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LOCAL INSTITUTIONS AND THE DYNAMICS OF COMMUNITY SORTING

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This paper studies the dynamics by which populations with heterogeneous preferences for local public good provision sort themselves into communities. I conduct laboratory experiments to consider which institutions may best facilitate efficient self-organization when residents are able to move freely between locations. I find that institutions requiring all residents of a community to pay equal taxes enable subjects to sort into stable, homogeneous communities. However, populations can find themselves stuck at local, inefficient equilibria. Though sorted, residents may fail to attain the level of public good provision best suited for them and the system dynamics are crucial for determining whether subjects reach optimally-designed communities. When residents are able to vote for local tax policies with their ballots as well as with their feet, the inefficient local equilibria are eliminated, and each community converges to the most efficient outcome for its population.

The ability of individuals to move between communities, groups, and organizations is fundamental. Mobility allows us to choose our friends and neighbors, to enter the locations that best satisfy our preferences, and to select the policies to which we must adhere. Self-organization can promote efficiency by enabling agents to sort themselves by their preferences for local outcomes, and thus to overcome preference revelation and collective action problems that cannot be internally solved by a single community.

The aim of this paper is to test experimentally the relative success of various institutions in promoting efficient local public good provision in societies with highly divergent preferences, when residents are able to move between locations.

In 1956, Charles Tiebout suggested that mobility can lead to efficient public good provision. He introduced the idea of local public goods, which were excludable geographically, and proposed a market-based solution to the problem of efficient public expenditures at the local

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level. Tiebout's proposal was not presented, and likely not intended, as a descriptive model of residential choice and public finance, but as an innovative "conceptual solution" to the problem of demand revelation.[1] His paper was written in direct response to Musgrave (1939) and Samuelson (1954), who independently concluded that efficient provision of public goods through a decentralized pricing mechanism was impossible: since residents who did not contribute to the financing of the public good could not be excluded from consuming it, they had incentive to strategically underreport their true demand and to free-ride off of their neighbors.

Local public goods allowed for spatial exclusion – since they were available only to those living within a jurisdiction, anyone wishing to consume the local public good would have to move into the community and pay the associated local taxes. If residents were able to move freely between jurisdictions then, rather than having to truthfully report their preferences within a community, Tiebout proposed that they would instead "vote with their feet," and relocate to the community that perfectly matched their needs. In doing so, households would reveal their true preferences and could thus be taxed according to their demand.

Since the inability to measure a household's true demand for public goods is the central motivation for Tiebout's proposal, it is perhaps unsurprising that attempts to directly test whether migration patterns are driven by preferences have proven difficult and that the evidence has often been varied and inconclusive. But public goods preferences can be readily generated in laboratory experiments by adjusting the payoffs that subjects receive from the outcome of a public goods game, and the dynamics of mobility and community formation may then be observed in a controlled environment. In addition, experiments can test the effectiveness of various institutions that would otherwise be very costly to assess in the field. In this paper, I conduct experiments to test elements of Tiebout's proposition. These experiments are not intended as a precise depiction of local public finance and residential choice in all its complexity, but, rather, as an attempt to gain insight into the fundamental mechanism and processes that Tiebout envisioned by studying movement decisions within a simple environment.

I consider whether mobility is, in itself, sufficient for achieving optimal public good provision, analyze the dynamics that may prevent optimality from being reached, and, given these dynamics, assess which institutions may be most successful in facilitating efficient self-organization. I find that the system dynamics are crucial for determining whether a population arrives at an efficient allocation and that an institution's success depends on its susceptibility to coordination failure.

This paper considers a simple environment with three natural properties. First, the population has heterogeneous preferences for the public good: there are those who greatly benefit from the public good provided within their community, and those who benefit very little. Second, efficient public good provision is hindered by institutional design limitations. A community cannot force its residents to reveal their preference type against their own self-interest, and thus may have difficulty charging different prices to different types within a single community. Finally, there are multiple locations and agents have full mobility between them.

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[1] Tiebout (1956), p. 424. Oates (2006) provides a discussion of whether Tiebout intended his paper as a descriptive theory or purely as a clever thought experiment.

A voluntary provision mechanism, which allows residents to contribute different amounts within the same community and is therefore susceptible to free-riding, is compared with three provision mechanisms requiring all residents to make the same local contributions. These latter three institutions generate a unique strong Nash equilibrium in which agents separate and consolidate by preference type, and consume at their optimum. This local contribution rate is variously determined a) by a fixed, posted per-capita tax, b) by a fixed, posted provision quantity, or c) by majority rule, with the institution varying between experimental sessions. The first two reflect Tiebout's assumption that there exist a large number of available communities, representing a complete range of expenditure packages that are "more or less set" (Tiebout, 1956, p. 418). In these sessions, each location is associated with a known policy for the duration of the experiment and among the available locations are those offering the optimal policies for each preference type. The voting institution incorporates a simple form of local governance that is responsive to the preferences of the current population.

I find that voluntary contribution communities are highly unstable. The subjects continually move between locations throughout the experimental session and these locations experience fluctuations in the local provision levels. Those subjects who benefit most from public good provision often exit larger communities with declining provision in favor of smaller, less profitable ones, and frequent movement is associated with lower payoffs. Although subjects converge toward the Nash equilibrium contribution levels, this chronic movement leads to efficiency significantly below that predicted under the Nash equilibrium for a single, fixed community.

Under all three of the institutions requiring all members of a community to make equal contributions, subjects separate by type into an optimal partition. When they are able to vote only with their feet, by moving between communities offering fixed taxes or provision levels, subjects often become stuck at local, inefficient equilibria such that they under- or over-provide the public good. Though they sort into separate, homogenous communities, the subjects often fail to attain the optimal provision within these communities, because they are unable to coordinate on the location offering the optimal tax-provision bundle for their type. This suggests that the existence of optimally-designed communities does not guarantee that they will be entered and that inertia, or the desire to be around others, can prevent optimality from being reached.

