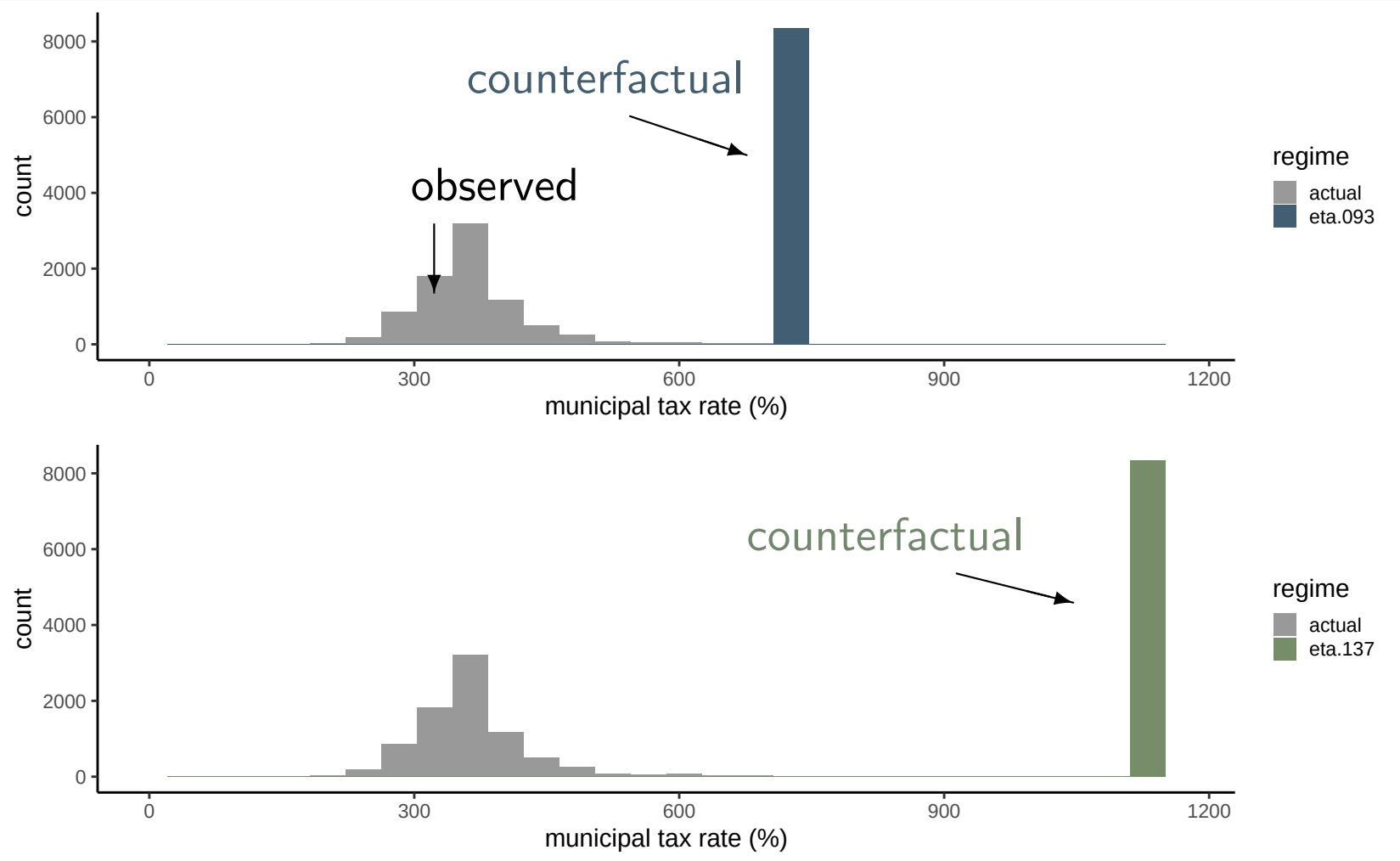
welfare change



Japan, $\eta = .086, \varepsilon = 0$.

Decentralized regime in Germany

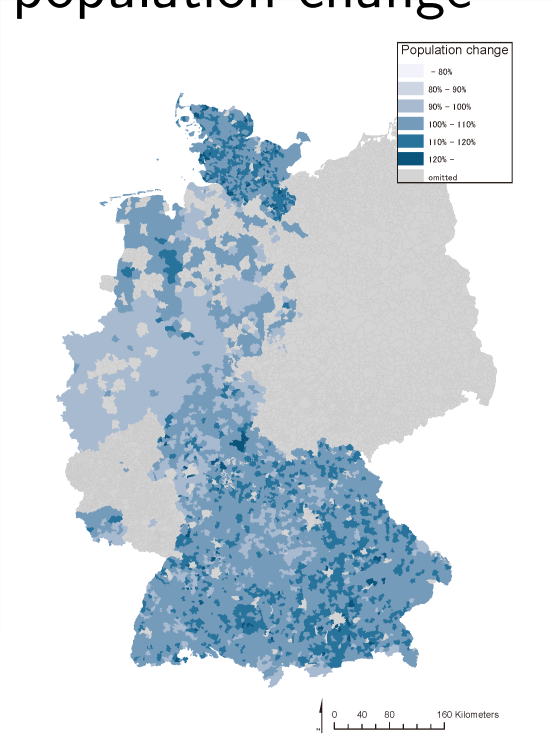
- In Germany, decentralized regime **raises** tax rates



