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Welfare Consequences of Mobility Restrictions in the Tiebout Model: An Agent-Based Modeling Approach

Soomi Lee
University of La Verne
slee4@laverne.edu

Yuri Mansury
Illinois Institute of Technology
ymansury@iit.edu

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Abstract

We apply the Agent-Based Model (ABM) to the Tiebout model (1956) as a tool for evaluating the welfare implications of limited residential mobility, the core element of the model. Our model embraces not only Tiebout's original model but also subsequent theoretical advancements, including the Tiebout-Oats-Hamilton model and the endogenous political processes between local governments and voters. We instrument a widely used mobility-limiting property tax policy, property tax assessment growth limits, to examine their impacts on welfare. Our key contribution lies in our application of ABM to the Tiebout model, showcasing a real-world policy impact on welfare to demonstrate how adjustments in a single factor ripple through the complex urban system.

JEL Code: H2, H3, H7
Keywords: Tiebout, property tax, agent-based model

I. Introduction

What are the welfare consequences of imperfect mobility in Tiebout's world? This paper examines changes in welfare and efficiency when free residential mobility, the core of Tiebout's (1956) efficiency mechanism, is restricted.

Researchers have found evidence that people "vote with their feet." However, due to the observability, endogeneity, and interactions with the supply side, it is difficult to assess the welfare of citizens. Studies show mixed evidence to support Tiebout (1956): welfare effects vary across a wide range of contexts and assumptions.

Real-world applications of Tiebout's model are much more complex than his "pure model" that Tiebout lays out in his original paper (1956). Residential mobility in the real world involves interactions with zoning, property tax policies, and housing market characteristics that constrain full residential mobility, in addition to the political endogeneity. These real-world restrictions change the welfare of the overall population but more importantly affect welfare of subpopulations differently, especially by homeownership. Thus, it is evident that econometric approaches with observational data may not fully capture the complexity of the mechanism with heterogeneous agents in various institutional contexts to assess the welfare effects of mobility or a lack thereof.

We take a complexity approach to revisit the welfare implications of limited residential mobility in Tiebout's world by introducing the Agent-Based Model (ABM). The ABM allows us to explore how institutional conditions lead to welfare gains and losses for citizens. It allows us to simulate how changes in a single factor, such as a property tax relief for homeowners or changes in the number of jurisdictions to choose from, ripple through the complex urban system, holding all other factors constant. We believe that studying the Tiebout model with the ABM approach contributes to the literature by discovering new insights into Tiebout's world with real-world implications.

In this paper, we conducted the simulations with three main questions in mind. First, to examine the welfare implications for political endogeneity, we vary the political processes to determine the amenities in an endogenous and exogenous political environment. In an endogenous scenario, municipal governments adjust their public good bundles in response to the current residents through an election process, whereas in the exogenous scenario, they do not adjust the initial amenity bundles. The endogenous local political process to determine the public good bundles makes local governments more responsive to residents' preferences than Tiebout's original model accounts for (Gerber and Gibson 2009) and emphasize a greater role of local governments than migration in the sorting process (Holcombe 1989).

Second, for the welfare implications of limited mobility, we introduce a real-world property tax policy, the property tax assessment limits, to see how these policies impact the welfare and exchange efficiency for citizens and for homeowners and renters differently. Assessment limits have important implications in the real world and the Tiebout model. They exert the "lock-in effect” that reduces residential mobility for homeowners but not renters. This leads to a difference in residential mobility between homeowners and renters and depending on the homeowner’s housing tenure. More importantly, they create tax price differentials among homeowners for the same public good bundles. Thus, assessment limits weaken the welfare and efficiency mechanism central to the Tiebout model.

Third, to examine the welfare implications for decentralization and welfare enhancement, we vary the supply-side conditions including the number of competing jurisdictions and the number of public goods. It relates to the initial insight of Tiebout in response to the Samuelson condition (1954).

The paper is organized as follows. In Section II, we discuss the literature. Section III describes the model. Section IV reports the results. We conclude the paper in Section V.

II. Tiebout, Efficiency, and Welfare

- **The Tiebout Hypothesis**

Responding to Samuelson (1954) and Musgrave (1959), Tiebout (1956) illustrates that in a market-like environment for local public goods, residential mobility (voting with one’s feet) creates a preference revelation mechanism for efficiency. Oates (1969) extends Tiebout’s idea that property taxes function like the "price" because they fund public good bundles and are capitalized into property values. The Tiebout-Oates framework provides the benefit view of property taxes, linking property taxes levied at the local level fund local public good packages.

Hamilton (1975) incorporates the practice of local zoning ordinances into Tiebout (1956). In the Tiebout-Hamilton model, zoning, combined with property taxes, ensures that houses have similar values and people pay roughly the same amount in property taxes for the same level of public services. This eliminates "the poor chasing the rich," the free-rider problem in the original Tiebout model, and improves efficiency. Thus, Tiebout’s pure theory operates in the real world via housing markets in conjunction with property taxes and zoning. Calabrese, Epple, and Romano (2007) find that zoning leads to Tiebout welfare gains in aggregate because it reduces housing market distortions, leading to a more efficient provision of public goods. Konishi (2008) reports results consistent with Calabrese et al. (2007) in that the Tiebout-Hamilton model provides the existence and efficiency of equilibrium.[1]

One of the important implications in Tiebout (1959) is the efficiency and welfare properties of a decentralized system. Bewley (1981) contends that Tiebout’s hypothesis holds only when there are as many municipalities as there are people. That is, an efficient allocation occurs only when citizens sort themselves into homogeneous settlements, each with exactly one inhabitant. His

[1] Epple and Zlenitz (1981), however, argue that even with full residential mobility, inefficiencies can exist because local governments still have control over immobile land and even when they do not have control over mobile residents. Thus, local governments can use the land not for residents’ welfare but for their own purposes, causing inefficiencies.

two-region model shows that public goods allocation is inefficient in a democratic system where the local governments' objective is to maximize their constituents' welfare.[2] A vast literature has empirically examined Tiebout's efficiency argument. Following Dowding et al. (1994) We discuss two sides of efficiency discussions: efficiency from the supply side and welfare on the demand side.

- **Supply side's technical efficiency**

On the supply side, studies examine the level of expenditures of local governments as an indicator of efficiency. In this case, efficiency implies technical efficiency that produces higher quality and quantity of public goods at a lower cost. In Tiebout, competition among local governments is the key to technical efficiency, which invokes discussions on whether consolidation or fragmentation is more efficient in public good provision. Empirically, this question is examined by looking at the relationship between the number of local governments in a region and expenditure levels. The empirical literature provides mixed evidence.

Nelson (1987) finds that decentralization is associated with lower spending for multi-purpose governments but not for single-purpose districts in the U.S. However, using municipalities in England, Dowding and Mergoupis (2003) conclude that fragmentation is not more efficient than centralization. Krane et al. also find that decentralization does not result in lower expenditures. Some argue that single-purpose governments are often capital-intensive, and therefore, they lose efficiency by losing economies of scale if they are fragmented. Also, small, fragmented governments do not have large rent for bureaucrats to gain, and this reduces the opportunities for inefficiency. In addition, because of their intra-jurisdictional homogeneity, they tend to have less redistributive functions at the local level, which also leads to lower expenditures and greater efficiency.

Several studies of U.S. school districts provide inconclusive evidence on whether a decentralized education system with many school districts is more efficient. Bradford and Oates (1974) find evidence of welfare gains from decentralization. Hanushek and Yilmaz (2013) also find that centralization of public education through school district consolidation and equalization of district power leads to welfare losses for all families. However, Fernandez and Rogerson (1998) report that public education is provided more efficiently under a centralized education system, but Calabrese (2012) uses the same calibration as Fernandez and Rogerson (1998) and finds no difference between centralization and decentralization.

These studies face theoretical and empirical challenges. First, technical efficiency is measured in terms of expenditure. However, equating lower expenditures with greater efficiency is valid if variations in the quantity and quality of public goods are uncorrelated with variations in expenditures (Boyne 1992; Dowding et al. 1994). While expenditure is a reasonable and observable measure, it does not fully capture technical efficiency.