Under the voting institution, which enables subjects to vote with both their feet and with ballots, these communities converge to the optimal outcome for their populations. Voting with their feet enables subjects to sort by moving to the community that they like, while voting with their ballots enables them to then move the community to their liking once they have arrived. This suggests that an internal mechanism that allows residents to influence community policy without needing to relocate may be necessary for overcoming coordination failure and achieving optimal allocations. Though Tiebout did not address the question of local governance, these experiments suggest that both local politics and system dynamics may be essential for determining whether local public goods are provided efficiently.

The paper proceeds as follows: Section 1 reviews theoretical extensions and empirical tests of Tiebout's hypothesis as well as previous experimental results on endogenous group formation; Section 2 sketches the simple Tiebout-style environment used in the experiments;

Section 3 describes the experimental design; Section 4 presents the experimental results; and Section 5 concludes.

I. Local Public Goods, Community Sorting, and the Tiebout Hypothesis

The theoretical literature has since filled in and extended Tiebout's sparse framework, formalizing his insights while incorporating housing prices, land provision, spillovers and crowding, as well as considering income heterogeneity and redistribution, and analyzing the determination of public good supply and its political requirements. This literature suggests that sorting may be difficult to achieve and whether an efficient allocation is reached often depends on the specifics of the environment.

One approach has been to complete Tiebout's analogy of local public goods as private goods, by integrating the model into general equilibrium theory. This work has largely found that Tiebout's proposition holds only under highly restrictive conditions.[2] The general equilibrium interpretation is reflected in the experimental sessions in this paper that have fixed local taxes or provision levels and offer agents a wide-range of budget-balanced expenditure packages.

An alternative approach departs from Tiebout's assumptions by incorporating models of local governance and considers the simultaneity of selecting a community and voicing political preferences while there. These models have primarily focused on majority rule, and are captured by the voting institution considered in this paper.[3] This literature strives to capture the highly complex process of residential choice, but often the resulting conclusions and equilibrium characterizations are dependent upon the particular features of the models.[4] The goal of this

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[2] When the number of jurisdictions is fixed, often there does not exist an equilibrium that satisfies the First Welfare Theorem (for instance, Ellickson, 1979; Bewley, 1981). When allowing for the entry of entrepreneurial communities, approximate equilibria (ε-equilibria) may converge to Pareto optimality in large economies (see Wooders, 1999 for an overview).

[3] An exception is Kollman, Miller, and Page (1997), which considers a computational Tiebout model under democratic referenda, direct competition, and proportional representation institutions. They find that the institution that produces the worst outcomes in a fixed, single jurisdiction society is actually the most successful when agents can move between jurisdictions (and vice-versa), as the institutions that cause residents of heterogeneous communities to be least satisfied encourage exit and therefore promote sorting.

[4] Westhoff (1977) considers a majority voting rule by which residents select the level of public service expenditure within their community through the form of a tax rate, and establishes the existence of an equilibrium with separation by types. Rose-Ackerman (1979) adds divisible land markets and shows that equilibrium may not exist. Epple, Filimon, and Romer (1984/1993) introduce housing prices and characterize their equilibrium result with the property that communities populated by residents with the highest incomes also have the highest levels of public services and the highest housing prices. Other models determine public good provision through a wealth tax, either at the national or local level (Dunz, 1989; Nechyba, 1997). Konishi (1996) includes spillovers from other residents, as well as snob effects and demonstrates equilibrium existence with majority voting. Epple and Platt (1998) allow for preference heterogeneity, in addition to income variation, within this framework and find an equilibrium in which communities are heterogeneous along both income and preference dimensions while still satisfying the ascending bundles property. Pogodzinski and Sjoquist (1991) allow for differences in preferences, though not income, and find that the social choice rules within the jurisdictions determine the effect of production costs on capitalization. Others have shown that sorting can occur not only by the local policies, but also by community-wide values (Benabou, 1996a/b and Epple and Romano, 1998 address neighborhood and peer effects). Preferences over jurisdictional locale have also been incorporated, for instance by Cassidy, Epple, and Romer (1989), who assume

paper is to strip away this complexity, return to the simplified setting that Tiebout addressed, and to study the underlying dynamics of the residential sorting process in the absence of specific environmental factors.

There is also a vast empirical literature aimed at testing the implications of the Tiebout model within communities in the United States. Many studies have shown local sorting along demographic factors such as income, race, and education, as well as by political and cultural preferences.[5] However, the extent to which residents move in response to their preferences for public goods, sort into communities where other residents share their preferences, and consume their optimal package of local services, is far less clear (Dowding, John, and Biggs, 1994).

Consistent with Tiebout's assumptions, American cities vary greatly in public services provided and demanded.[6] While survey data have suggested that a household's decision to move is rarely based on public expenditure considerations,[7] there is also considerable evidence that public services (especially education quality) and tax rates are significant factors in neighborhood choice once a household has already decided to move.[8] However, the few direct tests of migration based on local policies and environmental impacts have produced conflicting conclusions.[9]

The difficulty in measuring public goods preferences and how they drive movement decisions suggest that laboratory experiments can play a significant role in understanding the mechanisms of residential choice and community sorting. The experiments in this paper, which allow agents with different preferences to sort by local tax and provision policies, are the first of their kind, but build on recent experiments on voluntary public good provision in endogenously-formed groups. Voluntary contributions experiments in fixed, exogenously-assigned groups have consistently found that initial contributions are midway between optimal and Nash equilibrium levels, but that these contributions quickly decline and approach the theoretical equilibrium (Ledyard, 1995). Experiments that allow subjects to select their group in each period have shown that free-mobility is not sufficient to sustain contributions and, if movement is unrestricted, free-riders will chase cooperators from location to location (Ehrhart and Keser, 1999).