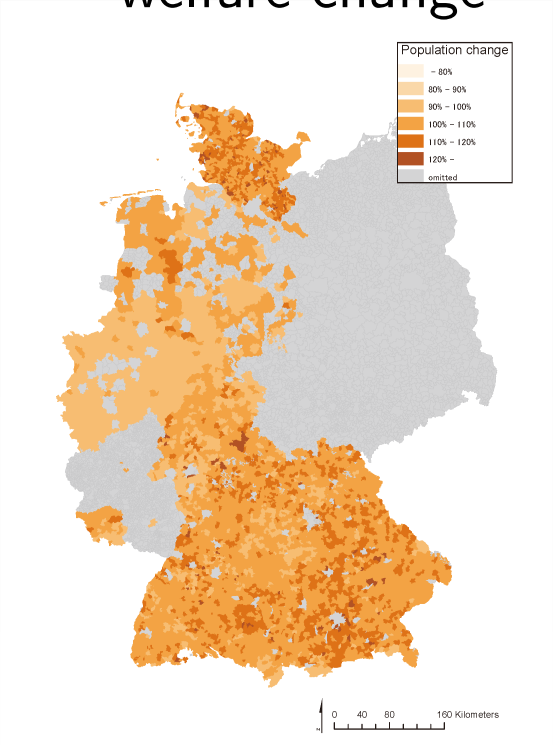
Decentralized regime in Germany

- Changes seem spatially auto-correlated

population change



welfare change



Germany, $\eta = .093, \varepsilon = 0.$

Decentralized regime in Germany

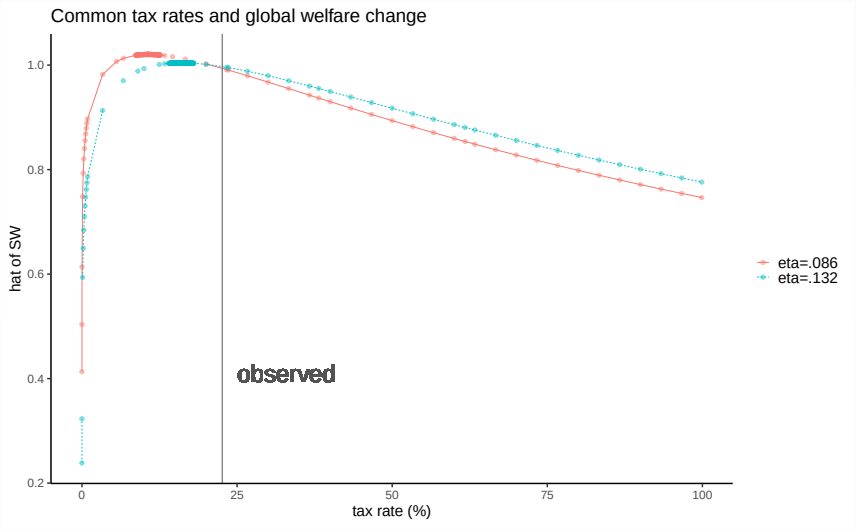
obs $\rightarrow$ decentralized regime,

	Japan	Germany
tax rate	↘	↗
cost of living	↘	↗
wage	↗	↘
pub good	↘	↗
pop agglomeration	↘	↘
city-level & social welfare	↗	↗
η on social welfare change	↘	↗

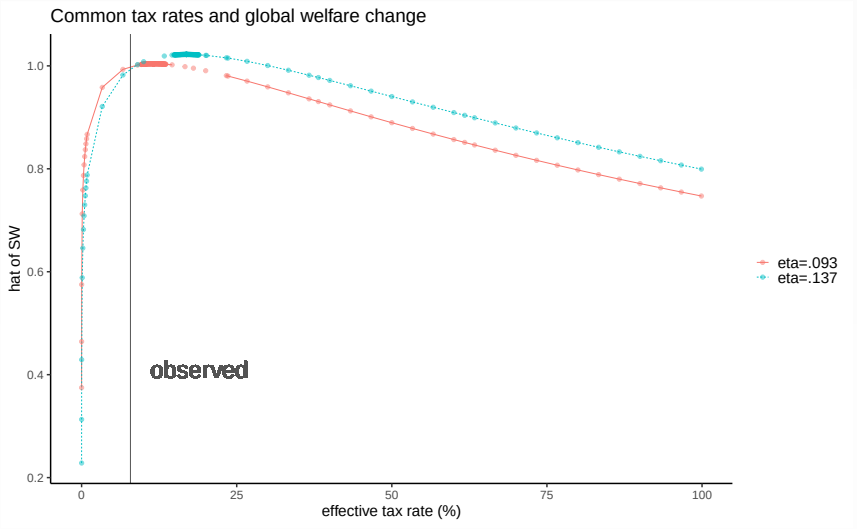
Centralized regime

- Social welfare is concave in a common tax rate

Japan



Germany



- optimal $<$ obs in Japan
- optimal $>$ obs in Germany

Centralized regime in Japan

- Centralized tax rates are less than half of obs level.

Table: Japan, $\eta = .086$ and $\varepsilon = 0$.

variable	description	mean	S.D.	median
τ_i'	Property tax rate	10.6%	—	—
	Property tax rate (stock conversion)	0.36%	—	—
$\tau_i^{*\prime}$	Municipal-level property tax rate (stock conversion)	0.59%	0.12%	0.58%
n_i'	City population	74237.1	282512	24770
$\hat{n}_i$	Change of city population	103.6%	9.9%	101.8%
$\hat{p}_i$	Change of housing price	104.6%	3.1%	104.1%
$\hat{w}_i$	Change of wage rate	103.9%	0.4%	104.0%
$\hat{g}_i$	Change of public goods	57.3%	4.1%	56.6%
$\hat{r}_i$	Change of land rent	120.4%	18.0%	117.3%
$\hat{u}_a$	Change of reservation utility	100.4%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	103.5%	2.9%	103.0%
$\hat{W}_i$	City's welfare change	106.1%	11.0%	104.1%
EV_{Wi}/I_{Wi}	Worker's equivalent variation / income	0.4%	0.0	0.4%
EV_{Li}/I_{Li}	Landlord's equivalent variation / income	4.9%	0.0	4.9%
$S\hat{W}$	Change of social welfare	102.0%	—	—

For cases with another parameter set, ▸ Appendix

Centralized regime in Japan

- Centralized regime requires lowering tax rates than observed ones as well as decentralized ones in Japan
  - Observed (seemingly coordinated) regime looks too aggressive
- Welfare gains are close to those under the decentralized regime. The gains from preventing from race to the top may be limited.
- Landlords are likely to be better off largely
- The opposite is true for Germany