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[2] While Bewley does not specify how democracy works in his model, his result is consistent with Bruckner's earlier analysis (1979), which showed that allocations may not be optimal in Tiebout's world with majority voting rule.

Second, efficiency depends on the nature of the public good (Ostrom 1961). If what is provided is pure public good, inter-jurisdictional spillovers will reduce efficiency. In addition, capital-intensive public goods may require a consolidated government to realize economies of scale. Brueckner (2004), in his theoretical model and quantitative simulation, shows that the welfare from decentralization depends in part on the cost function of public goods. Third, the way in which public goods are provided is also important. Municipalities may choose to provide public goods by contracting them out or by producing them themselves, which also affects the technical efficiency of public goods provision.

- **Welfare consequences and mobility**

On the demand side, studies examine consumer welfare by measuring satisfaction with public goods. This is the allocative efficiency that results from the technical efficiency of competing, multiple, heterogeneous jurisdictions. However, the empirical evidence is mixed. Ostrom and Park (1999) test whether decentralization can increase consumer welfare by measuring their satisfaction with public goods. They find that for police services, smaller jurisdictions tend to have higher resident satisfaction and higher clearance rates. According to Ostrom (1990), it is the organic interactions between consumers and producers that leads to a Pareto-superior allocation. However, Lowery and Lyon (year) find the opposite, with Danish and Dutch data showing that higher satisfaction is associated with centralization.

The problem with allocative efficiency is similar to the problem with technical efficiency. First, subjective satisfaction does not fully capture allocative efficiency. Second, the studies examine only a single public good (policing) and are not generalizable to other services or tax-public good packages. In fact, the Tiebout model is about a tax-benefit package, not a specific public good. Moreover, the characteristics of public goods - economies of scale and externalities - should be considered, as studies show that larger spillovers lead to more inefficiency from decentralization (Chu and Yang 2012; Kuhlmey and Hintermann 2019; Calabrese 2012).

- **Limited mobility**

It is crucial to have full residential mobility for the entire allocative efficiency to work since it solves the preference revelation problem that arises with public goods.[3] Full mobility refers to no restrictions for consumer-voters to move freely between different jurisdictions to best match their preferences for public goods and tax levels. This self-sorting results in higher consumer welfare and higher allocative efficiency. With limited mobility, however, consumers

[3] Assumption 1. “Consumer-voters are fully mobile and will move to that community where their preference patterns, which are set, are best satisfied (p.419).” “The act of moving or failing to move is crucial. Moving or failing to move replaces the usual market test of willingness to buy a good and reveals the consumer-voter’s demand for public goods. This each locality has a revenue and expenditure pattern that reflects the desires of its residents. The next step is to see this implies for the allocation of public goods at the local level (p.420).” “There is no way in which the consumer can avoid revealing his preferences in a spatial economy. Spatial mobility provides the local public-goods counterpart to the private market’s shopping trip (p.420).”

have fewer opportunities to move to jurisdictions that match their preferences. As a result, individuals may have to settle in areas that do not provide the optimal mix of public goods and taxes, leading to lower overall consumer welfare and allocative efficiency. There are limited studies exploring the welfare consequences of policy-driven limited mobility. We will explore this in our model using assessment limits, a widely used property tax rule to provide tax incentives for homeowners to stay in place.

- **Political Endogeneity**

The public choice literature views local governments as competing for mobile consumers of public services in a fragmented system (Ostrom et al., 1961; Bish, 2014). In this strand of the literature, local governments constantly innovate and develop distinctive services to gain competitiveness. Failure to adapt to changing consumer preferences would give residents an incentive to move elsewhere, contributing to population loss and a shrinking tax base.

It is difficult for empirical studies to capture the endogenous sorting through the political process between voters and local governments to disentangle welfare consequences. The empirical evidence supports the theoretical public choice argument. Just as voters respond to the fiscal environment of local governments through residential mobility, local governments also respond to voters by adjusting tax-benefit packages to meet voters' existing, changing, and new demands (Borcherding & Deacon 1972; Percy & Hawkins, 1992; Boyne, 1996).

For example, rural and suburban residents are more likely to favor automobile-friendly infrastructure, while urban residents are more likely to support public transportation (Parker et al., 2018). Municipalities are rushing to develop broadband infrastructure in response to rising demand for high-speed internet (Feld, 2019). The elderly demand less school funding than the population with school-age children (Figlio and Fletcher 2012). Voting preferences for public education spending change over the life cycle (Epple, Romano, and Sieg 2012), so even with the exact same residents, preferences might change, and local governments may change the public good bundle accordingly. All of this suggests a dynamic environment in which local services evolve to attract and retain citizen customers.

- **Complex and evolving system**

Endogenous and decentralized public good provision drives the dynamics of a complex system by autonomous participants on both the demand and supply sides. In a complex system, changes on one side induce behavioral adjustments on the other side without central control. Ostrom (1993) characterizes similar working dynamics in local governance as a "two-way relationship among participants." Citing examples from the American public education system, Ostrom contended that it is the mutual interactions between consumers (i.e., residents) and producers (e.g., school districts) in a bottom-up setting that leads to an optimal allocation of public goods (Davis & Ostrom, 1991).

Bottom-up and interdependent actions affect the institutional structure, which contrasts with top-down models where actors have no ability to do so. There is substantial evidence of citizen actions influencing local policies, which in turn induce subsequent reactions of institutions to political participants (Cox et al., 2009). Ostrom (2010) concludes that these iterative actions and reactions ultimately converge into an improved policy that makes everyone better off.

However, the theoretical prediction is far from guaranteed. Ostrom herself admitted there are many cases where locally evolved institutional arrangements failed to improve outcomes (Dietz et al., 2003). Indeed, how micro behavior changes macro outcomes is hard to establish when many individuals and multiple jurisdictions interact and influence each other's decisions (Åberg, 2000; Schelling, 1978). The challenge is that explaining an aggregate phenomenon requires an understanding of the mechanism through which a distinct macro-level property emerges from the sum of individual actions (Billary, 2015).

The generative approach to social science is one approach to the challenge. It employs computational agent-based models (ABMs) to simulate emergent social realities (Epstein, 2006). The goal is to identify the set of micro-behaviors that are responsible for the emergence of a macro-phenomenon. A generative social scientist uses ABMs to demonstrate how system-level properties arise from (or "grow") the actions of individuals making up the system (Epstein & Axtell, 1996).

III. Assessment Limits and the Lock-in Effect

Our model examines how a policy-driven mobility constraint affects welfare consequences. In particular, we introduce an assessment limit (also known as an assessment limit, assessment cap, or property tax cap), a widely used property tax policy in the U.S., to the Tiebout model because it discourages homeowner's residential mobility. An assessment limit is one type of property tax limit. As Figure presents, it was adopted since California's anti-tax movement, known as the Tax Revolt and Proposition 13, in the 1970s. California's 2% assessment limit adoption inspired many other states to adopt their own version.

[Figure 1 about here]

Assessment limits control the growth of an assessed value that could fluctuate erratically without them. The policy ensures stable and predictable property tax bills for property owners. The goal of the assessment limit is ultimately to prevent involuntary displacement due to an unexpected property tax increase.

Table 1 presents the list of sixteen states and D.C. implementing assessment limits. As of 2024, eleven states and D.C. have implemented a state-wide assessment limit, while five states allow local governments to opt in without a state-level implementation.

[Table 1 about here]

[Figure 2 about here]

Some states reset the initial assessment value at the current market value upon sale. This reset rule is known as the "welcome stranger provision," under which new homeowners pay more property taxes than existing homeowners for a property with a similar market value and local public service. However, states like Arizona and Oregon do not reset the assessed value upon sale. States that adopted assessment limits usually have a rate cap, except for Connecticut, Maryland, and New York. For example, California's state maximum rate is one percent of the assessed value. With rate caps, assessment limits increase the predictability and stability of property tax liability for property owners in the face of volatile housing market conditions. Rapid home price appreciation and subsequent property tax hikes have prompted voters' support for assessment limits to protect property owners from being priced out of their homes due to unexpectedly high property tax bills.