When subjects differ in the returns that they receive from the public good, there is a clear dynamic in which those who benefit the most from local provision found and develop groups.

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that some locations are superior to others and deBartolome and Ross (2003), who assume that location preference varies by income.

[5] See for instance: Costa and Kahn (2000) and Bishop (2008).

[6] Stein (1987) finds high variation in the bundles of services provided across communities. Gramlich and Rubinfeld (1982) find that variation in demand for public services is much lower within communities than throughout a wider population. Rhode and Strumpf (2003) found between-community disparities in local policies are on the decline.

[7] Rhode and Strumpf (2003).

[8] See for instance: Reschovsky (1979), Percy, Hawkins, and Maier (1995), and Fox, Herzog, and Schlottman (1989).

[9] For instance, a set of studies examining population changes in response to environmental impacts have found only marginal or no evidence of an effect on migration patterns (Been and Gupta, 1997; Cameron and McConnaha, 2006; Greenstone and Gallagher, 2008) while Banzhaf and Walsh (2008) find that increases in toxic air pollutants are associated with population decreases as well as exit of higher income households and/or entry of lower income households.

They are then followed by others even when entry fees are relatively large, provision declines, and the cycle restarts (Robbett, 2010). This chasing phenomenon persists even when the public good is purely non-rivalrous, such that there is never monetary incentive to found a new group. This suggests that people are often unwilling to remain where others are contributing less than they are, and so group stability may be contingent upon requiring equal contributions from all members.

Implementation of formal boundary rules or other mechanisms that current members may use to control group composition have been highly successful in increasing and sustaining contributions, though subjects are sometimes prone to over-exclusion (Ahn, Isaac, and Salmon, 2008/2009; Charness and Yang, 2010; Weber, 2006; Page, Putterman, and Unel, 2005). Finally, experiments have also shown that subjects will vote with their feet for institutions allowing them to punish free-riders (Gürerk, Irlenbusch, and Rockenbach, 2006).

II. Environment

I construct a basic Tiebout-style environment, in which residents may move between communities providing different quantities of the public good. In each time period, all agents simultaneously select their location, where they receive a payoff that is increasing over public good provision in the community and decreasing over the amount that they personally contribute toward provision.

There is a finite set of agents, $N = \{1, \dots, n\}$, and of locations, $L = \{1, \dots, k\}$.

A *state* $(\boldsymbol{l}, \mathbf{x})$ is an n-tuple of locations $\boldsymbol{l} = (l^1, \dots l^n)$, where l^i is an integer between 1 and k, and an n-tuple of contributions $\mathbf{x} = (x^1, \dots, x^n)$.

The feasible values of $\mathbf{x}$ follow one of two cases. In the first case, contributions are voluntary and, for all i, x^i may be any number greater than or equal to 0. In the second case, contributions are uniform for all members of a location, such that for any two agents i and j, $l^i = l^j$ implies that $x^i = x^j$. In this case, there is a mapping $t: L \Rightarrow \mathbb{R}^+$ such that $x^i = t(l^i)$.

There exists a public good that is:

a) Purely non-rivalrous: the public good is not depleted by the presence of additional community members;
b) Produced at constant returns to scale: the public good provided is equal to the total contributions;
c) Local: an agent's contributions finance the public good only within his location and an agent receives a return from a location's public good if and only if he resides in that location (there are no spillovers).

Let X^j be the quantity of public good provided in location *j*. Then,

$$X^j = \sum_{i \text{ s.t. } l^i = j} x^i \qquad (1)$$

The non-rivalry of the public good is a departure from Tiebout's assumptions. He suggested production technology as the motivation for providing public goods at the local level and assumed that communities face a per-capita cost curve that is u-shaped over the number of residents, implying an optimal community size that is less than the total population.

These experiments consider a non-rivalrous public goods environment in order to study movement solely in response to preference differences, without the complication of crowding concerns that are particular to production technologies. In addition, if the population has highly divergent preferences and everyone within a location must pay a uniform local tax, then a pure public good in this environment need not imply that a population would prefer to cluster in a single location. The experimental design in this paper has the property that preference types would prefer to separate when community members face a uniform tax policy. Finally, the pure public good environment gives subjects the best possible shot at being comparatively successful in the voluntary contributions case, when free-riding is the only obstacle to a society achieving the most efficient possible outcome by pooling its resources into a single community.

In each period, each agent *i* receives a payoff from residing in location l^i:

$$\pi^i(\mathbf{l},\mathbf{x}) = A^i \ln(X^{l^i}) - x^i \qquad (2)$$

Agents differ only in the parameter A^i, which determines their marginal rate of substitution between the public good and private consumption.[10] It is easily shown that the best response of agent *i* is to contribute the exact amount necessary to bring the collective community contributions to A^i:

$$x^{*i} = \max(0, A^i - \sum_{s.t. l^j = l^i, j \neq i} x^j) \qquad (3)$$

Thus when agents are able to voluntarily contribute any amount to the public good, in equilibrium each community's total provision will equal the maximum value of A represented in the community. However, the efficient provision for the community (which maximizes the

[10] This is a modification of the Cobb-Douglas preference function that has several useful properties – in particular, that agents are strictly better off as the level of public good in their community increases, that each type of agent has a preferred tax policy, and that an agent's best-response is to contribute less than his preferred tax when contributions are voluntary.

aggregate payoffs of its residents) is equal to the *sum* of the parameters A in the community. Therefore, when contributions are voluntary, the public good is underprovided in equilibrium.