Homevoter regime in Japan

- Homevoter sets lower taxes than decentralized ones

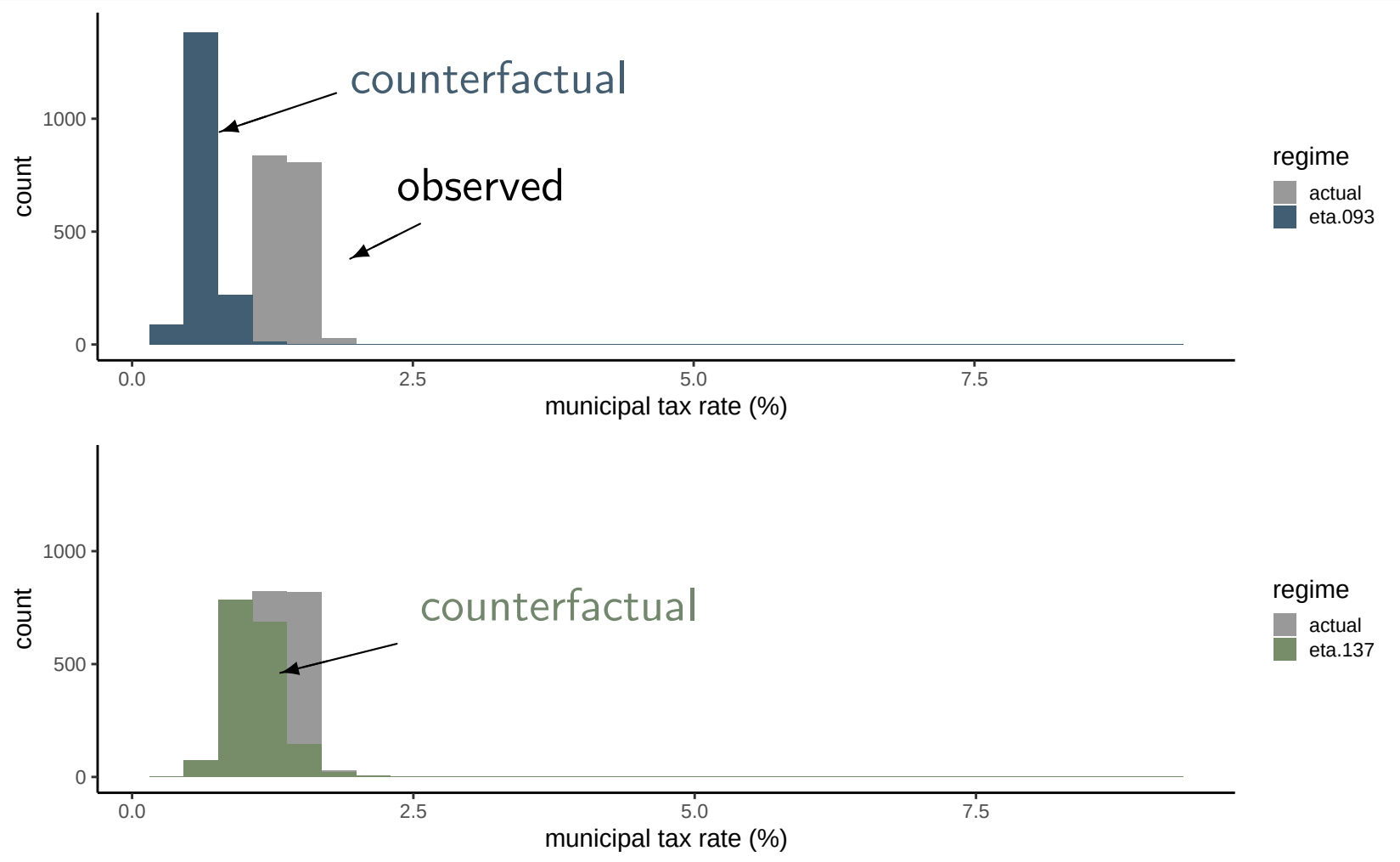
Table: Japan, $\eta = .086$ and $\varepsilon = 0$.

variable	description	mean	S.D.	median
τ_i'	Property tax rate	11.5%	0.9%	11.5%
	Property tax rate (stock conversion)	0.39%	0.04%	0.39%
$\tau_i^{*\prime}$	Municipal-level property tax rate (stock conversion)	0.65%	0.14%	0.63%
n_i'	City population	74237.1	282335	24775.8
$\hat{n}_i$	Change of city population	103.6%	8.6%	101.8%
$\hat{p}_i$	Change of housing price	104.2%	2.8%	103.7%
$\hat{w}_i$	Change of wage rate	102.8%	0.4%	102.9%
$\hat{g}_i$	Change of public goods	59.3%	5.1%	58.5%
$\hat{r}_i$	Change of land rent	118.4%	14.3%	115.7%
$\hat{u}_a$	Change of reservation utility	100.5%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	103.0%	2.1%	102.6%
$\hat{W}_i$	City's welfare change	105.7%	9.3%	103.9%
EV_{Wi}/I_{Wi}	Worker's equivalent variation / income	0.6%	0.0	0.6%
EV_{Li}/I_{Li}	Landlord's equivalent variation / income	4.7%	0.0	4.7%
$S\hat{W}$	Change of social welfare	101.8%	—	—

