Tiebout Sorting and Inefficiency

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Motivation

Tiebout Sorting and Efficiency:

Where preferences are heterogeneous and scale economies in provision of local public goods are not too great:
- There are potential efficiency gains to decentralized provision
- Gains arise from tailoring local public goods to differences in preferences
- By self-selection into locations, households choose their preferred alternative

Tiebout Sorting and Reality:

Conventional wisdom (?)
- Decentralized provision in practice is subject to some imperfections
- Some efficiency losses are produced by these imperfections, but a substantial proportion of the potential gains in efficiency are nonetheless realized
- Hence, decentralization is still preferred to centralization from an efficiency perspective (though not necessarily from an equity perspective)

We ask whether this conventional wisdom is correct.
Sources of Imperfection in Decentralized Provision

Collective Choice:

Voting outcomes within communities will not generally result in efficient choice of public goods within communities

Distortionary Taxes:

- Financing of local public goods creates deadweight losses
- Property taxes create housing market distortions

Inefficient Rationing of Access to Communities:

- Differentials in housing price premia ration accesses to communities with differing local public good qualities
- Congestion in housing/land use and in public goods consumption needs to be efficiently priced, and tax-inclusive housing prices will not generally accomplish this.
Investigating Inefficiencies in Decentralized Provision

We characterize three allocations:
• Equilibrium with centralized provision (with property taxation and no sorting of types)
• Equilibrium with decentralized provision (with property taxation and sorting of types)
• The no-transfer efficient allocation (which has sorting)

Calibrate computational model

Compute the welfare change (CV + Housing Market Rents) in going from centralized provision to the latter two allocations

Calculate inefficiencies in decentralized allocation due to:
• Collective choice,
• Distortionary taxation, and
• Inefficient rationing of community access
Preview of Findings

- Decentralized provision causes an average welfare loss for realistic parameters when there is potential for substantial gain from sorting

- A community choice externality is the main reason potential gains are not realized

- The decentralized equilibrium is not “stratified enough” relative to the efficient allocation – too many middle class households move into richer communities

Rest of Talk:

- Summarize theoretical model
- Present quantitative findings
- Consider robustness
- Conclude
The Theoretical Model: Households

Note: We consider what we believe to be the most standard model of a multi-jurisdictional MA.

Preferences defined over:
- Housing (measure in quality units) \( h \)
- Numeraire \( x \)
- Congested local public good \( g \) (e.g., per student ed expenditure)

Households differ by endowed income \( y \) with continuous density \( f(y) \)

Household utility function is CES:

\[
U = \left[ \alpha_x x^\rho + \alpha_h h^\rho + \alpha_g g^\rho \right]^{1/\rho}, \ \rho < 1.
\]  

Theoretical properties of equilibrium hold much more generally but we use this utility function in our computations. It is fairly flexible and permits variation in parameters.
Communities/Jurisdictions

In the decentralized equilibrium, there are J jurisdictions in a common labor market (metro area).

- Exogenously determined community boundaries
- Hence exogenously given land areas $L_j$

Housing is competitively supplied with constant returns from land and elastically supplied mobile factor ($q$), with production function: $H = L^\gamma q^{1-\gamma}$, $\gamma \in (0,1)$. This implies housing supply function:

$$H^j_s = L_j \left( p^j_s \right)^{1-\gamma} \left( \frac{1-\gamma}{w} \right)^{1-\gamma};$$

where $w$ is the price of the mobile factor.

Land is owned by absentee agents as is most commonly assumed. (We’ll count their rents in our welfare analysis.)
Equilibrium community characteristics to be determined include:

Net-of-tax housing price: \( p_s \)

Property tax rate: \( t \)

Gross-of-tax housing price: \( p_t \equiv (1+t)p_s \)

Local (congested) public good: \( g \)
Equilibrium is Determined in Three Stages

Stage 1: Households buy a home in a community and housing producers supply housing in each community

Stage 2: Households vote on the community’s property tax rate to finance the local public good

Stage 3: Public good levels are provided to satisfy the community budget constraint and consumption occurs

All households have rational expectations, and hence correctly anticipate continuation equilibrium values.

This specification is referred to as “myopic voting” in the literature, because households take as given residences and the housing supply price when voting. (This is, however, fully rational given the above presumed timing.) Robustness of findings to alternative characterizations of timing of choices is investigated in our sensitivity analysis.
Indirect Utility Function

To examine equilibrium community choice and voting, an indirect utility function is useful. Consider a community with anticipated gross-of-tax price of housing, $p_t$, and local public good level, $g$.