Under an institution with uniform tax policies, all residents of community *j* pay an equal tax, t(j). In addition, let n(j) denote the number of residents of community *j*. Then the payoff function in equation (2) becomes:

$$\pi^i(\mathbf{l},\mathbf{x}) = A^i \ln(t(l^i) * n(l^i)) - t(l^i) \qquad (4)$$

For any given number of residents, each agent has single peaked preferences over the tax in their community, such that *i's* utility is maximized at tax $t = A^i$. Thus for each resident there is a trade off between being in a large community and being in a community where the tax is close to their ideal policy. When the values of A in the society diverge sufficiently, as in the experiments described in the following section, there does not exist any intermediate tax rate that would make all agents better off pooling their resources than they would be sorting by type and consuming at their optimal taxes in smaller communities.

In these experiments, there are four agents for whom A = 5 ("Low Types") and four agents for whom A = 85 ("High Types"). Figure 1 shows the payoff functions of each type over tax rate, for communities of four agents (separate) and communities of eight agents (pooled). The range of taxes for which the High Types receive higher payoffs by pooling their resources in an eight-person community than by segregating in a four-person community with their optimal tax policy of 85 is: $t \in (19.72, 227.7)$. On the other hand, the Low Types would receive higher payoffs from pooling only if the larger community offered a tax in the range $t \in (1.16, 13.4)$. As these ranges do not overlap, there is no tax rate for which both types would receive higher payoffs by being in a single community than they would by separating.

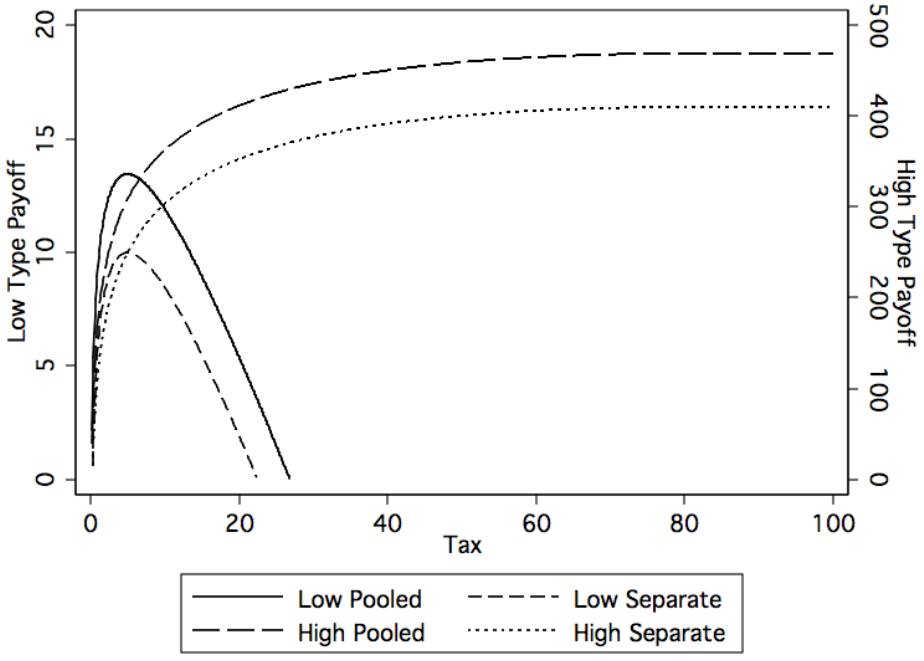

Figure 1: Payoff functions for the two types in communities of 8 (pooled) or 4 (separate) agents.

III. Experimental Design

All experimental sessions were conducted at the Harvard Decision Science Laboratory in Cambridge, Massachusetts. Participation was restricted to graduate and undergraduate students. Though most participants were Harvard University students, other local universities such as Boston University, Tufts, and Northeastern were also represented. Subjects participated in groups of sixteen people at a time, and interacted with seven anonymous others in the room using the experimental software z-Tree (Fischbacher, 2007).

Subjects played a 20-period repeated game. In each period, they first chose a location and then made a contribution to the local public good. There were six available locations, which remained the same for the duration of the experiment, and were labeled "Group 1" through "Group 6." The method of determining the contribution the subjects made depended on the institution governing their session. The four institutions were Voluntary Contributions, Fixed Tax, Fixed Quantity, and Voting.

In Voluntary Contributions (*VCM)* sessions, each subject could contribute however much they wished. The latter three institutions required all members of a community to make identical contributions. Under the *Fixed Tax* institution, each of the locations was associated with a fixed, posted tax (t). Anyone who entered the location was required to contribute this amount in each period, for the duration of their time in that location. The provision quantity then depended on the number of residents who entered (i.e. t times the number of residents). Under the *Fixed Quantity* institution, each location was associated with a fixed, posted provision quantity (X) that was provided in this location in every period in which it was populated. The per-capita taxes were then dependent upon the number of residents who entered (i.e. X divided by the number of residents). Among the locations offered in the Fixed Tax and Fixed Quantity conditions were those offering the optimal bundles for each of the preference types in the experiment. These institutions are most similar to Tiebout's description of communities as offering public goods packages that remained fairly constant over time. Finally, under the *Voting* institution, the location's current members voted on the local tax policy in each period. The median voter's preference was implemented and all members were then required to contribute this amount in the period.