An assessment limit is significant concerning the Tiebout model because of its impact on residential mobility. Research shows that assessment limits discourage homeowners from voluntary moves. The negative impact of assessment limits on residential mobility, also known as the "lock-in effect," is well-documented in the public finance literature. Many of them have studied the cases in California, Michigan, Florida, and D.C. Under an assessment limit, property sales decrease (Stohs et al. 2001), the average tenure for homeowners increases compared to renters (Nagy, 1997; Wasi and White, 2005), and effective property tax rates decline (Fleissing, 2016; Flessing 2018; Miller and Sklarz, 2016). Studies using a natural experiment find a causal effect of assessment limits on reduced residential mobility (Ferreira 2010; Ihlanfeldt 2011).

IV. The Agent-Based Model

1. Setup[4]

Our agent-based model (ABM) draws inspiration from Tiebout's (1956) notion of "voting with one's feet," which refers to how spatial relocation signals preferences for local public goods. It features three types of agents:

1. Jurisdictions[5]
2. Citizens
3. Parties

Every jurisdiction, j = 1, 2, …, *nj*, is defined by a vector of current amenities, $\mathbf{CA_j}$, which lists their positions on various public goods. The vector's size is *na*, corresponding to how many local public goods citizens consider in their location decisions. For example, *na* would be equal to 3 if a jurisdiction offers public education, sidewalks, and fire protection.

Each vector's component, $ca_{j,i} \in \mathbf{CA_j}$, where *i* = 1, 2, … *na*, is a binary variable taking the value of one if the jurisdiction is in favor of providing the public good, and zero otherwise.

[4] We provide the list of ABM variables in the Appendix.

[5] In the rest of the paper, we use the terms "municipalities," "places," "locations," "jurisdictions," "communities," or "neighborhoods" interchangeably.

The model imagines a population of N citizens, indexed by c = 1, 2, …, N. Initially, the N citizens are randomly placed across *nj* jurisdictions. Each citizen is endowed with initial wealth (*money*) drawn from a normal distribution with mean μ and standard deviation σ:

$$money_c \sim N(\mu, \sigma).$$

Citizens evaluate the attractiveness of location *j* in three steps. First, they assess their satisfaction with location *j*'s amenities using the following function:

$$putil_{c,j} \; = \sum_{j=1}^{na} ca_{j,i} * \omega_{c,i} \quad (1),$$

where $\boldsymbol{\omega}_c$ is the citizen's weight vector for the *na* amenities. Each weight $\omega_{c,i}$ is randomly assigned from a uniform distribution:

$$\omega_{c,i} \sim U(0{,}400) \,/\, na \,.$$

Note that a greater number of amenities result in smaller weights. For example, with *na* = 2, weights range from 0 to 200. But if citizens consider 20 amenities instead, the weights adjust to between 0 and 20.

Second, citizens calculate how much money they have after covering house costs and the jurisdiction's per capita "fees," denoted as f_j. Everyone also pays property taxes.[6] The remaining amount is called money left, *mleft*:

$$mleft_{\,c,j} = money_c - f_j - ptr \cdot hcost_j, \qquad (2)$$

where *ptr* denotes the property tax rate and $hcost_j$ the housing costs in jurisdiction *j*.

Finally, citizens determine their total satisfaction from location *j* using a Cobb-Douglass function that combines the jurisdiction's amenities and their remaining money:

$$util_{c,j} = {putil_{c,j}}^{\alpha} \cdot {mleft_{\,c,j}}^{1-\alpha}, \qquad (3)$$

where α is the Cobb-Douglas share parameter between public goods and private consumption.

Nationally, there are *np* political parties, indexed by p = 1, 2, …, *np*. Each party has a local chapter in every jurisdiction. These chapters are characterized by a platform vector, p_{pj}, which reflects their positions on various amenities. A value of 1 indicates support for the amenity and 0 indicates opposition. For instance, a chapter that supports public education but opposes sidewalks and fire protection would be represented by the vector [1, 0, 0].

[6] However, only homeowners receive the benefits of tax caps.

The production costs of amenities follow a normal distribution, characterized by a mean $\square_c$ and standard deviation $\square_c$. This is represented by the vector **AC**. To determine the budget to provide the amenities, jurisdictions calculate the sum of the products of these costs and the current platform:

$$jcost_j = \sum_{i=1}^{na} ca_{j,i} * ac_i \ ,$$

where $ac_i \in \mathbf{AC}$.

2. Sequence of Events

In each period, the agent-based model proceeds as follows.

(1) Determine per capita resident "fees" for each jurisdiction:
   a. Residents pay property taxes equal to the property tax rate, *ptr*, times their house cost, $hcost_j$ (see equation (2) above and step 8 below). The total property tax revenue for jurisdiction j, denoted as $trev_j$, is the sum of all homeowners' contributions. Tax caps, $tcap_j$, play a crucial role in differentiating housing values and housing costs for citizens in this process (see step 8).
   b. Compute the net costs of amenities by subtracting total property tax revenues from the total costs of amenities, $jcost_j$ - $trev_j$.
   c. To find the per capita resident "fees," denoted as *fj*, divide the total net costs by the population of the jurisdiction. It could be negative (when the net cost is positive, zero (when the net cost is zero), or positive (when the net cost is negative).

(2) Calculate agents' utility:
   a. Compute utilities from local amenities, *putil*, using equation (1) above.
   b. Determine how much money citizens are left with for private consumption after paying housing costs, jurisdiction's "fees," and property taxes using equation (2) above.
   c. Each citizen's utility is calculated using equation (3) above.

(3) Allow relocations:
   a. Citizens evaluate their utilities from remaining in their homes against the expected utilities of relocating to a different jurisdiction.
   b. Citizens either stay in or move to the jurisdiction that offers the highest expected utility
   c. In the first year of relocation, property tax payments are based on the new home's market value. Note that relocation resets their property taxes.

(4) If amenities are endogenous, parties adjust their platforms:
   a. Each party randomly selects 10% of voters to participate in the poll.

b. All participants assess their utility from each party's platform (the vector ppj, which indicates their stance on amenities, with 1 for support and 0 for opposition) within their respective jurisdictions.
c. Participants indicate how they would vote based on these utility comparisons. Each party uses this polling information to assess their expected share of votes in the next election if they maintain their current platform.
d. Each party experiments by randomly switching an element of their platform vector p_{pj} (e.g., flipping their support for an amenity from 1 to 0 or vice versa).
e. After running a second poll, if the new platform increases its expected vote share over the status quo, the party adopts the updated platform.

(5) Citizens cast their ballots in their current jurisdiction:
a. Citizens vote for the local party branch whose platform offers them the highest utility.
b. After all the votes are counted, the percentage of votes each party received in each jurisdiction is determined.

(6) In an endogenous scenario, allow jurisdictions to modify amenity offerings based on the latest election.
a. Under the "multi-party proportional" system, the provision of an amenity depends on the vote share of parties supporting it.[7] For example, if party A wins 30% of the votes and supports fire protection, the fire protection service gains a weight of 0.3*1, proportional to the party's vote share.
b. An amenity is provided if it accumulates more than 50% of the votes after all party shares are considered; otherwise, it is not provided.
c. Each jurisdiction's amenity vector is updated based on election results.

(7) Compute the costs of providing amenities:
a. Each jurisdiction's total cost, $jcost_j$, is calculated as the sum product of its updated amenity vector and the associated costs of providing each amenity.

(8) Update property values:
a. Adjust each property's market value based on the jurisdiction's appreciation rate.
b. For current residents, the taxable property value is adjusted by the tax cap, $tcap_j$ from the previous period's value.
c. If the tax cap exceeds the appreciation rate, the appreciation rate replaces the tax cap.
d. Set the housing cost for current residents equal to the taxable property value.
e. For new residents, the taxable property value is reset to the property's market value.

(9) Increase citizens' money:
a. Adjust each citizen's money by the money growth rate.
b. Repeat steps 1-8 for the next period.

[7] With only two political parties, the "multi-party proportional" rule is equivalent to a "winner-takes-all" system.