For cases with another parameter set, ▸ Appendix

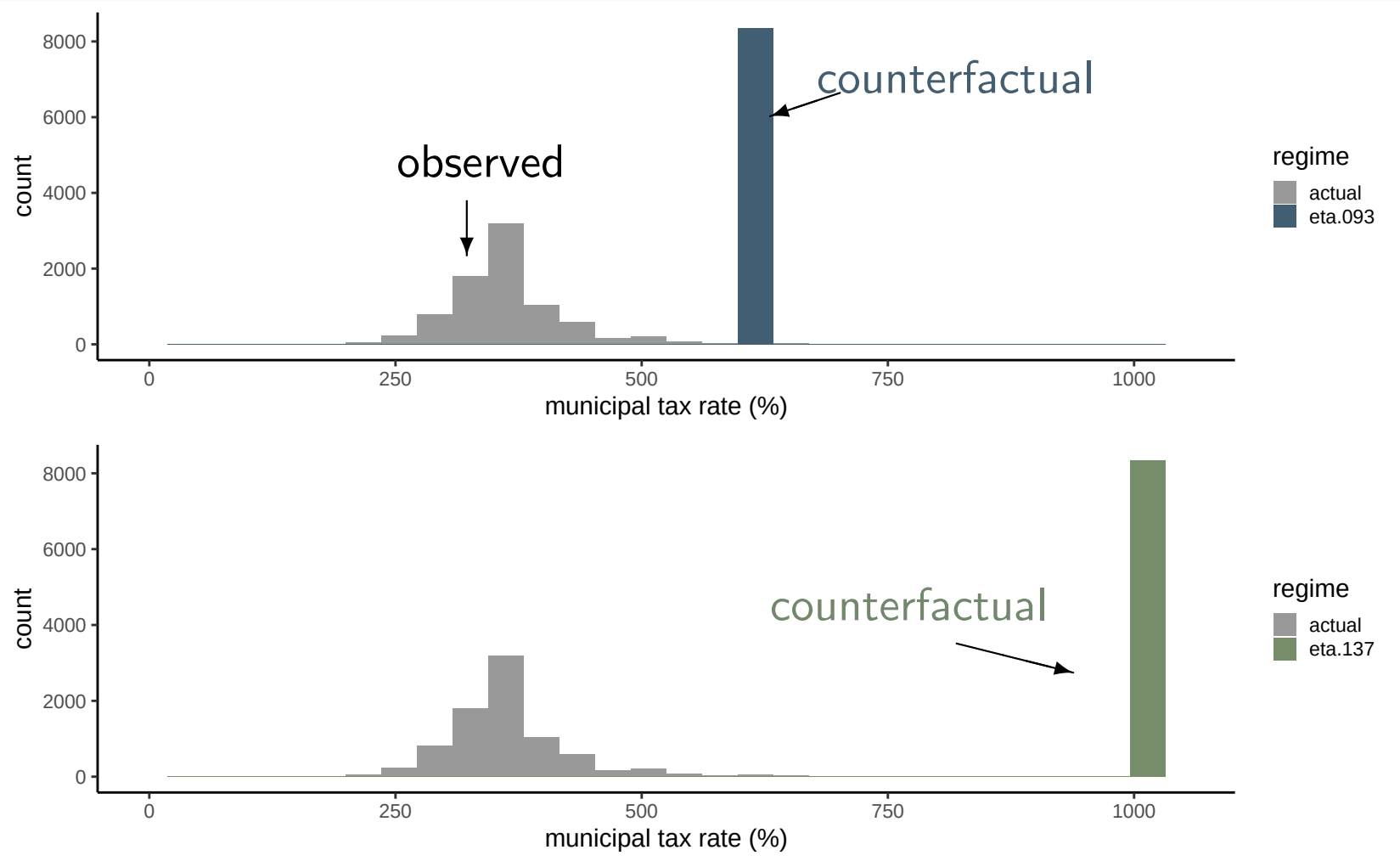
Homevoter regime in Japan

- Homevoters set lower taxes than decentralized ones



Homevoter regime in Germany

- in Germany, taxes are also lower than decentralized ones



minor remarks

- Coefficients of variation of counterfactual tax rates are also smaller than those of obs.
- Population flows caused by policy shocks are limited. Thus the population distribution is very stable.
- Ex post tax rate t_i' is not predicted by ex ante tax t_i or ex ante population n_i.
- Only a few cities are in a corner solution.
- Only a few cities violate Assumption 2. They are often a peripheral village.

conclusion

- We characterize property taxation qualitatively & quantitatively by a computable model giving a policy-relevant implication
- Fiscal decentralization causes race to the top (without economies of agglomeration) and can be harmful because of migration in theory. But this inefficiency is not the case in Japan and Germany.
- Japan and Germany share similar equilibrium properties of property taxation except observed states.

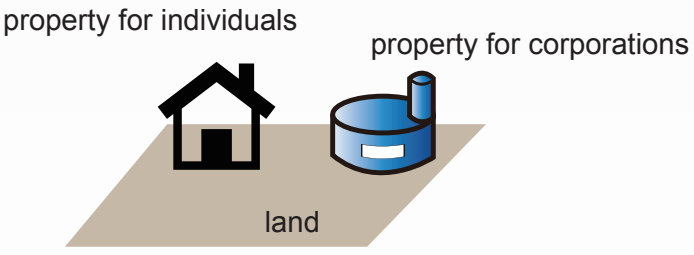
possible extensions & robustness checks

- We are working for the following extensions
  - another region (U.S. and East Germany)
  - another regime (e.g., Leviathan, yardstick)
  - another spatial unit (that considers intercity commuting)
  - another parameter set to improve goodness-of-fit
  - shocks to heterogeneous characteristics (amenity and technology)
- We've tried the followings
  - use a different measure for lowerbound (H_i/n_iF_i)
  - Millian welfare makes tax being close to zero (SOC is violated).
  - capital price is not unity
  - Lump-sum transfer instead of public goods
  - Taste difference (e.g., $\eta_W \neq \eta_L$) $\rightarrow$ not interesting
  - 'Large' city $\rightarrow$ heavy computational burden, almost no insight
  - the number of cities $\rightarrow$ no change
  - inter-city transfer (e.g., 地方交付税交付金) $\rightarrow$ lowering taxes

Appendix: concepts of land and structure service

- 'Structure service' is Fixed Property to be taxed

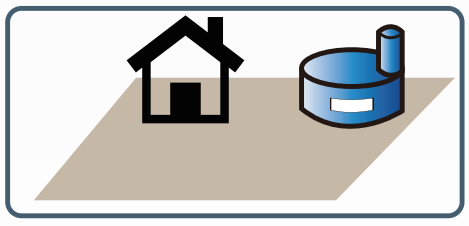
real world



model

(`structure' includes the real land)

structure service (x)



tax on x (t)