A total of seventeen sessions were run: five sessions under the Voting institution and four under each of the other three institutions. Each session was populated by eight subjects. Four subjects in each session were randomly assigned to be "High Types," who greatly benefited from public good provision in their community, and four were "Low Types," who benefited very little. Subjects did not receive specific information on the payoffs of the other participants, but were aware that there was variation in the population.

At the start of each period, subjects simultaneously selected the location they wished to enter. They then submitted a contribution and received their payoff for the period. This payoff

was given by equation (2), in which A = 85 for High Types and A = 5 for Low Types.[11] Finally, they observed the outcomes of all locations over the previous three periods before making their next move. This included the number of residents and the subject's personal payoff from the location (in all conditions), along with any fixed policies associated with the locations (in the Fixed Tax and Fixed Quantity conditions), the previously enacted policies (in the Voting condition), or the total and personal contributions (in the Voluntary Contributions condition). Figure 2 shows the procedure of the stage game under each of these four conditions.

In the first period, all subjects, in all conditions, began in the same initial location. The policy of this location under the Fixed Tax and Fixed Quantity institutions was selected to be the same as the policy enacted in the Voting condition if all subjects voted for their ideal policy. Moving – selecting a different location than in the previous period – carried a cost of five experimental units.

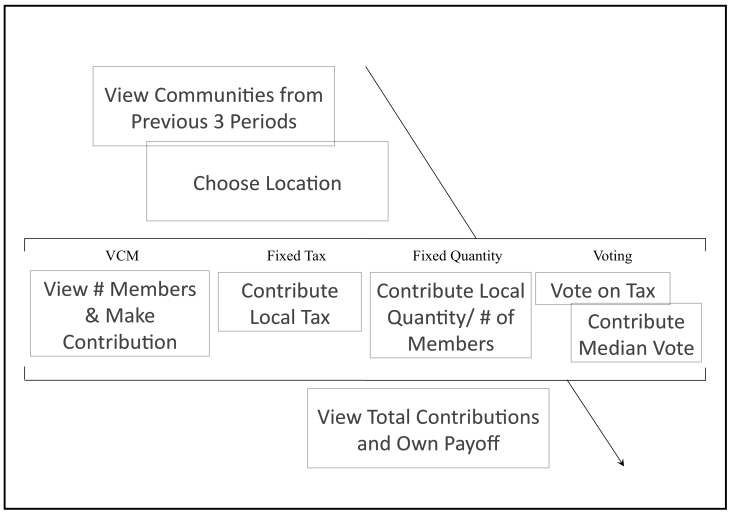

Figure 2: Experimental Procedure under VCM, Fixed Tax, Fixed Quantity, and Voting.

A partition of agents is Nash stable if there does not exist any agent who would receive a higher payoff by unilaterally moving to a different location. A partition of agents is strong Nash stable if there does not exist any *set* of agents, all of whom would receive a weakly higher payoff and at least one of whom would receive a strictly higher payoff, by *coalitionally* moving to different locations.

Since the public good is pure, the state in which the entire population resides in a single location is strong Nash stable under Voluntary Contributions. However, under the Nash equilibrium contributions, this community underprovides the public good: the Low Types do not contribute anything and the High Types contribute 85 among the four of them. Thus the total provision level is equal to 85: less than one quarter of the optimal level for the population.

[11] Subjects were not presented with this equation directly. They were instead given payoff tables, showing the payoff they would receive for various combinations of total contributions made in their community and personal contributions. The experiment began only after all participants correctly answered a series of comprehension questions regarding the procedure and their payoffs.

The payoffs for the two types are sufficiently different that there exists a unique strong Nash equilibrium under Fixed Tax, Fixed Quantity, and Voting in which the two types separate into two homogenous communities where they consume the optimal tax-provision pair for their type. In this state, the Low Types are together in a location with (t, X) = (5,20) and the High Types are together in a location with (t, X) = (85, 340).

However, under both Fixed Tax and Fixed Quantity, two forms of suboptimal Nash stable states exist. In the first, the types separate and consolidate but are in locations where the tax policy differs from the optimal for that population. Though High Types would prefer to be in a community with t = 85, any state in which all four are together paying $t \in (8.7, 315)$ is Nash stable. Similarly, any state in which all four Low types are together paying $t \in (0.5, 18.5)$ is Nash stable. The second form of suboptimal Nash stable states occur when the types are pooled in a single community with an intermediate tax policy. Any state in which all members are together in a community with tax $t \in (4, 23)$ is Nash stable, as no subject would wish to independently exit a community of seven others in favor of striking out on his own. Both of these are eliminated as equilibria under the Voting institution.

IV. Results and Discussion

Efficiency Convergence

I first compare efficiency convergence under the four institutions, relative to the baseline of the Nash equilibrium prediction under Voluntary Contributions, in which all subjects locate together but the public good is severely underprovided. The voluntary contribution Nash equilibrium is taken as the baseline since it is both the outcome that Tiebout was attempting to improve upon and the outcome to which standard public goods games tend to converge. The average efficiency over the final five periods of the twenty-period experiment under each institution is given in Figure 3.[12] The most efficient outcome is represented by the dashed line, but is achievable only when residents can solve the demand revelation problem within a single community. The strong Nash state is the highest feasible outcome when residents sort into multiple communities and is represented by the dotted line.

[12] Efficiency is smoothed over the final five periods so as to avoid over or under-emphasizing incidental deviations.