IV. Results

In this section, we report the effects of assessment limits on migration and welfare from our ABM simulations. All simulations are performed with the following parameter values:

- Election rule: multiparty proportional
- Number of parties: 2 parties
- Number of local public goods: 5
- Number of jurisdictions: 6 to 60
- Property tax rate per tick: 5 percent
- Money growth rate per tick: 2 percent
- Housing value appreciation rates: jurisdiction-specific variable randomly drawn from a uniform distribution ranging from 2% to 20%.

Our main interest is to compare the welfare consequences in different scenarios with varying levels of assessment limits. We consider the average utility per person (overall welfare level) and utility per dollar (allocative efficiency) with different levels of assessment limits, from property tax freezes (0% tax increase once an agent buys a new residential property) to no assessment limits. Before examining them, we establish agents' migration behaviors first.

1. Migration

We analyzed how various levels of property tax caps influence migration patterns in both endogenous and exogenous scenarios. In Figure 3.A., the average migration rates are depicted on the Y-axis against different tax cap levels on the X-axis, with the endogenous scenario represented by a red solid line and the exogenous scenario by a blue line.

[Figure 3 about here]

Figure 3 demonstrates how assessment limits (property tax caps) affect residential mobility by showing average migration rates across different levels of assessment limits. The data represents migration patterns across jurisdictions ranging from 6 to 60 jurisdictions.

Our findings about property tax caps and migration patterns are as follows. First, under a complete tax freeze (no property tax increase after moving in and losing the benefit after moving out), migration levels are the lowest, as expected. Second, as tax caps become less restrictive and allow larger annual tax increases, residential mobility increases. This occurs because higher tax caps reduce the financial benefits of staying in one place for homeowners. This pattern confirms the "lock-in effects" documented in existing literature, where tax caps discourage homeowners from moving, and therefore, residential mobility is lower among homeowners than among renters.

The relationship appears in both endogenous and exogenous scenarios. In the endogenous scenario, municipalities adjust policies to residents' preferences. In the exogenous scenario, on the contrary, they maintain a fixed set of public good bundles. Our results show that the endogenous scenario shows lower overall migration levels than the exogenous scenario. The difference occurs because municipalities in the exogenous scenario do not adapt their public amenities to match resident preferences. In both cases, however, the association between tax higher cap levels and higher migration rates holds consistent, though at different levels. This confirms the lock-in effect in the literature supporting the hypothesis that larger property tax subsidies that can be lost when moving out discourage residential mobility.

2. Utility per person (overall welfare)

We show the changes in the overall welfare levels as mobility restrictions change in Figure 4. Welfare levels are on the Y axis, and the tax cap levels are on the X axis. We report the endogenous scenario here, but the exogenous scenario also shows the same pattern that higher tax caps are associated with lower welfare levels. Total welfare levels are higher in endogenous than exogenous scenarios.

In Figure 4, we illustrate how overall welfare levels vary with changes in mobility restrictions. The Y-axis represents utilities per person, which indicates social welfare, while the X-axis shows the tax cap levels. We present the results for the endogenous scenario; however, the exogenous scenario exhibits a similar trend, indicating that higher tax caps are linked to lower welfare levels. Additionally, total welfare levels are greater in the endogenous scenario compared to the exogenous scenario.

[Figure 4 about here]

What stands out is a phase transition, during which the system's behavior changes significantly. Between the tax freeze policy and 4% tax caps where property tax benefits are large, the welfare level (the blue line) is higher than the market condition without property tax caps (the red line). However, beyond that point, we observe substantial changes in welfare levels in response to incremental changes in tax caps. This dramatic shift indicates that the impact of a marginal change in property tax caps will not produce a linear or proportional effect on the overall welfare of the system. In our scenarios where jurisdictions' housing market appreciation rates vary between 2% to 20%, more than 4% of annual property tax caps will not enhance the overall welfare compared to a no tax cap policy (i.e., pure market condition). the implication of this result is the need for policymakers' understanding of "phase transitions" to identify moments when the tax cap policy becomes significant or insignificant.

Since property tax caps benefit homeowners, the policy is expected to impact homeowners and renters differently. Homeowners are expected to lose overall welfare as the tax caps increase (i.e., property tax benefits become smaller), while renters' welfare levels should not change with tax cap levels because they do not benefit from the policy.

Figure 4.B. shows the stark differences as expected. Homeowners always maintain higher welfare levels than renters mainly because their income is set to be greater than renters. Homeowners gain the highest welfare level in the tax freeze (0% tax cap) scenario and the level declines as property tax benefits are less generous. On the other hand, renters' welfare level is the lowest in the tax freeze scenario, but the level steadily increases with a higher tax cap level.

The welfare gaps between homeowners and renters, therefore, become smaller with a higher tax cap, as a result.

The phase transition in Figure 4.A. seems driven by the decline in homeowners' welfare. To explore the distributional effect of tax cap policies on the welfare levels of homeowners and renters, we computed the welfare levels by income quartiles.

[Figure 5 about here]

Figure 5. A. shows that homeowners' welfare generally declines at all income quartiles we examine. However, homeowners in the 25^{th} income quartile incurred the greatest welfare loss due to less generous property tax subsidies (higher property tax caps). Homeowners at the highest income quartile, at 75%, experience minimal welfare losses. For renters, welfare levels stay stable until a tax cap of 6% is reached, at which point renters see a slight improvement in their welfare. This small gain primarily benefits those in the top income quartile. As property tax caps rise, homeowners face reduced benefits, which particularly impacts low-income homeowners negatively. In contrast, high-income renters benefit most from these decreased subsidies.

3. Utility per dollar

This section examines how property tax caps affect the utility gained for each dollar spent. It serves as a measure of welfare by showing the amount of utility received per unit of money used. In Figure 6, the vertical axis (Y-axis) represents utilities per dollar, while the horizontal axis (X-axis) displays different levels of tax caps, where lower tax caps signify greater property tax benefits. The focus here is on how tax cap levels influence the efficiency of resource allocation between public goods and private goods.

[Figure 6 about here]

In Figure 6.A., we plot welfare per dollar against different tax cap levels in both endogenous and exogenous scenarios. Our findings indicate that endogenous systems demonstrate greater efficiency at all tax cap levels compared to exogenous systems, with an approximate difference of 13%. The findings indicate that the system produces greater benefits under resource constraints when jurisdictions tailor their public goods to meet the needs of their residents.

Figure 6.A shows that efficiency decreases in both endogenous and exogenous cases as tax caps rise. Figure 6.B illustrates that this drop in utility per dollar is mainly due to homeowners. Note that 6.B. is based on an endogenous scenario. Homeowners gain the most value for given money when there is a property tax freeze, which leaves them with more money for private spending. However, around the 3% tax cap, homeowners start to see a decline in their value for money. Specifically, there is over a 30% reduction in utility per dollar when comparing the tax freeze to the 10% tax cap. In contrast, renters' utility per dollar remains relatively unchanged as tax cap policies do not directly affect them. However, as homeowners receive fewer property tax benefits, renters' utility gradually increases.

4. Decentralization

Tiebout's central argument is influenced by Samuelson's inquiry regarding the ideal level of public goods. One of the key implications of the Tiebout Hypothesis is how political decentralization impacts overall welfare. In Figure 7, we illustrate the relationship between decentralization and welfare (Y-axis) as the number of jurisdictions changes (X-axis) under three different tax limits: a property tax freeze (represented by the blue line), a 5% cap on annual increases (the green line), and no caps at all (shown by the red line).

[Figure 7 about here]

In all tax cap scenarios, homeowners experience the highest level of welfare when there are fewer jurisdictions to choose from. As the number of jurisdictions increases, homeowner's **exchange efficiency level** tends to decrease. Specifically, welfare levels begin to diminish once there are around 30 jurisdictions, regardless of the tax cap levels in place.

The most significant decline in utility per dollar occurs under the tax freeze scenario. In this case, property tax freezes compel homeowners to stay in the same house to retain their tax benefits, which they lose if they relocate. This creates a disincentive to move, which leads to inefficiencies when relocation could potentially enhance utility per dollar. The impact on exchange efficiency is less pronounced under the 5% tax cap scenario. Conversely, the no cap scenario shows the lowest level of utility per dollar among the tax cap scenarios. It has minimal changes in utility per dollar and maintains a consistent level until the number of jurisdictions becomes more than 40.