In the first stage, a household with income $y$ in community with $(g, p_t)$ would choose $h$ to:

$$\text{Max}_h U(y - p_t h, h, g)$$

This yields the ordinary demand function $h_d(p,y)$. For CES utility, this is given by:

$$h_d(p_t^j, y) \equiv yz(p_t^j); \quad z(p_t^j) = \left[ p_t^j + \left( \frac{\alpha}{\alpha_x} \right)^{\frac{1}{1-\rho}} \left( p_t^j \right)^{\frac{1}{1-\rho}} \right]^{-1}.$$
The household’s indirect utility function is then:

\[ V(p_t, g; y) = [\alpha_x (y - p_t yz(p_t))^\rho + \alpha_h (yz(p_t))^\rho + \alpha_g g^\rho]^\frac{1}{\rho}. \]

\( V(\cdot) \) satisfies a single-crossing property in the \((g, p_t)\) plane:

\[ \left. \frac{dp_t}{dg} \right|_{V=\text{const.}} = \frac{\alpha_g g^{\rho - 1} y^{-\rho}}{\alpha_x (1 - p_t z)^{\rho - 1} z}. \]

Then:

\[ \text{sign} \left\{ d \left[ \left. \frac{dp_t}{dg} \right|_{V=\text{const.}} \right] / dy \right\} = - \text{sign} \rho. \]

We’ll assume that \( \rho < 0 \), which corresponds to an elasticity of substitution between goods that is less than 1. From (10), the slope of indifference curves of the indirect utility function then rise with income (SRI). This means that higher income individuals are willing to bear a higher increase in housing price for increased \( g \) (and has implications for sorting discussed in a minute.)
Stage One (Residential Choice)

In the first stage, the household chooses jurisdiction \( j \) to maximize \( V(g_j, p_j, y) \), anticipating (correctly) \( g_j \) and \( p_j \), \( j = 1, 2, \ldots, J \).

The following are necessary conditions characterizing a Tiebout (sorting) equilibrium:

**Proposition 2**: Tiebout equilibria with jurisdictions numbered such that \( g_1 < g_2 < \ldots < g_J \):

a. Have **ascending bundles**: \( p_1 < p_2, \ldots, < p_J \)

b. Are **income stratified**: If household with income \( y_2 \) resides in higher-numbered jurisdiction than household with income \( y_1 \) and SRI holds, then \( y_1 \leq y_2 \) with equality for at most one income level.

c. Exhibit **boundary indifference** and strict preference for non-boundary households: A household with income level \( y_j^b \), \( j = 1, 2, \ldots, J - 1 \), exists who is indifferent between residing in \( j \) and \( j+1 \). All other households strictly prefer their residential choice.
Stage One Continued: Housing Markets

Let \( f_j(y) \) be the density of types locating in Community \( j \)

Housing market clearance must hold in all communities for anticipated \( t_j \):

\[
\int_0^\infty h_d((1 + t_j)p^j_s, y)f_j(y)dy = H^j_s(p^j_s);
\]

which establishes the housing stock and net-of-tax housing price.
Stage Three (Consumption)

Prior to Stage Three, \((p_s^j, t_j)\), housing purchases of all households, and the allocation of households to communities have been determined in all \(j\).

In Stage Three, the gross-of-tax housing price in \(j\) is determined to satisfy:

\[
(3) \quad p_t^j = (1 + t_j)p_s^j
\]

All Community Budgets Balance

\[
(4) \quad g_j = t_j p_s^j h_j
\]

where \(h_j\) denote per capita housing consumption. And numeraire consumption results:

\[
(5) \quad x = y - (1 + t_j)p_s^j h_j(y).
\]

(While \(h_j(y) = h_d(p_t^j, y)\), \(h\) has been established and will not vary with \(p_t^j\) and this stage.)
Stage Two (Voting)

Prior to Stage 3, \((p^j_s, h_j(y), f_j(y))\) have been determined in all \(j\).

Combining (3) and (4), we have the voter’s perceived link between the gross-of-tax housing price and the local public good level:

\[
p_j = p^j_s + \frac{g_j}{h_j}
\]

A voter prefers the tax that maximizes a closely related indirect utility function:

\[
\tilde{V}(p^i, g_j; y) = U(y - p^i_j h_j(y), h_j(y), g_j)
\]

subject to the above budget constraint.