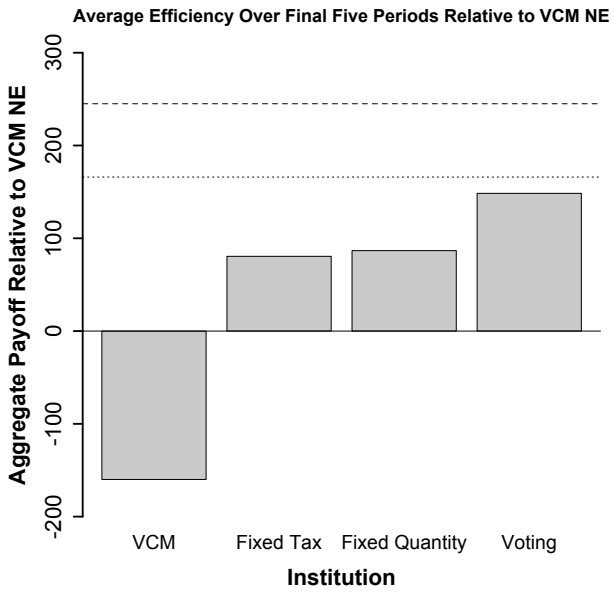

Figure 3: Average Efficiency Under Each Institution

First, we see that the subjects achieve very low payoffs when contributions are voluntary, even relative to the Nash equilibrium prediction, suggesting that they are squandering their resources. Subjects may do worse than the Nash equilibrium outcome if they either locate in a single location but contribute less than the Nash equilibrium provision, or locate in multiple locations and diffuse their resources (or both). Efficiency under both Fixed Tax and Fixed Quantity is significantly greater than the baseline, at 33% and 35% respectively – or approximately 50% of the strong Nash outcome. Finally, efficiency under Voting is significantly higher, and nearly reaches the strong Nash outcome. Thus, while the Fixed Tax and Fixed Quantity institutions lead to moderate improvements in efficiency relative to our baseline, they still fall short of facilitating efficient public good provision, and only under Voting do the subjects approach the optimal allocation.[13]

Sources of Inefficiency

There are two distinct causes of inefficiency in this environment: subjects may fail to properly sort by type or, upon sorting, may fail to provide the optimal level of public good for their community.

A. Sorting

I first look at whether subjects reach a sorted partition. Figure 4 shows the proportion of time, over the final five periods of the experiment, that the types are sorted into two separated, consolidated groups. A subject is *sorted* if he is in a location with at least two of the three others of his type, and with no more than one member of the other type.

[13] The effect of institution on efficiency is significant, VCM efficiency is significantly below zero, and Voting efficiency is significantly higher than Fixed Tax and Fixed Quantity efficiency, all at the .01 level.

For all three institutions under which community members must contribute equal amounts, subjects are highly successful in sorting into two homogeneous groups. Over the final five periods, subjects in these three conditions are sorted 94% of the time. While there is little difference in community composition by the end of the twenty-period sessions under Fixed Tax, Fixed Quantity, and Voting, the institutions do vary in how rapidly subjects sort. Subjects require an average of 2.5 periods to first reach a sorted partition under Fixed Tax, 3.6 periods under Fixed Quantity, 5.95 periods under Voting and 10.2 periods under VCM.

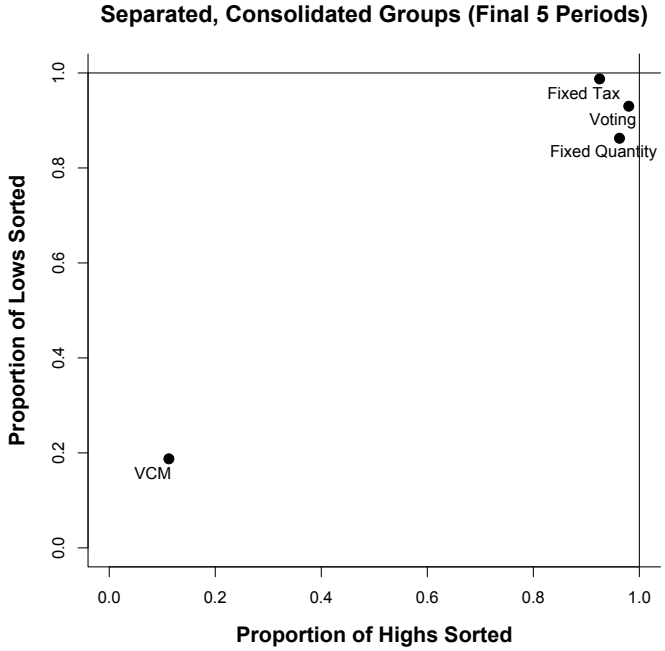

Figure 4: Sorting by Type in the Final Five Periods

B. Local Provision

Although subjects are eventually well-sorted under all three tax institutions, the question remains as to whether they provide the optimal level of public goods for their type within these homogenous communities. Unsurprisingly, contributions greatly differ from the optimal amounts when provision is voluntary. However, High Types under Fixed Tax and Fixed Quantity, as well as Low Types under Fixed Quantity, often deviate from their optimal contribution as well. Over the final five periods, High Types' contributions deviate from their optimum by approximately 30% under both of these institutions, while Low Types contributions differ from their optimum by 150% under Fixed Quantity. Finally, when subjects are able to vote for their local tax rate, contributions differ from optimal levels by 0.8% overall.

Dynamics

I next consider the dynamics under each of the four institutions that lead to these final outcomes.

A. Voluntary Contributions

The top left panel of Figure 5 shows the average contribution over time for each of the two types. This graph suggests that subjects are free-riding but that they are converging toward the equilibrium contribution level, and that the severe inefficiency we see in Figure 2 is not driven by under-contributing relative to the Nash equilibrium level.