Overall, across all three scenarios, the utility per dollar varies under different tax cap scenarios with fewer jurisdictions but begins to converge after around 40 jurisdictions. This indicates that there may be an optimal number of jurisdictions under any tax cap scenario to maximize utility per dollar for homeowners. It suggests that for homeowners, there is an optimal level of decentralization.

When examining the three different levels of tax policy for renters in Figure 7B, it becomes clear that there is no consistent pattern among the three tax cap scenarios like in the homeowners' case. The various tax caps do not show significant differences in welfare outcomes for renters. However, renters appear to have a slight advantage when there's no property tax cap (red solid line). This is because tax caps do not directly impact renters; they essentially absorb the cost of property taxes through their rent without receiving any associated benefits. This again suggests an optimal level of decentralization under this particular scenario.

We conducted robustness checks by running our ABM with the same set of parameters but using different random seeds. The results from these checks were qualitatively similar to those obtained in the main analysis. It suggests that our findings are not sensitive to the specific random seed used. Results tables from the robustness checks are available upon request.

V. Conclusion

This paper uses an Agent-Based Model to examine the welfare consequences of limited mobility in Tiebout (1956). We simulate various scenarios to understand the impacts of assessment limits, a real-world policy tool to stabilize homeowners' property tax liability, that are known to have a powerful lock-in effect. Our simulations incorporate the Tiebout-Oates-Hamilton model where we build a pricing system of public good bundles via housing price. We also incorporate political endogeneity to illustrate that Tiebout sorting is not only driven by residential mobility not also by local politics (Holcombe 1989).

Our main findings the following. First, lower property tax growth limits (more property tax benefits and greater lock-in incentives) lower overall migration by 17 percent. Second, the society enjoys greater welfare when property taxes are not allowed to grow more than 4%. We find that there is a phase transition, a nonlinear pattern showing that the overall welfare gains due to the tax caps disappear and are restored to the level observed in the no-cap market scenario. Third, this drop in welfare is driven by homeowners but not renters since only homeowners enjoy the welfare gains from tax caps. Fourth, what is striking is the distributional welfare impact. that the welfare loss was the greatest among the homeowners in the lowest income quartile; homeowners in the highest income quartile hardly experience welfare losses. Lastly, under all tax cap levels, homeowners are better off with fewer jurisdictions to choose from. They are worse off as more jurisdictions to choose from after a certain threshold level. In contrast, the number of jurisdictions or tax cap levels do not seem to affect renters' welfare.

We believe that our complexity approach to simulate various scenarios enhances our understandings of the Tiebout hypothesis. It is one of our major contributions to the Tiebout literature. We also contribute to the public finance literature by providing how widely implemented assessment limits change the welfare of homeowners and renters, which econometric studies cannot fully capture.

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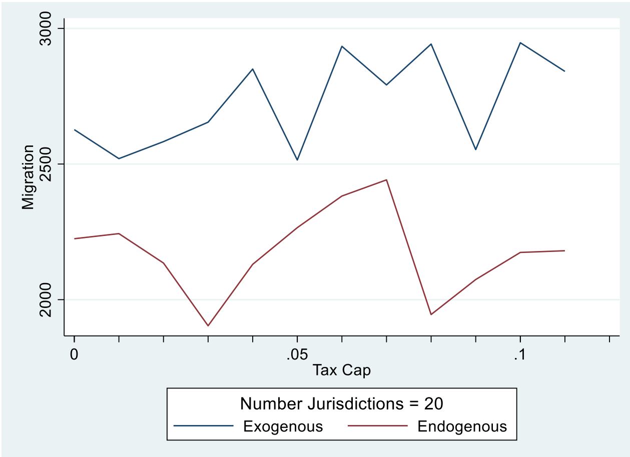
Appendix

A. List of ABM Variables

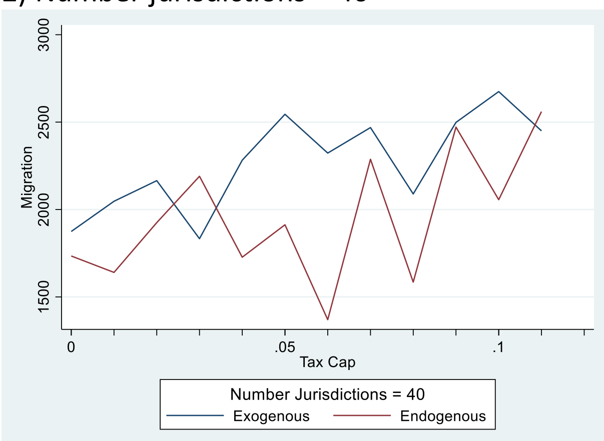
Variable Name	Symbol	Type	Initial/default value
Cobb-Douglass share parameter	α	Exogenous	0.5
Vector of amenity costs	$\mathbf{AC}$	Endogenous	Random vector of numbers
Vector of current amenities	$\mathbf{CA_j}$	Exogenous	Random sequence of 1s and 0s
Jurisdiction j's per capita fees	f_j	Endogenous	Calculated using step 1 below
j's housing cost	$hcost_j$	Endogenous	Randomly drawn
j's cost of providing amenities	$jcost_j$	Endogenous	$\mathbf{AC}' \cdot \mathbf{CA}_j$
Citizen's wealth	$money_c$	Endogenous	Randomly drawn
Number of citizens	N	Exogenous	3,000
Number of amenities	na	Exogenous	5
Number of jurisdictions	nj	Exogenous	6
Number of parties	np	Exogenous	2
Party's platform vector	p_{pj}	Endogenous*	Random sequence of 1s and 0s
Property tax rate	ptr	Exogenous	5%
Utility from amenities	$putil_{c,j}$	Endogenous	0
Jurisdiction's tax cap	$tcap_j$	Exogenous	0(no cap), 1% – 11%
Jurisdiction's tax revenue	$trev_j$	Endogenous	0
Citizen's utility from location j	$util_{c,j}$	Endogenous	0
Citizen's weight vector	$\boldsymbol{\omega}_c$	Exogenous	Random vector of numbers between 0 and 400

B. Migration patterns

1) Number of jurisdictions =20



2) Number jurisdictions = 40



3) Number jurisdictions = 60

Table 1.
Assessment limits in the US states

ST	Adoption Year	Coverage[f]	Eligible property	Reset	Annual maximum limit
AZ	1980, 2012	S	All	N	10%
AR	2000, 2012	S/C	All	Y	0%, 5%, 10%
CA	1978	S/C	All	Y	2%
CT	1987	Local	All	N/A	N/A
DC	2002	District	OO[d]	Y	10%, 2%
FL	1992[a]	S/C	OO	Y	3%
GA	1983H, 2010F	Local	OO	Y	0%
IL	1991	Local	OO	Y	7%
MD	1957, 1975	S	OO	Y	10%
MI	1994	S/C	All	Y	5%
MT	1975 (a 2003, 2009)	S/C	All	Y	16.66%/6 years
NM	2000	S/C	All	Y	3%
NY	1971N, 1981A	Local[c]	R[e]	N	6-8%
OK	1996	S/C	All	Y	5%
OR	1997[b]	S/C	All	N	3%
SC	2006	S/C	OO	Y	15%/5 years
TX	1997	S/C	OO	Y	10%

[a] Residential. Effective in 1995. 2008 for non-residential properties

[b] First adopted in 1980 and repealed in 1985. The current rule was adopted in 1997.