The indirect utility function \(\tilde{V}(\cdot)\) likewise satisfies the single-crossing condition SRI.
Stage Two Continued

*Proposition 1: Given the jurisdictional population, majority voting equilibrium exists and is the preferred choice of the median-income household in jurisdiction j.*

This follows from SRI.
The Single-Jurisdiction Benchmark: The MA is one jurisdiction with housing supply the usual aggregation of the J jurisdictional housing supplies. The figure below shows the voting equilibrium in the right panel where the indifference curve ($\tilde{V} = \text{cost.}$) is that at the optimum for the median-income household.
Multi-Community Equilibrium

Each Community Must Satisfy Conditions on the Preceding Page, and Each Adjacent Pair of Communities Must Satisfy the Following:

We’ll see a lot more detail on such equilibria in a few minutes.
Efficient Benchmark

Proposition B1 (Appendix). In an efficient allocation with sorting:

(i) Property taxes are zero with market clearance; local public goods are financed by head taxes:
\[ (t_j = 0, T_j = g_j) \]

(ii) \( g_i \) satisfies the Samuelsonian condition in each community:
\[
\int_{0}^{\infty} \frac{\partial U_j}{\partial g_j} f_j \, dy = N_j, \text{ where } N_j \text{ is the number of residents; and}
\]

(iii) each household is assigned to the community where its utility is at a maximum.

Note: This proposition implies: If head taxes are set efficiently, household choice of community of residence (and housing) would be efficient.

A head tax efficiently prices the congestion effect on local public good consumption and the non-distorted housing price efficiently prices housing/land consumption.
Computational Model

Constant Elasticity of Substitution Utility Function:

\[ U = \left[ \alpha_x x^\rho + \alpha_h h^\rho + \alpha_g g^\rho \right]^{1/\rho}, \quad \rho < 1. \]

The elasticity of substitution is: \( s = 1/(1-\rho) \). If \( \sigma < 1 \), SRI is satisfied.

Metropolitan income is distributed lognormal: \( \ln(y) \sim N(\mu, \sigma^2) \)

Cobb-Douglas Housing Production Function, implying housing supply function:

\[
H_s^j = L_j \left( p_s^j \right)^{\frac{1-\gamma}{\gamma}} \left( \frac{1-\gamma}{w} \right)^{\frac{1-\gamma}{\gamma}}.
\]

We normalize the price of non-land inputs to one, with no loss of generality.

\( \gamma \) is the share of land in housing production, implying supply price elasticity: \( (1-\gamma)/\gamma \).
Calibration

Share of land in housing production is on the order of .25, hence set $\gamma = .25$. This implies a housing supply elasticity of 3.

Utility parameters chosen by:
Normalizing $\alpha_x = 1$ (without loss of generality).
Choosing $\alpha_h$ and $\alpha_g$ such that, in the centralized (i.e. one-community) equilibrium:
- Expenditure share on housing equals 20%,
- Expenditure share on local public good equals 7%

We choose baseline elasticity of substitution so that the housing price elasticity of demand is close to minus one, implying $\rho = -.01$ (and $s$ close to 1), then obtaining $\alpha_h = .356$ and $\alpha_g = .094$.

In sensitivity analyses, we explore variation of above parameters.

Income distribution is calibrated to 1999 mean ($54,710) and median ($36,942), implying: $\mu = .886$ and $\sigma = 10.52$. 
Decentralized equilibria are computed with five communities:

- One large “central city” with 40% of metropolitan land area
- Four “suburbs” each with 15% of metropolitan land area
Welfare analysis computes household CV plus housing rents in going from the centralized equilibrium to the:

- Decentralized Tiebout equilibrium
- Efficient sorting allocation

Baseline calibration yields Decentralized Equilibrium with lower welfare (Consumer Surplus plus Economic Rent) than the Centralized Equilibrium when there is potential for gain!