(t includes tax on the actual land)

$x = B\, h^{\gamma}\, k^{1-\gamma}$

hypothetical `land' (h)

(no tax, inelastic supply H)

capital (k)

(no tax, free mobile across regions)

Appendix: some suppressed equations

- factor demands by structure service sector:

$$\text{land price: } r_i \propto \gamma(B_i p_i)^{1/\gamma}.$$

- factor demand by numeraire sector:

$$\text{wage rate: } w_i = \alpha A_i n_i^{\varepsilon}(m_i/l_i)^{1-\alpha} = \alpha A_i n_i^{\varepsilon+\alpha-1} m_i^{1-\alpha}.$$

$$\text{structure price with tax: } t_i p_i = (1-\alpha) A_i m_i^{-\alpha} n_i^{\alpha+\varepsilon}.$$

- housing market clearing condition:

$$p_i = [\Lambda_i(t_i)]^{\alpha\gamma/(\alpha+\gamma-\alpha\gamma)} n_i^{\gamma(\alpha+\varepsilon)/(\alpha+\gamma-\alpha\gamma)}.$$

- indirect utility of a worker

$$u_{Wi} = \xi_i w_i (t_i p_i)^{-\mu} g_i^{\eta} \propto n_i^{\frac{(\alpha+\varepsilon)(1-\mu\gamma+\eta)}{\alpha+\gamma-\alpha\gamma}-1}.$$

Appendix: some suppressed equations (cont.)

- Hat algebra expresses endog vars as a composite of obs, e.g.,

$$\text{wage rate: } w_i = \frac{\alpha}{1-\alpha}\frac{t_i p_i m_i}{n_i}.$$

- Relative change in supply & corp-demand (in value) of structure service:

$$\hat{p}_i \hat{x}_i = \hat{p}_i^{1/\gamma} = \hat{r}_i, \quad \hat{p}_i \hat{m}_i = \hat{p}_i^{(\alpha-1)/\alpha} \hat{t}_i^{-1/\alpha} \hat{\lambda}_i^{\varepsilon/\alpha+1}.$$

- Utility change:

$$\begin{aligned}\hat{u}_{Wi} &= \hat{w}_i (\hat{t}_i \hat{p}_i)^{-\mu} \hat{g}_i^{\eta} \\ &= \hat{\tau}_i^{\eta} \hat{t}_i^{-\frac{(1+\eta)(1-\alpha)+\alpha\mu}{\alpha+\gamma-\alpha\gamma}} \left[\frac{t_i - \mu\gamma}{t_i' - \mu\gamma}\right]^{\frac{\alpha(1-\gamma\mu+\eta)}{\alpha+\gamma-\alpha\gamma}-1} \hat{\lambda}_i^{\frac{(\alpha+\varepsilon)(1-\gamma\mu+\eta)}{\alpha+\gamma-\alpha\gamma}-1}.\end{aligned}$$

Appendix: estimate tax rates

- want to represent a simple form (1 composite service & 1 discount), with decomposing $\tau_i = \bar{\tau}_i \times \tau_i^*$,

$$\text{mkt value} \times \bar{\tau}_i \times \tau_i^* = \text{ tax revenue.}$$

- type j's discount consists of assessment gap (often .7) and institutional discount (e.g., 1/6 for land for small housing)

$$\text{taxable value} = \sum_j (p_i x_i)_j^{(\text{stock})} \times \text{ discount}_j$$

$$\begin{aligned}
&= (0.7/6)(p_i x_i)_{\text{land for small housing}} + (0.7/3)(p_i x_i)_{\text{land for housing}} \\
&+ 0.7^2 (p_i x_i)_{\text{land for other housing}} + 0.7 (p_i x_i)_{\text{land not for housing}} \\
&+ (p_i x_i)_{\text{housing}} + (p_i x_i)_{\text{depreciating asset}}.
\end{aligned}$$

$$\text{mkt value} = \sum_j (p_i x_i)_j^{(\text{stock})}, \text{ and thus } \bar{\tau}_i^{(\text{stock})} = \frac{\text{taxable value}}{\text{mkt value}}.$$

Appendix: estimate tax rates (cont.)

- stock-flow conversion uses (1) discount cashflow, and (2) a definition of effective rate. They simultaneously determine 2 unknowns ($p_i x_i$ and $\bar{\tau}_i \tau_i^*$) (similarly $p_i m_i$)

$$\text{mkt value} = \frac{(1 - \bar{\tau}_i \tau_i^*)(p_i x_i)}{1.03 - 1}.$$

$$\bar{\tau}_i \tau_i^* (p_i x_i) = \text{ tax revenue .}$$

  $p_i x_i$ is rent of structure service (flow measure).

  e.g., a 300 thous. USD asset (stock measure) $\simeq$ it provides 10 thous. USD housing service annually (then $p_i x_i \simeq 10000$). 1% on stock value ($=$ 3 thous. tax/year) is equivalent $\tau_i = 30\%$ on flow value.

- stock-flow rates have one-to-one relationship:

$$\bar{\tau}_i \tau_i^{(\text{stock})} = \frac{\bar{\tau}_i \tau_i^{(\text{flow})}}{1 - \bar{\tau}_i \tau_i^{(\text{flow})}} (1.03 - 1).$$

Appendix: estimate tax rates (cont.)