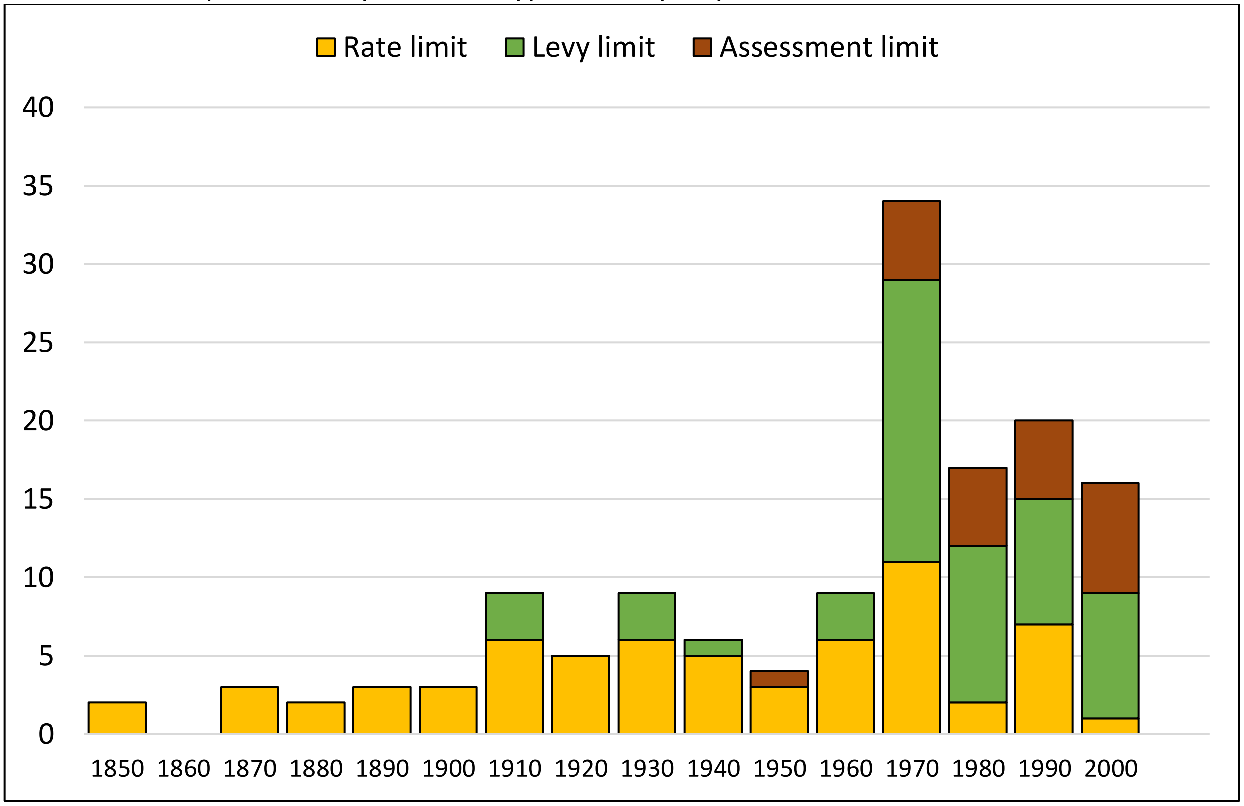
[c] New York City and Nassau County only.

[d] Owner-occupied only.

[e] Residential properties with fewer than ten units.

[f] S=statewide, S/C=statewide & constitutional, Local=no state-wide implementation and local option only.

Figure 1.
Adoption History of Three Types of Property Tax Limits in the U.S. States



Data source: Lincoln Institute of Land Policy.

Figure 2
Mechanism of Property Tax Assessment Limits

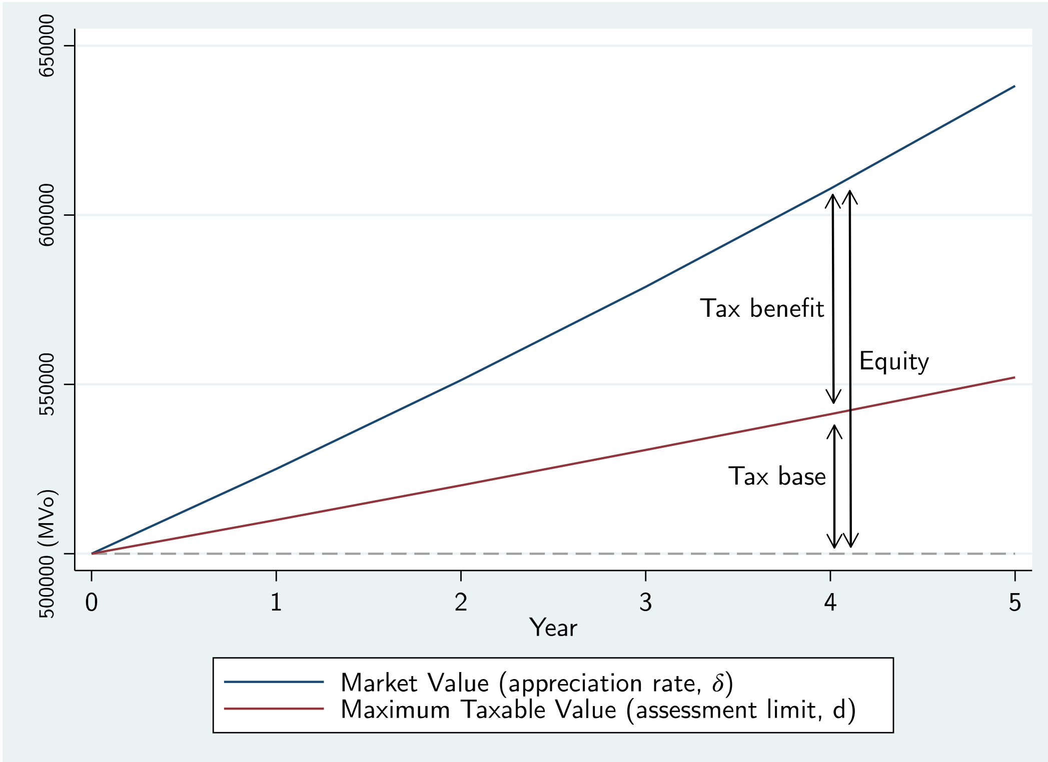


Figure 3.
Migration and Property Tax Cap Levels

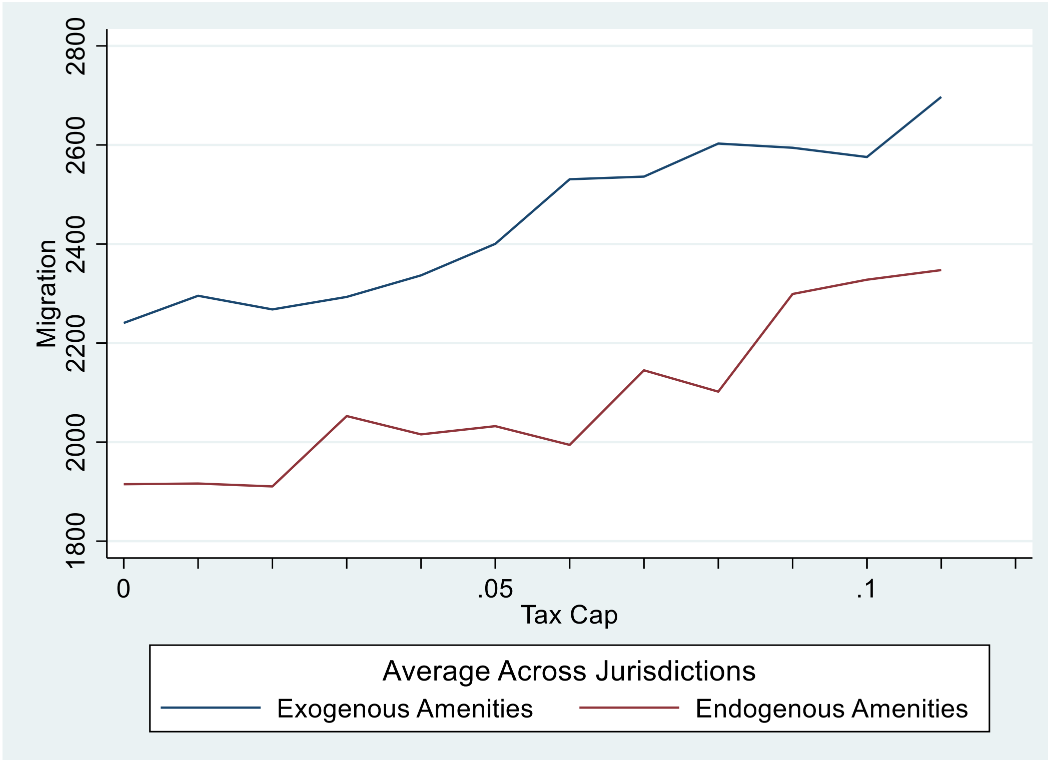
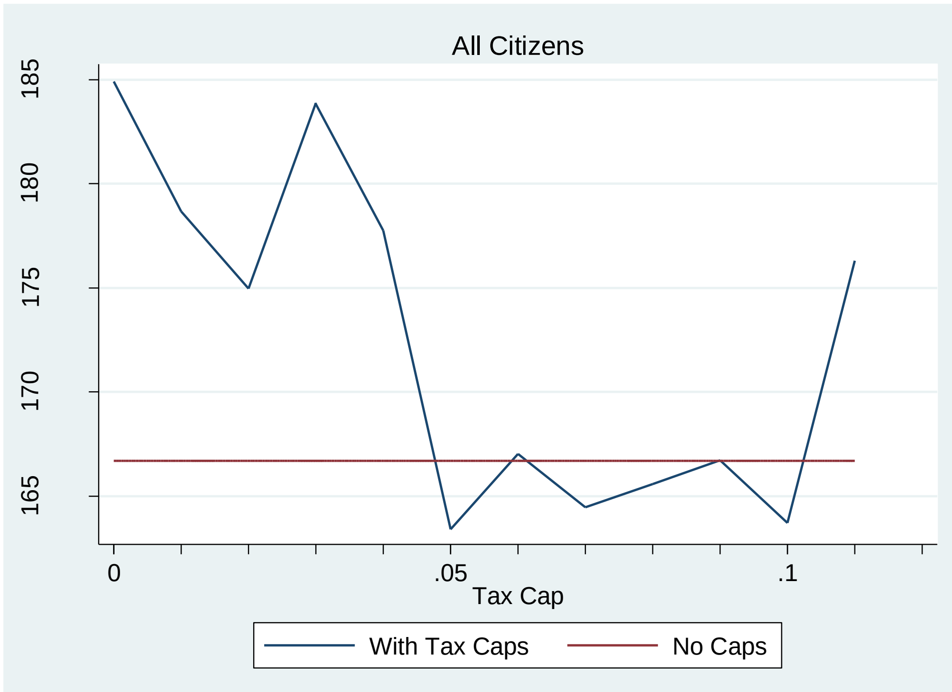