(See Table 2)
## Table 2 *

<table>
<thead>
<tr>
<th>Positive Properties</th>
<th>Property Tax One Jurisdiction</th>
<th>Property Tax Multiple Jurisdictions</th>
<th>Head Tax Multiple Jurisdictions</th>
<th>Property Tax / Fixed Boundaries Multiple Jurisdictions</th>
<th>Efficient Allocation Multiple Jurisdictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>$17.13</td>
<td>$12.69</td>
<td>$12.93</td>
<td>$16.62</td>
<td>$13.02</td>
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<td>P2</td>
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<td>$13.76</td>
<td>$17.53</td>
<td>$17.53</td>
<td>$13.75</td>
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<tr>
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<td>$16.62</td>
<td>$13.77</td>
<td>$17.53</td>
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<tr>
<td>P4</td>
<td>$18.43</td>
<td>$13.78</td>
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<tr>
<td>P5</td>
<td>$22.61</td>
<td>$13.78</td>
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<td>$17.34</td>
<td>$13.61</td>
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<tr>
<td>Y1</td>
<td>$28.589</td>
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<td>$57,950</td>
<td>$57,950</td>
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<td>$82,073</td>
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<td>$84,067</td>
<td>$84,067</td>
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<tr>
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<td>$122,768</td>
<td>$122,768</td>
<td>$122,768</td>
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<tr>
<td>Y4</td>
<td>$89,598</td>
<td>$192,823</td>
<td>$197,811</td>
<td>$197,811</td>
<td>$197,811</td>
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<tr>
<td>Median Income J1</td>
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<td>$17,140</td>
<td>$25,741</td>
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<td>$26,076</td>
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<tr>
<td>Median Income J2</td>
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<td>$67,131</td>
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<td>$68,840</td>
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<tr>
<td>Median Income J3</td>
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<td>$97,029</td>
<td>$99,320</td>
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<td>$99,320</td>
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<tr>
<td>Median Income J4</td>
<td>$69,929</td>
<td>$144,849</td>
<td>$148,279</td>
<td>$148,279</td>
<td>$148,279</td>
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<tr>
<td>Median Income J5</td>
<td>$128,816</td>
<td>$249,542</td>
<td>$255,322</td>
<td>$255,322</td>
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<tr>
<td>N1</td>
<td>39%</td>
<td>68%</td>
<td>69%</td>
<td>69%</td>
<td>69%</td>
</tr>
<tr>
<td>N2</td>
<td>15%</td>
<td>13%</td>
<td>13%</td>
<td>13%</td>
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<tr>
<td>N3</td>
<td>15%</td>
<td>9%</td>
<td>9%</td>
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<tr>
<td>N4</td>
<td>15%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
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<tr>
<td>N5</td>
<td>16%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
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</tr>
<tr>
<td>T1</td>
<td>35%</td>
<td>35.33%</td>
<td>35.17%</td>
<td>35.17%</td>
<td>35.17%</td>
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<tr>
<td>T2</td>
<td>35.24%</td>
<td>35.17%</td>
<td>35.17%</td>
<td>35.17%</td>
<td>35.17%</td>
</tr>
<tr>
<td>T3</td>
<td>35.20%</td>
<td>35.17%</td>
<td>35.17%</td>
<td>35.17%</td>
<td>35.17%</td>
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<tr>
<td>T4</td>
<td>35.14%</td>
<td>35.16%</td>
<td>35.16%</td>
<td>35.16%</td>
<td>35.16%</td>
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<tr>
<td>T5</td>
<td>34.96%</td>
<td>35.11%</td>
<td>35.11%</td>
<td>35.11%</td>
<td>35.11%</td>
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<tr>
<td>G1</td>
<td>$3,830</td>
<td>$1,195</td>
<td>$1,691</td>
<td>$1,952</td>
<td>$1,829</td>
</tr>
<tr>
<td>G2</td>
<td>$2,390</td>
<td>$4,410</td>
<td>$4,887</td>
<td>$4,569</td>
<td>$4,659</td>
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<tr>
<td>G3</td>
<td>$3,359</td>
<td>$6,374</td>
<td>$7,071</td>
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<td>$9,516</td>
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<td>$9,987</td>
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<tr>
<td>G5</td>
<td>$10,987</td>
<td>$16,393</td>
<td>$20,665</td>
<td>$17,922</td>
<td>$17,922</td>
</tr>
</tbody>
</table>