- we want to avoid unnecessary confusion from stock-flow distinction
- e.g., the model predicts wage rate is proportional to (gross) property value (owned by firms) (per capita):

$$w_i = \frac{\alpha}{1-\alpha} \frac{t_i \times p_i m_i}{n_i}.$$

Stock-based measures and flow-based measures give very different levels of w_i on average:

$$w_i^{(\text{stock})} = \frac{3}{2} \times (1 + 0.89\%) \times 3,323 = 5029,$$
$$w_i^{(\text{flow})} = \frac{3}{2} \times (1 + 22.6\%) \times 131 = 241.$$

▸ Return to tax rate

Appendix: German tax system

- Ad valorem average tax rate for Germany:

$$(\text{assessed value}) \times \underbrace{(\text{base rate}) \times (\text{multiplier})}_{\text{effective tax rate}} = (\text{tax revenue})$$

  - Tax multiplier (*Hebesatz*) is determined by municipality. 0–900%.
  - Base rate (Steuermesszahl) is determined by state. .26%–1.0%
  - Assessed value (Einheitswert) is determined by historical records (not by current market prices). (should be carefully interpretted)

- Focus on 'Property tax B' (Property tax A is on agricultural land and fairly small)

Appendix: German tax system

- Specific taxation may be appropriate for German tax system (δ_i is exogenous assessed price):

$$c_i + (p_i + \tau_i \delta_i) d_i = \text{Income}_i. \qquad \text{(budget')}$$

- No sizable difference from the ad-valorem specification (while computational burden gets heavier)

▸ Return to tax rate

Appendix: German data

variable	description	mean	S.D.	median
τ_i	average property tax rate	7.9%	1.3%	7.8%
	average property tax rate (stock measure)	0.26%	0.05%	0.26%
$\tau_i^{*\prime}$	Municipal-level property tax rate (stock measure)	367.1%	70.0%	365.0%
$p_i x_i / n_i$	value of housing services per capita	1447.5	1131.2	1387.7
$p_i d_i$	value of housing services HHs own per capita	482.5	377.1	462.6
$p_i m_i / n_i$	value of housing services firms own per capita	965.0	754.1	925.1
$p_i m_i / (p_i x_i)$	share of corporates' housing	66.7%	0.0%	66.7%
n_i	city population	7669.2	36534.8	1939
w_i	wage rate	2081.7	1617.2	1994.7
g_i	tax revenues	1.32×10^6	8.96×10^6	0.20×10^6
$r_i H_i / n_i$	land rent income per capita	361.9	282.8	346.9
$H_i / (n_i F_i)$	share of immobile landlords in population	63.6%	10.9%	64.7%

▸ Return to Data

Appendix: Decentralized regime with econ of agglomeration

Table: $\varepsilon = .02$

variable	description	Japan $\eta = .086$	Japan $\eta = .132$	Germany $\eta = .093$	Germany $\eta = .137$
τ_i'	Property tax rate	13.5%	20.3%	14.8%	21.3%
		(0.8%)	(0.4%)	(0.1%)	(0.5%)
$\tau_i^{*\prime}$	Municipal-level tax rate (stock)	0.76%	1.26%	743.8%	1158.2%
		(0.16%)	(0.25%)	(3.9%)	(33.2%)
n_i'	City population	74237.2	74236.9	7669.2	7669.2
		(280634)	(288312)	(33745.7)	(27388.7)
$\hat{n}_i$	Change of city population	104.7%	102.9%	106.9%	129.6%
		(12.1%)	(16.9%)	(10.6%)	(209.0%)
$\hat{p}_i$	Change of housing price	103.8%	101.2%	99.1%	100.2%
		(3.4%)	(3.3%)	(1.4%)	(6.4%)
$\hat{W}_i$	City's welfare change	107.0%	103.3%	106.8%	131.8%
		(13.0%)	(17.7%)	(10.3%)	(210.0%)
$S\hat{W}$	Change of social welfare	101.8%	100.1%	100.2%	102.1%

Note: Standard deviations in parentheses.

Appendix: Decentralized regime

Table: Germny, $\varepsilon = 0$.

variable	description	$\eta = .093$ mean	S.D.	median	$\eta = .137$ mean	S.D.	median
τ_i'	Property tax rate	14.7%	0.1%	14.7%	21.1%	0.2%	21.1%
	Property tax rate (stock)	0.52%	0.00%	0.52%	0.80%	0.01%	0.80%
$\tau_i^{*\prime}$	Municipal-level tax rate (stock)	736.7%	3.8%	736.8%	1149.0%	12.2%	1149.6%
n_i'	City population	7669.2	34469.6	2051.7	7669.2	30044.8	2287.6
$\hat{n}_i$	Change of city population	105.1%	7.1%	103.9%	116.7%	33.5%	112.5%
$\hat{p}_i$	Change of housing price	98.8%	0.9%	103.9%	98.7%	3.3%	98.2%
$\hat{w}_i$	Change of wage rate	96.8%	0.9%	98.6%	93.4%	2.7%	93.6%
$\hat{g}_i$	Change of public goods	183.6%	55.5%	176.4%	272.7%	270.7%	251.0%
$\hat{r}_i$	Change of land rent	95.2%	3.9%	94.4%	95.7%	18.0%	93.2%
$\hat{u}_a$	Change of reservation utility	101.1%	—	—	103.8%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	100.6%	1.6%	100.4%	104.6%	8.3%	103.7%
$\hat{W}_i$	City's welfare change	105.0%	6.8%	103.8%	118.6%	33.6%	114.3%
EV_{Wi}	Worker's equivalent var	16.5	12.8	15.8	59.2	46.0	56.7
CV_{Wi}	Worker's compensating var	15.8	12.2	15.1	53.3	40.9	50.7
EV_{Li}	Landlord's equivalent var	13.3	51.1	7.5	101.5	266.5	72.3
CV_{Li}	Landlord's compensating var	12.3	46.3	7.2	87.4	156.0	65.1
$\bar{EV}_i$	average equivalent var	15.2	30.4	10.2	86.4	156.0	67.6
$\bar{CV}_i$	average compensating var	14.3	27.6	9.8	57.6	117.6	61.0
$\hat{SW}$	Change of social welfare	100.2%	—	—	101.9%	—	—

▸ Return to Decentralized regime

Appendix: Centralized regime

Table: Japan, $\eta = .132$ and $\varepsilon = 0$.