Figure 4.
Changes in average welfare levels at different tax cap levels

A. Welfare response to tax caps



B. By homeownership

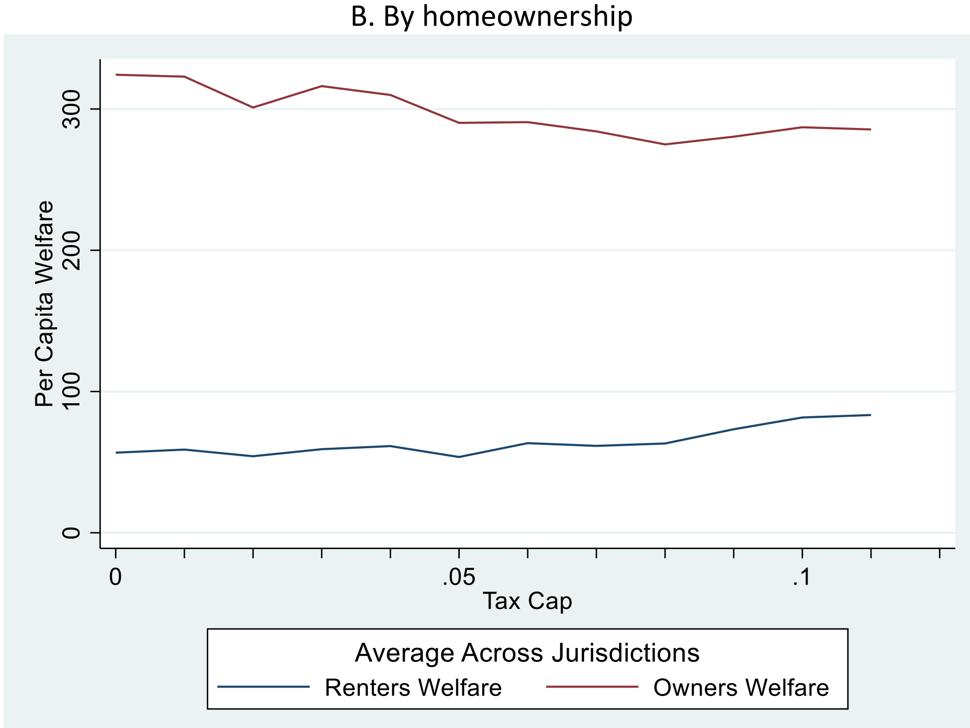
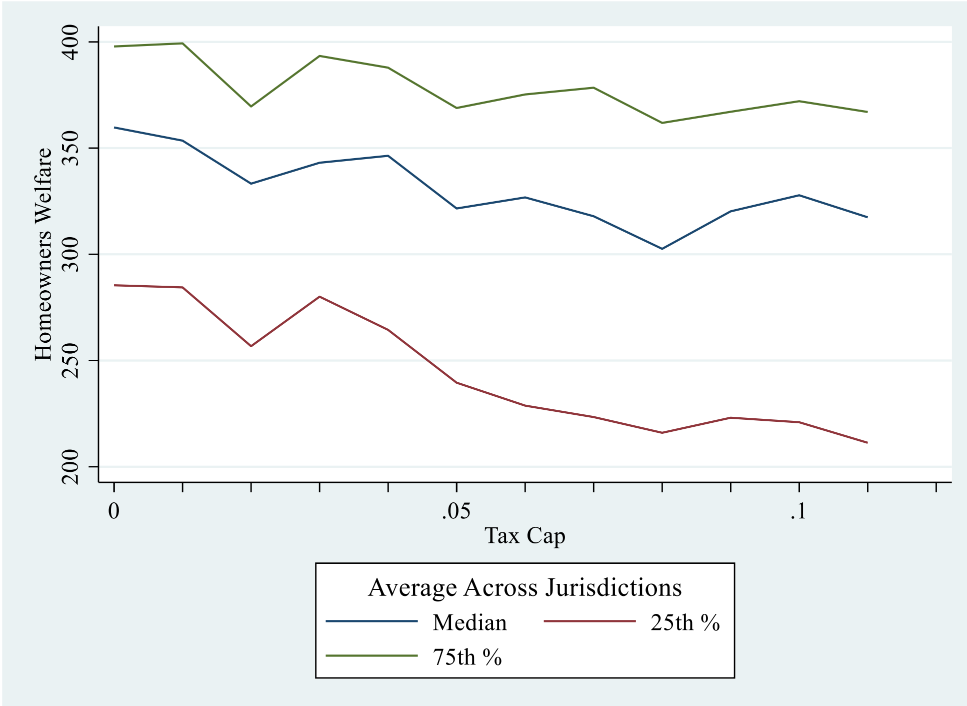