### Distributional and Welfare Results

<table>
<thead>
<tr>
<th>Interval of income made worse off</th>
<th>Low bound</th>
<th>$8,500</th>
<th>$0</th>
<th>$0</th>
<th>$0</th>
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</thead>
<tbody>
<tr>
<td>High bound</td>
<td>$349,500</td>
<td>$66,500</td>
<td>$57,500</td>
<td>$65,500</td>
<td></td>
</tr>
<tr>
<td>% pop. made worse off</td>
<td>95%</td>
<td>75%</td>
<td>69%</td>
<td>74%</td>
<td></td>
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<tr>
<td>Aggregate per capita CV</td>
<td>-41</td>
<td>714</td>
<td>1158</td>
<td>726</td>
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<tr>
<td>Change in Rents</td>
<td>-0.22</td>
<td>721</td>
<td>-3.17</td>
<td>711</td>
<td></td>
</tr>
<tr>
<td>CV + Change in Rents</td>
<td>-41.68</td>
<td>1434.82</td>
<td>1154.37</td>
<td>1437.13</td>
<td></td>
</tr>
</tbody>
</table>

25
To investigate sources of efficiency losses from decentralization, we compare:

- Decentralized equilibrium with head taxes
  
  This comparison demonstrates that voting is a very minor source of inefficiency (99.8% of potential gain would be realized)

- Allocation in which households are assigned to communities as in the efficient allocation, but they then vote on public good provision with property.

  This comparison demonstrates that property taxation and voting combined are modest sources of inefficiency when externalities from household choice of community are eliminated (80.3% of the gain would be realized).

Together, the above results point to externalities from household choice of community as the primary source of inefficiency in decentralized equilibrium.

Study of the results in Table 2 reveals that the decentralized allocation is not stratified enough! Too many middle income households move into the “suburbs.”
The Residential Choice Externality

We provide a theoretical characterization of the residential choice externality as follows. Solve the \textbf{second best} social planner’s problem where (i) \textbf{property taxation is the only option for financing the public good}; (ii) housing markets clear; (iii) the planner places given weight $\omega(y)$ on household $y$’s utility in the social objective function and can make transfer $r(y)$ to household $y$; and (iv) the \textbf{planner assigns households to communities}.

Household with income $y$ is assigned to the community that maximizes:

$$\omega(y)V(p^j, g_j; y) - \lambda_j(g_j - \tau_j(y)\theta_j); \text{ where}$$

$$\tau_j(y) = \frac{t_jp^j_d(p^i, y + r(y))}{(1 + t_j)} \text{ is the household’s property tax payment;}$$

$\lambda_j$ is a positive multiplier (on the local balanced budget constraint); and

$\theta_j \in (0, 1)$ and increases from 0 to 1 as the housing supply elasticity increases.
Since a household would choose the community that maximizes $V(\cdot)$,

$$-\lambda_j(g_j - \tau_j(y)\theta_j)$$

measures the residential choice externality.

Interpretation: Since part of property taxation is absorbed by land owners ($\theta_j < 1$), the externality will tend to be negative and of higher magnitude in richer communities with higher $g$. Moreover, the externality for those with below average housing demand (whose $\tau_j < g_j$ necessarily), will have higher magnitude negative externality.

This is consistent with the computations. The primary cause of inefficiency is that relatively poorer households crowd richer communities.
Investigation of Robustness

Our baseline voting model is the “myopic voting” model most common in the literature.

We consider two other characterizations of voting equilibrium:

Alternative 2: “Moderate myopia”

Stage 1: Households commit to jurisdictions
Stage 2: Households vote over their community’s property tax rate while
    anticipating impact of the tax rate on the community’s housing market given
    the assumption of fixed community population
Stage 3: Households purchase housing, housing market clears, community
    budgets balance determining public good levels, consumption occurs

Thus, conditional on their presumption of fixed community populations, households
correctly predict how the tax rate affects the community housing market equilibrium and
associated budget-balance impact of their tax choice on local public good provision.
Alternative 3: Utility-taking

Stage 1: Households choose jurisdictions
Stage 2: Households vote over the property tax rate taking utility available to all households in all other jurisdictions as given and anticipating the change in housing market equilibrium and migration in their community that will be induced by a choice of the community tax rate
Stage 3: Households purchase housing, housing market clears, community budgets balance determining public good levels, consumption occurs

Thus, households make a “small community” assumption and correctly anticipate all effects of a tax change that are would arise under that assumption.

Notes: No one moves in equilibrium, but the potential of moving substantially affects equilibrium. Also, this is an approximation to a Nash equilibrium among voters in all communities – which would be horrendously difficult to compute in a five community model.
Efficiency Implications of Alternative Voting Models:

Moderate Myopia: There is remarkably little difference in outcomes between the baseline myopic model and the outcome under moderate myopia.