variable	description	mean	S.D.	median
τ_i'	Property tax rate	15.6%	—	—
	Property tax rate (stock conversion)	0.55%	—	—
$\tau_i^{*\prime}$	Municipal-level property tax rate (stock conversion)	0.91%	0.18%	0.89%
n_i'	City population	74237.1	287858	24262.8
$\hat{n}_i$	Change of city population	101.9%	9.2%	100.0%
$\hat{p}_i$	Change of housing price	102.4%	2.6%	101.8%
$\hat{w}_i$	Change of wage rate	101.7%	0.7%	101.8%
$\hat{g}_i$	Change of public goods	77.3%	8.3%	75.9%
$\hat{r}_i$	Change of land rent	110.6%	15.8%	107.6%
$\hat{u}_a$	Change of reservation utility	99.8%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	101.2%	2.1%	100.7%
$\hat{W}_i$	City's welfare change	102.6%	9.9%	100.6%
EV_{Wi}	Worker's equivalent variation	-0.7	1.2	-0.5
CV_{Wi}	Worker's compensating variation	-0.7	1.3	-0.5
EV_{Li}	Landlord's equivalent variation	8.7	26.9	3.9
CV_{Li}	Landlord's compensating variation	8.9	27.4	4.0
$\bar{EV}_i$	average equivalent variation	6.7	21.7	3.1
$\bar{CV}_i$	average compensating variation	6.8	22.0	3.1
$\hat{SW}$	Change of social welfare	100.4%	—	—

Appendix: Centralized regime with econ of agglomeration

Table: $\varepsilon = .02$.

variable	description	Japan $\eta = .086$	Japan $\eta = .132$	Germany $\eta = .093$	Germany $\eta = .137$
τ_i'	Property tax rate	10.6%	16.1%	11.7%	16.8%
		(0.0%)	(0.0%)	(0.0%)	(0.0%)
$\tau_i^{*\prime}$	Municipal-level tax rate (stock)	0.59%	0.95%	567.4%	866.8%
		(0.12%)	(0.19%)	(0.00%)	(0.01%)
n_i'	City population	74237.1	74237.1	7669.2	7669.2
		(280620)	(288298)	(33745.6)	(28339.6)
$\hat{n}_i$	Change of city population	104.9%	103.0%	106.9%	126.0%
		(14.6%)	(19.4%)	(10.6%)	(202.6%)
$\hat{p}_i$	Change of housing price	104.9%	102.5%	100.1%	101.0%
		(3.8%)	(3.7%)	(1.4%)	(6.3%)
$\hat{W}_i$	City's welfare change	107.4%	103.8%	107.1%	128.7%
		(15.9%)	(20.6%)	(10.3%)	(204.5%)
$S\hat{W}$	Change of social welfare	102.0%	100.4%	100.4%	102.4%

Note: Standard deviations in parentheses.

Appendix: Centralized regime in Germany

Table: Germany, $\varepsilon = 0$.

variable	description	$\eta = .093$ mean	S.D.	median	$\eta = .137$ mean	S.D.	median
τ_i'	Property tax rate	11.6%	—	—	16.9%	—	—
	Property tax rate (stock)	0.42%	—	—	0.61%	—	—
$\tau_i^{*\prime}$	Municipal tax rate (stock)	561.4%	0.0%	561.4%	871.7%	0.0%	871.7%
n_i'	City population	7669.2	34469.6	2051.7	7669.2	30044.8	2287.6
$\hat{n}_i$	Change of city population	105.1%	7.1%	103.9%	116.7%	33.5%	112.5%
$\hat{p}_i$	Change of housing price	99.8%	0.9%	99.6%	100.0%	3.4%	99.5%
$\hat{w}_i$	Change of wage rate	97.9%	1.3%	98.0%	94.8%	2.8%	95.1%
$\hat{g}_i$	Change of public goods	150.9%	45.6%	145.0%	229.7%	228.0%	211.4%
$\hat{r}_i$	Change of land rent	99.2%	4.0%	98.3%	100.9%	19.0%	98.2%
$\hat{u}_a$	Change of reservation utility	100.8%	—	—	103.5%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	101.1%	1.6%	100.8%	105.3%	8.6%	104.3%
$\hat{W}_i$	City's welfare change 105.2%	6.9%	104.0%	119.0%	33.7%	114.6%	
EV_{Wi}	Worker's equivalent var	12.3	9.5	11.7	54.1	42.0	51.8
CV_{Wi}	Worker's compensating var	11.9	9.2	11.4	49.5	38.0	47.1
EV_{Li}	Landlord's equivalent var	25.2	56.7	16.8	119.4	281.5	87.1
CV_{Li}	Landlord's compensating var	24.0	52.2	16.3	105.2	213.0	80.0
$\bar{EV}_i$	average equivalent var	20.5	33.6	15.1	94.9	164.0	75.3
$\bar{CV}_i$	average compensating var	19.6	31.1	14.7	84.6	126.4	69.1
$\hat{SW}$	Change of social welfare	100.4%	—	—	102.2%	—	—

▸ Return to Centralized regime

Appendix: Homevoter regime

- Again, a higher η raises taxes but lowers welfare gains

Table: Japan, $\eta = .132$ and $\varepsilon = 0$.

variable	description	mean	S.D.	median
τ_i'	Property tax rate	18.1%	0.5%	18.1%
	Property tax rate (stock conversion)	0.66%	0.03%	0.66%
$\tau_i^{*\prime}$	Municipal-level property tax rate (stock conversion)	1.10%	0.22%	1.07%
n_i'	City population	74237.2	288438	24213.4
$\hat{n}_i$	Change of city population	101.6%	8.5%	99.9%
$\hat{p}_i$	Change of housing price	101.7%	2.4%	101.1%
$\hat{w}_i$	Change of wage rate	101.3%	1.0%	101.5%
$\hat{g}_i$	Change of public goods	87.4%	9.8%	85.7%
$\hat{r}_i$	Change of land rent	107.3%	13.0%	104.5%
$\hat{u}_a$	Change of reservation utility	100.0%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	101.1%	2.1%	100.6%
$\hat{W}_i$	City's welfare change	102.3%	9.0%	100.4%
EV_{Wi}	Worker's equivalent variation	0.0	0.1	0.0
CV_{Wi}	Worker's compensating variation	0.0	0.1	0.0
EV_{Li}	Landlord's equivalent variation	6.7	23.3	2.5
CV_{Li}	Landlord's compensating variation	6.8	23.5	2.5
$\bar{EV}_i$	average equivalent variation	5.3	18.8	2.0
$\bar{CV}_i$	average compensating variation	5.4	18.9	2.0
$S\hat{W}$	Change of social welfare	100.3%	—	—