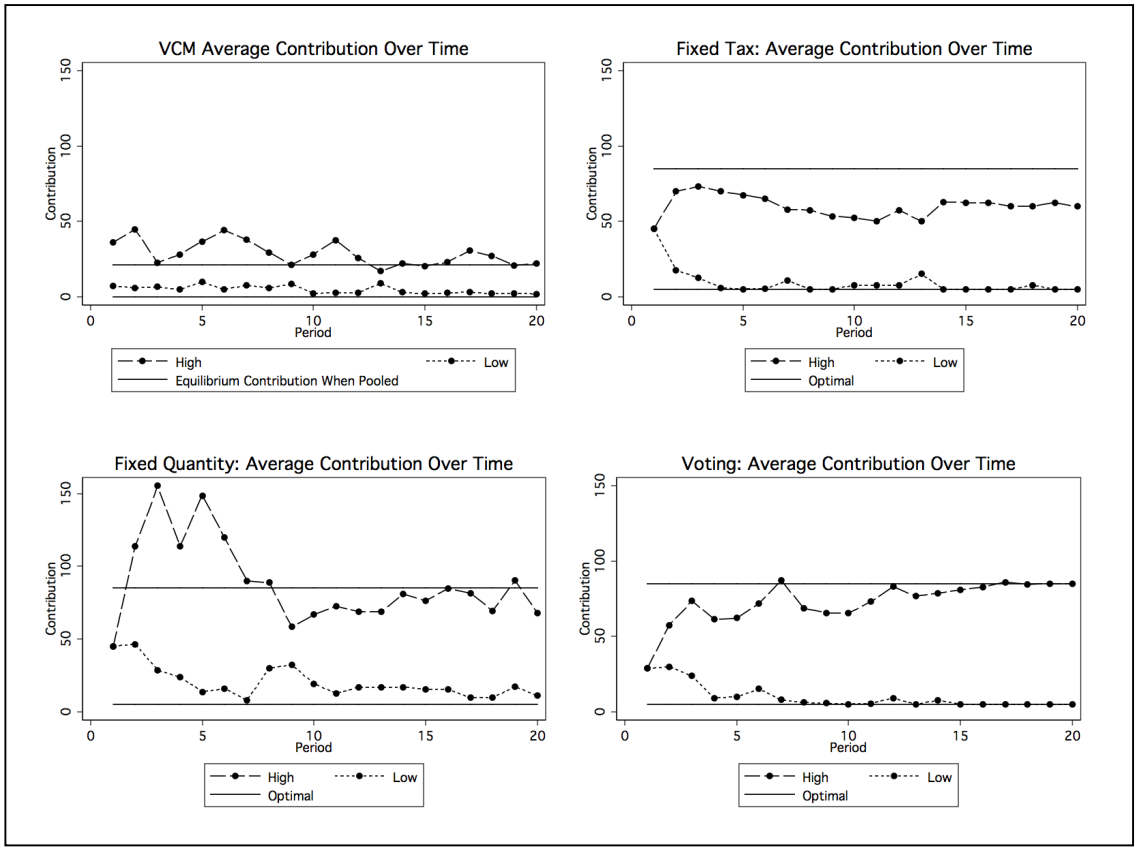

Figure 5: Average Contributions Over Time Under VCM, Fixed Tax, Fixed Quantity, and Voting

Though a community with all members of the population in a single location is both efficient and strong Nash stable, subjects do exit the all-inclusive community and they continue to move over the course of the session. All subjects are together in a single location for only half of all periods. While movement significantly declines over time under all three institutions with local mandatory tax rates, there is no such stabilization under Voluntary Contributions and, toward the end of the session, movement occurs with more than twice the frequency of the other institutions.

Though it is the High Types who benefit most from being in communities providing the public good, they are the ones who typically initiate this movement by exiting large communities in favor of previously empty locations. These dynamics are very similar to those previously found in a linear pure public goods environment when subjects with different returns from the public good could move between locations (Robbett, 2010). There is a difference, however, in the efficiency relative to the Nash equilibrium. When payoffs are linear, no one contributes in

equilibrium. But in an environment where public goods *are* provided in equilibrium, agents benefit from being in larger communities, and frequent movement may be harmful. Thus, in this environment, the ability to move leads to a worse outcome for the subjects than if they played the Nash equilibrium within a fixed group and mobility is actually detrimental to efficiency.

Finally, we see that frequent movement is associated with lower payoffs. Table 1a presents fixed effects regressions of period-earnings on the subject's movement decision and contribution decision. Movement is associated with a large, immediate loss, though this is not significant when controlling for the size of their (new) community. Table 1b presents OLS regression results of subjects' total payoffs on frequency of movement, average contribution and type. Those subjects who move frequently earn significantly less during the course of the experiment.

Earnings (Fixed Effects)	(1)	(2)
	Coefficient	Coefficient
Move	-19.97*	-8.14
	(p<.001)	(p=.186)
Community Size	-	5.20*
		(p<.001)
Contribution	-.48*	-.449*
	(p<.001)	(p<.001)
Intercept	187.95*	153.4*
	(p<.001)	(p<.001)
Observations	640	640

Total Payoffs (OLS)	
	Coefficient
Moves	-88.28*
	(p=.003)
Contribution	1.53
	(p=.83)
High Dummy	6512.3*
	(p<.001)
Intercept	479.02*
	(p<.001)
R^2	0.98
Observations	32

Table 1. The Immediate Effect and Aggregate Effect of Movement on Earnings

B. Fixed Tax and Fixed Quantity

The Fixed Tax and Fixed Quantity institutions are most similar to the environment envisioned by Tiebout: there exist many communities offering a wide range of exogenously-determined local policies, which remain constant over time. The residents, in turn, select the community whose tax-provision pair best suits them, but do not influence the local policies in their chosen community.