Utility-Taking: Relative to the centralized equilibrium:
• Decentralized equilibrium with utility taking leads to substantially larger efficiency losses than occur with decentralization under either of the myopia alternatives.
• All households are worse off in the decentralized than in the centralized equilibrium.

(See Table 3 Below)

The poorer districts lower taxes to try to keep in their relatively higher income households and the richer districts increases taxes to try to keep out relatively poorer households – tax rates, housing prices, and public goods levels more steeply ascend.
(The household allocation is less efficient, but I’m not sure why??)
### Table 3: Alternative Voting Specifications

<table>
<thead>
<tr>
<th>Positive Properties</th>
<th>Moderate Myopia/Property Tax One Jurisdiction</th>
<th>Moderate Myopia/Property Tax Multiple Jurisdictions</th>
<th>Utility Taking Property Tax</th>
<th>Efficient Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 =</td>
<td>$17.092</td>
<td>$12.66</td>
<td>$10.23</td>
<td>$13.02</td>
</tr>
<tr>
<td>P2 =</td>
<td>$15.17</td>
<td>$14.05</td>
<td>$13.75</td>
<td></td>
</tr>
<tr>
<td>P3 =</td>
<td>$16.58</td>
<td>$17.01</td>
<td>$13.74</td>
<td></td>
</tr>
<tr>
<td>P4 =</td>
<td>$18.38</td>
<td>$20.38</td>
<td>$13.72</td>
<td></td>
</tr>
<tr>
<td>P5 =</td>
<td>$22.56</td>
<td>$26.22</td>
<td>$13.61</td>
<td></td>
</tr>
<tr>
<td>Y1 =</td>
<td>$28.587</td>
<td>$24.496</td>
<td>$57.950</td>
<td></td>
</tr>
<tr>
<td>Y2 =</td>
<td>$39.987</td>
<td>$35.891</td>
<td>$84.067</td>
<td></td>
</tr>
<tr>
<td>Y3 =</td>
<td>$56.927</td>
<td>$54.136</td>
<td>$122.768</td>
<td></td>
</tr>
<tr>
<td>Y4 =</td>
<td>$89.593</td>
<td>$89.158</td>
<td>$197.811</td>
<td></td>
</tr>
<tr>
<td>N1 =</td>
<td>39%</td>
<td>32%</td>
<td>69%</td>
<td></td>
</tr>
<tr>
<td>N2 =</td>
<td>15%</td>
<td>17%</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>N3 =</td>
<td>15%</td>
<td>18%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>N4 =</td>
<td>15%</td>
<td>17%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>N5 =</td>
<td>16%</td>
<td>16%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>T1 =</td>
<td>34.57%</td>
<td>34.82%</td>
<td>12.41%</td>
<td></td>
</tr>
<tr>
<td>T2 =</td>
<td>34.75%</td>
<td>22.70%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3 =</td>
<td>34.72%</td>
<td>35.07%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T4 =</td>
<td>34.68%</td>
<td>50.07%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T5 =</td>
<td>34.55%</td>
<td>64.09%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G1 =</td>
<td>$3,795</td>
<td>$1,182</td>
<td>$447</td>
<td>$1,829</td>
</tr>
<tr>
<td>G2 =</td>
<td>$2,366</td>
<td>$1,493</td>
<td>$4,569</td>
<td></td>
</tr>
<tr>
<td>G3 =</td>
<td>$3,325</td>
<td>$3,102</td>
<td>$6,612</td>
<td></td>
</tr>
<tr>
<td>G4 =</td>
<td>$4,939</td>
<td>$6,228</td>
<td>$9,987</td>
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</tr>
<tr>
<td>G5 =</td>
<td>$10,889</td>
<td>$16,524</td>
<td>$17,922</td>
<td></td>
</tr>
</tbody>
</table>

**Distributional and Welfare Results**

- **Interval of income made worse off**
  - Low bound: $8,500
  - High bound: $349,500
  - High bound: infinity
  - High bound: $65,500

- **% of pop. made worse off**
  - 95%
  - 100%
  - 74%

- **Aggregate per capita CV**
  - -41
  - -677
  - 726

- **Change in Rents**
  - 0.31
  - -215
  - 703

- **CV + Change in Rents**
  - -41.12
  - -892
  - 1428.57
Robustness to Parameter Variation
(Table 4)

Land share in housing (and housing supply elasticity):
Baseline calibration is $\gamma = .25$:
- $\gamma = .20$ decentralization yields in efficiency loss of $389$ per capita
  (relative to gain of $1,458$ under efficient allocation)
- $\gamma = .30$ decentralization yields efficiency gain of $186$ per capita
  (relative to gain of $1,416$ under the efficient allocation)

(With lower $\gamma$, the housing supply elasticity is higher, housing prices respond less to changes in demand and the residential choice externality worsens.)