Appendix: Homevoter regime with econ of agglomeration

Table: $\varepsilon = .02$.

variable	description	Japan $\eta = .086$	Japan $\eta = .132$	Germany $\eta = .093$	Germany $\eta = .137$
τ_i'	Property tax rate	12.0%	18.9%	13.2%	20.0%
		(0.8%)	(0.5%)	(0.0%)	(0.4%)
$\tau_i^{*\prime}$	Municipal-level tax rate (stock)	0.68%	1.16%	654.5%	1074.5%
		(0.15%)	(0.23%)	(2.0%)	(24.7%)
n_i'	City population	74237.2	74236.9	7669.2	7669.2
		(280634)	(288318)	(33745.6)	(27389.0)
$\hat{n}_i$	Change of city population	104.7%	102.9%	106.9%	129.6%
		(12.1%)	(17.0%)	(10.6%)	(209.0%)
$\hat{p}_i$	Change of housing price	104.4%	101.6%	99.6%	100.6%
		(3.4%)	(3.3%)	(1.4%)	(6.4%)
$\hat{W}_i$	City's welfare change	107.2%	103.5%	107.0%	132.0%
		(13.1%)	(17.8%)	(10.3%)	(210.3%)
$S\hat{W}$	Change of social welfare	102.0%	100.3%	100.4%	102.2%

Note: Standard deviations in parentheses.

Appendix: Homevoter regime in Germany

Table: Germany, $\varepsilon = 0$.

variable	description	$\eta = .093$ mean	S.D.	median	$\eta = .137$ mean	S.D.	median
τ_i'	Property tax rate	12.7%	0.0%	12.7%	19.2%	0.1%	19.2%
	Property tax rate (stock)	0.44%	0.00%	0.44%	0.71%	0.00%	0.71%
$\tau_i^{*\prime}$	Municipal-level tax rate (stock)	622.9%	1.3%	622.9%	1017.4%	7.1%	1017.7%
n_i'	City population	7669.2	34469.7	2051.7	7669.2	30044.9	2287.6
$\hat{n}_i$	Change of city population	105.1%	7.1%	103.9%	116.7%	33.5%	112.5%
$\hat{p}_i$	Change of housing price	99.4%	0.9%	99.2%	99.3%	3.3%	112.5%
$\hat{w}_i$	Change of wage rate	97.5%	1.3%	97.6%	94.1%	2.7%	94.3%
$\hat{g}_i$	Change of public goods	163.0%	49.3%	156.6%	253.5%	251.6%	233.3%
$\hat{r}_i$	Change of land rent	97.7%	4.0%	96.8%	98.1%	18.4%	95.4%
$\hat{u}_a$	Change of reservation utility	100.9%	—	—	103.7%	—	—
$\hat{u}_{Li}$	Change of landlord' utility	101.0%	1.6%	100.8%	105.0%	8.5%	104.0%
$\hat{W}_i$	City's welfare change	105.2%	6.9%	104.0%	118.8%	33.6%	114.5%
EV_{Wi}	Worker's equivalent var	14.6	11.4	14.0	58.0	45.1	55.6
CV_{Wi}	Worker's compensating var	14.1	10.9	13.5	52.6	40.3	50.0
EV_{Li}	Landlord's equivalent var	22.0	54.8	14.3	111.2	273.9	80.4
CV_{Li}	Landlord's compensating var	20.8	50.2	13.8	96.8	204.5	72.9
$\bar{EV}_i$	average equivalent var	19.6	32.9	14.3	91.7	160.3	72.5
$\bar{CV}_i$	average compensating var	18.6	30.3	13.8	80.9	122.2	65.8
$S\hat{W}$	Change of social welfare	100.4%	—	—	102.1%	—	—

▸ Return to Homevoter regime

Appendix: Extending the govt budget

- Local govts have other revenue sources like grants and transfers:

$$g_i = \text{prop tax revenue} + \text{other revenues}.$$

- Run simulations using this by assuming other revenues being constant.
- The equilibrium property tax rates get smaller (often near zero) than the benchmark ones (as long as using benchmark parameters) because govts need not to rely on the distortionary property tax revenue.

▸ Return to govt

Appendix: selected reference

1. Ahlfeldt, Gabriel M., Stephen J. Redding, Daniel M. Sturm, and Nikolaus Wolf, 2015, The economics of density: Evidence from the Berlin wall, Econometrica 83, 2127-2189.

2. Albouy, David, Frederic Robert-Nicoud, and Nathan Segert, 2017, The optimal distribution of population across cities, Journal of Urban Economics 107, 101–120.

3. Davis, Morris A., and Francois Ortalo-Magne, 2011, Housing expenditures, wages, rents, Review of Economic Dynamics 14, 248-261.

4. Dekle, Robert, Jonathan Eaton, and Samuel Kortum, 2007, Unbalanced trade, American Economic Review 97, 351-355.

5. Fischel, William A., 2001, The Homevoter Hypothesis How Home Values Influence Local Government Taxation, School Finance, and Land-Use Policies, Harvard University Press.

6. Haughwout, Andrew F., 2002, Public infrastructure investments, productivity and welfare in fixed geographic areas, Journal of Public Economics 83, 405-428.

7. Zodrow, George R. and Peter Mieszkowski, 1986, Pigou, Tiebout, property taxation, and the underprovision of local public goods, Journal of Urban Economics, 19, 356-370.