While High Types are more likely to exit larger groups in favor of smaller ones under Voluntary Contributions, this dynamic is reversed when communities have mandatory local taxes. Rather than being attracted to areas populated by High Types, the Low Types now flee the taxes, while the High Types tend to be more attracted to populated areas (in particular: they are attracted to other taxpayers). The Low Types exit the all-inclusive group in their first opportunity 93.75% of the time under the Fixed Tax and Fixed Quantity institutions, while less than half of the High Types do so. Figure 6a shows the average size of the community a subject exits, relative to the size of the community he enters, under both Voluntary Contributions and the Exogenous Tax conditions (Fixed Tax and Fixed Quantity). Figure 6b shows how the likelihood that a High Type exits his community declines over the number of other High Types in the community, both when this community provides the optimal policy and when it does not.

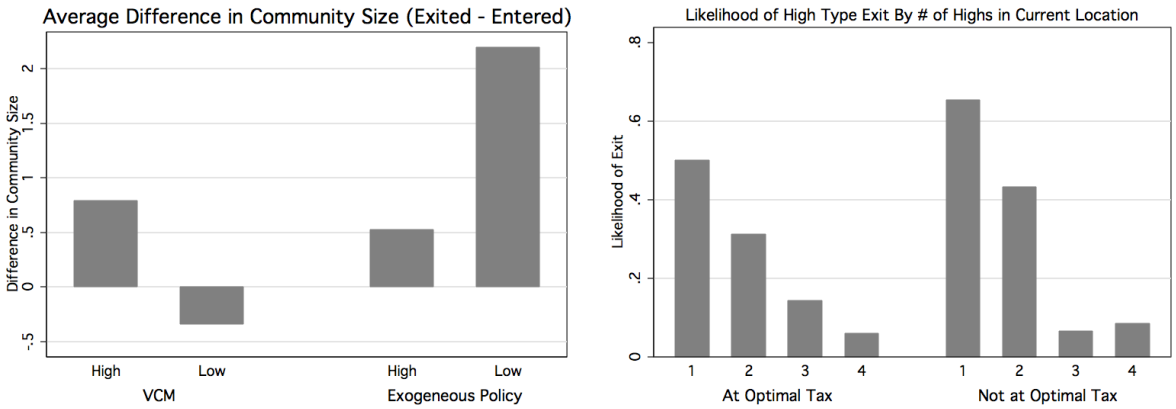

Figure 6: The importance of community size in movement decisions of the High Types.

This unwillingness of High Types to exit larger communities causes them to be susceptible to a coordination failure where, though they consolidate into a location with other High Types, they fail to attain the optimal tax and provision levels for their type. Figure 5 shows the average contribution over time under Fixed Tax (top right panel) and under Fixed Quantity (bottom left panel).

C. Voting

While subjects under the Voting institution take longer to sort themselves into two homogeneous communities than under Fixed Tax or Fixed Quantity, once they coordinate they are less likely to move. Furthermore, 92.5% of subjects vote for their optimal tax policy by the end of the session, and so the optimal policies for each type are eventually implemented within the sorted communities.

Thus mobility is most successful when communities have an internal process by which residents may adjust their local policies without being required to relocate. The ability to vote with one's feet allows types to separate and coordinate by moving to the community they like best. Subjects implementing their own local polices require only a few more periods to coordinate into separate, homogeneous communities than those choosing among locations with fixed policies. The ability to vote with one's ballot then allows the residents to adapt the community to their preferences, reducing the possibility that a community of like-minded residents fails to realize the policy best suited for them.

V. Conclusion

This paper uses laboratory experiments to study the dynamics of movement and local public good provision in a simple Tiebout environment and to test the effectiveness of four different institutions in facilitating efficient public good provision. The results suggest that institutions determining the level of local public good provision within a community can greatly affect residents' ability to coordinate with those who share their preferences and to converge to an optimal outcome.

Voluntary contributions communities enable residents with different preferences to make different contributions, without the need to relocate or divide their resources over multiple

communities, but are susceptible to the same free-riding and demand revelation problems that can plague public good provision at the federal level. This paper finds that voluntary contributions communities are characterized by free-riding, instability, and inefficient movement and replicates the dynamics previously found in local pure linear public goods games with two types of agents. This suggests these patterns and instability are robust to differences in the payoff function, with one distinction: when public goods are provided in equilibrium, this frequent movement may lead to efficiency significantly below equilibrium predictions, and mobility may actually be harmful to efficiency.

Taxes requiring all members of a community to make the same contribution to the local public good are highly successful at sorting subjects by preferences into consolidated, homogenous communities. However, subjects often coordinate into, and remain in, communities offering suboptimal tax-provision bundles for their type. Inertia caused by the desire to be around others (for instance, as the result of community ties), suggests that mobility in itself is not sufficient for achieving an optimal allocation of public goods and that the existence of optimally-designed policies is not sufficient for guaranteeing that communities offering these policies will be entered. (Potentially more concerning is the implication that new communities may then be entered only by the most extreme members of the society, whose preferences have not been satisfied elsewhere, and, if local policies cannot be adjusted when others follow, the society may wind up overly concentrated in communities with extreme policies.)

When subjects have an internal process for adapting the policies of the communities they have entered, the local communities converge to the optimal policies for their residents. While subjects require slightly longer to sort into homogeneous communities when fixed local policies are not provided, they are eventually just as successful at reaching an optimal partition and, when they can then vote on the local policy, residents converge toward consuming their optimal level of public goods.

Tiebout ended his discussion by asking whether local governments should have fixed expenditure policies (Tiebout, 1956, p.423). The results of these experiments suggest that, when agents have very different preferences, they will sort by preference type even when communities do not provide exogenous tax policies, and that local politics may be necessary for overcoming coordination problems, adjusting provision to the preferences of the residents, and reaching an efficient allocation.

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