Elasticity of Substitution: Baseline is $\rho = -.01$ ($s = .99$)
- $\rho = -.1$ ($s = .91$) Decentralization yields gain of $259$ per capita
  (relative to gain of $1,570$ under efficient allocation)
- $\rho = -.52$ ($s = .66$) Decentralization yields gain of $787$ per capita
  (relative to gain of $2,444$ under efficient allocation)

(Lower elasticity of substitution implies greater gains from sorting.)
### Table 4A: Sensitivity with Respect to \( \rho \)

<table>
<thead>
<tr>
<th>( \rho = -.05 )</th>
<th>( \rho = -.05 )</th>
<th>( \rho = -.1 )</th>
<th>( \rho = -.1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multiple Jurisdiction Equilibrium</strong></td>
<td><strong>Efficient Allocation</strong></td>
<td><strong>Multiple Jurisdiction Equilibrium</strong></td>
<td><strong>Efficient Allocation</strong></td>
</tr>
<tr>
<td>Interval of income made worse off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low bound</td>
<td>$39,500</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>High bound</td>
<td>$68,500</td>
<td>$66,500</td>
<td>$0</td>
</tr>
<tr>
<td>% of pop. made worse off</td>
<td>23%</td>
<td>75%</td>
<td>0%</td>
</tr>
<tr>
<td>Aggregate per capita CV</td>
<td>89</td>
<td>813</td>
<td>265</td>
</tr>
<tr>
<td>Change in Rents</td>
<td>-1.87</td>
<td>681</td>
<td>-5.56</td>
</tr>
<tr>
<td>CV + Change in Rents</td>
<td>86.79</td>
<td>1493.50</td>
<td>259.31</td>
</tr>
</tbody>
</table>

### Table 4B: Sensitivity with Respect to \( \gamma \)

<table>
<thead>
<tr>
<th>( \gamma = .2 )</th>
<th>( \gamma = .2 )</th>
<th>( \gamma = .3 )</th>
<th>( \gamma = .3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multiple Jurisdiction Equilibrium</strong></td>
<td><strong>Efficient Allocation</strong></td>
<td><strong>Multiple Jurisdiction Equilibrium</strong></td>
<td><strong>Efficient Allocation</strong></td>
</tr>
<tr>
<td>Interval of income made worse off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low bound</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>High bound</td>
<td>infinity</td>
<td>$62,500</td>
<td>$0</td>
</tr>
<tr>
<td>% of pop. Made worse off</td>
<td>100%</td>
<td>72%</td>
<td>0%</td>
</tr>
<tr>
<td>Aggregate per capita CV</td>
<td>-390</td>
<td>888</td>
<td>187</td>
</tr>
<tr>
<td>Change in Rents</td>
<td>0.49</td>
<td>570</td>
<td>-0.91</td>
</tr>
<tr>
<td>CV + Change in Rents</td>
<td>-389.39</td>
<td>1458.66</td>
<td>186.46</td>
</tr>
</tbody>
</table>
Implications of Computational Analysis:

- Baseline calibration yields efficiency losses from decentralization
- Sensitivity analyses suggest that, at best, decentralization achieves a small fraction of potential efficiency gain.
Conclusions

Economists tend to view Tiebout equilibrium as more efficient than centralized equilibrium recognizing that:

- Tiebout equilibria may adversely affect the poor, and
- Some efficiency losses occur in practice under decentralized equilibria

Our analysis suggests:
- Magnitude of efficiency losses with real-world decentralization may be larger than generally thought
- Inefficiency derives largely from an inefficient allocation of households to jurisdictions and housing to households: Why? One instrument (housing price) rations access to two goods (local public good and housing).
- Efficient allocation entails greater stratification than arises in our decentralized equilibrium
We have investigated robustness to several potential generalizations

- Still, our framework is Spartan, neglecting both peer effects and preference heterogeneity arising from sources other than income.
- Research on robustness to such generalizations is clearly warranted