Figure 5.
Distributional Outcomes by Homeownership and Income Quartiles

A. Homeowners



B. Renters

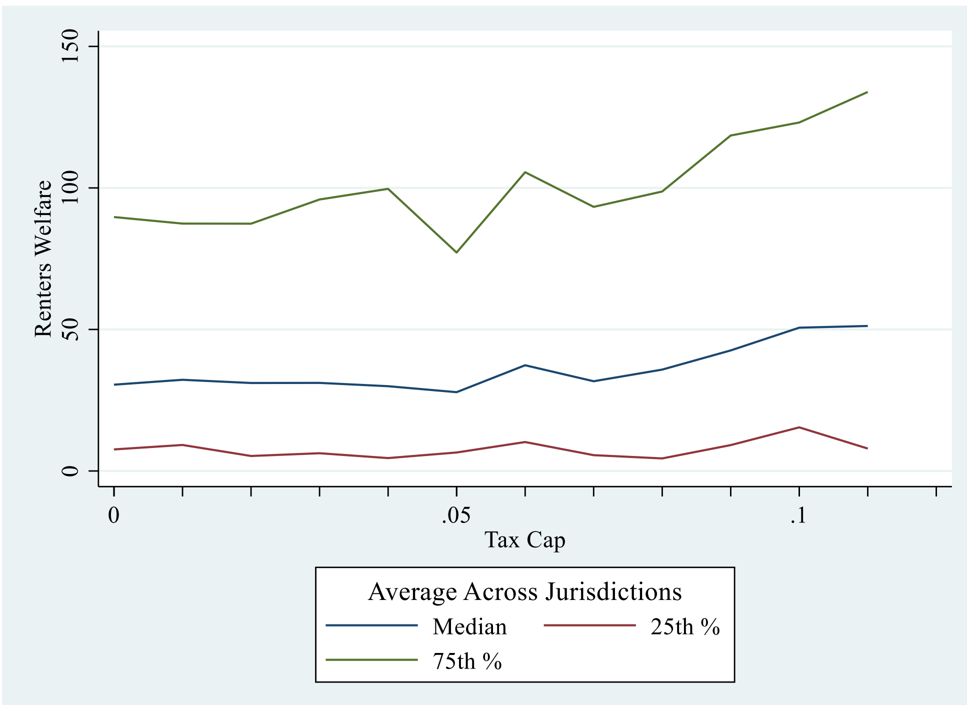
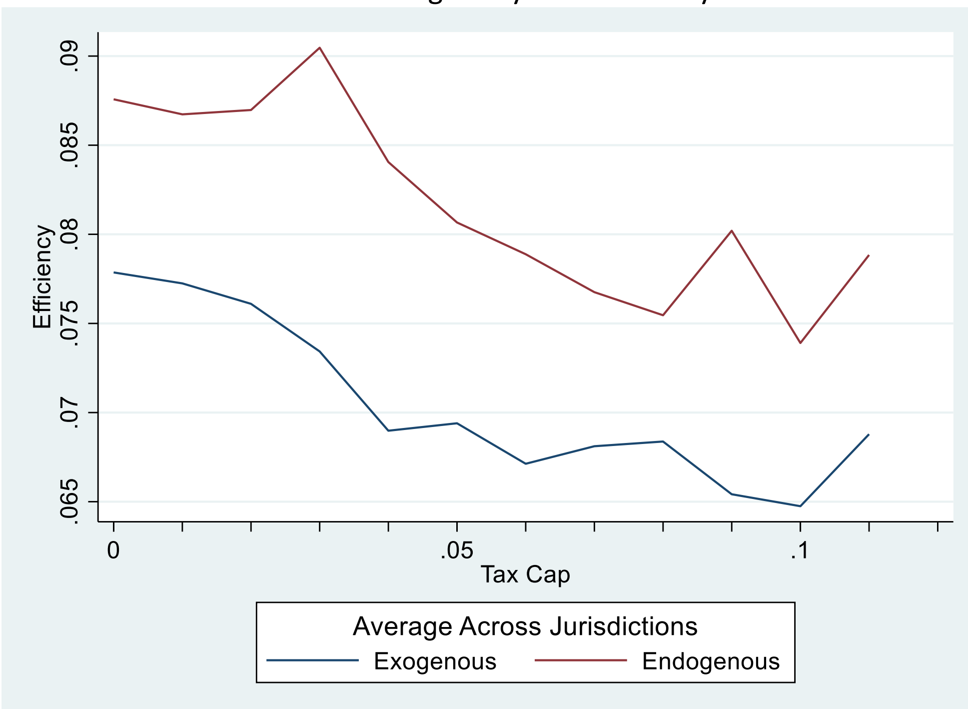


Figure 6.
Utilities per Dollar

A. Endogeneity and efficiency



B. Efficiency by Ownership

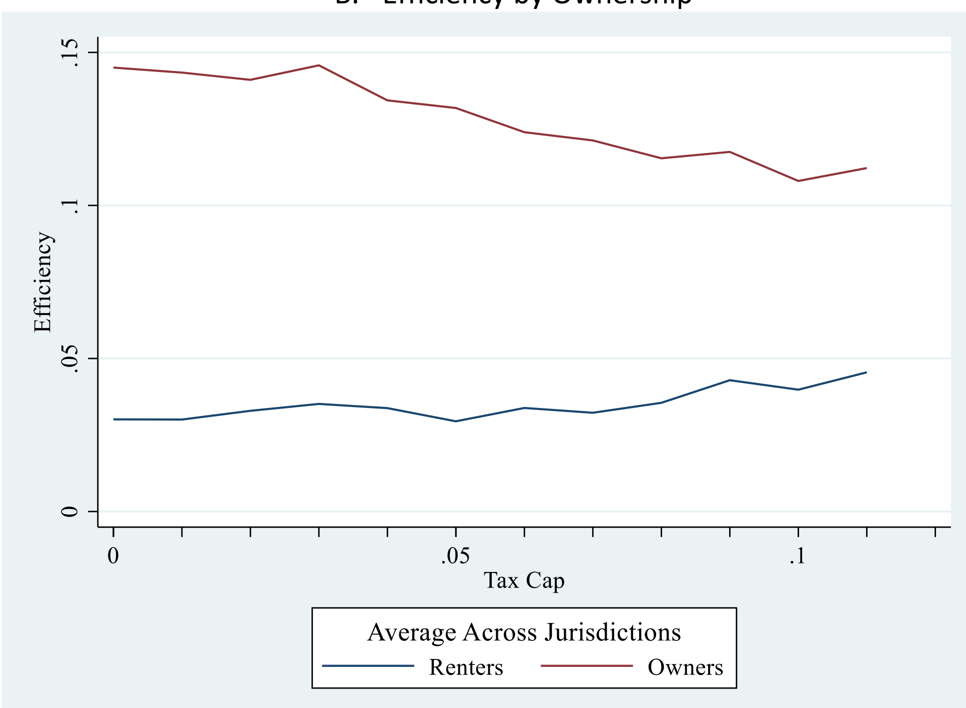
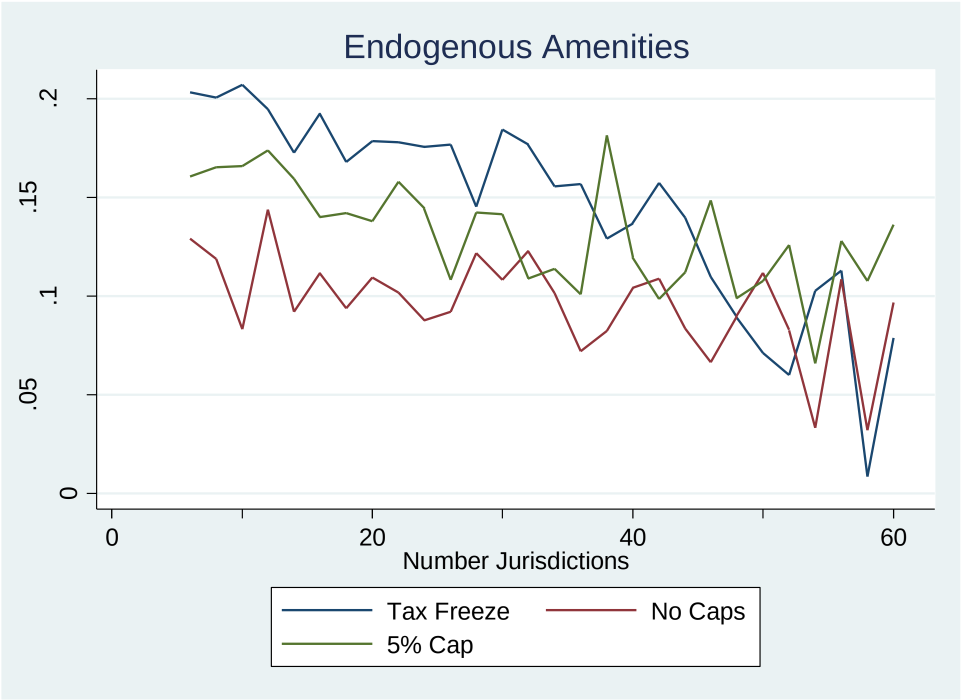


Figure 7.
Decentralization and Utilities per Dollar

A. Homeowners



B. Renters