Soc Choice Welf (2016) 46:543–568
DOI 10.1007/s00355-015-0928-x

ORIGINAL PAPER

Community dynamics in the lab

Andrea Robbett[1]

Received: 25 July 2014 / Accepted: 6 October 2015 / Published online: 12 October 2015

Abstract This paper studies the dynamics of community formation when members differ substantially in their returns from voluntary local public good provision. Laboratory experiments are conducted to examine how agents relocate in response to both community provision and membership composition, as well as how the growth and stability of communities are dictated by moving costs and crowding. When the public good is congestible, such that returns are lower for larger populations, I find communities are characterized by instability, cyclical fluctuations in local provision, and a dynamic in which low demanders continually chase high demanders through locations. When congestion is eliminated, subjects with different returns do sometimes co-exist. Yet chronic, inefficient movement persists, suggesting that instability is driven by intrinsic preferences for community composition, as well as by sensitivity to congestion.

1 Introduction

Local communities often vary greatly in their overall character and culture and, over time, can experience substantial transformations and changes in population. One defining attribute of communities is the public goods and services they offer, whether

I wish to thank Charles Plott, Leeat Yariv, Peter Matthews, Rod Kiewiet, John Ledyard, and Jean-Laurent Rosenthal, as well as two anonymous referees and the editor for their helpful comments, Meghan McKeown for lab assistance, and the Caltech Social Science Experimental Laboratory and the Harvard Decision Science Laboratory for their hospitality. Funding was provided by the Caltech Laboratory for Experimental Economics and Political Science and by Middlebury College.

✉ Andrea Robbett
arobbett@middlebury.edu

[1] Department of Economics, Middlebury College, Middlebury, VT 05753, USA

provided by local government through tax revenue, such as schools, libraries, and recreation areas, or voluntarily by residents, such as neighborhood watch programs, volunteer fire departments, street festivals, resident-built playgrounds, and community gardens. Residents typically vary in how much they value such amenities. This paper uses laboratory experiments to study the dynamics of local community formation, development, and stability when agents receive very different returns from a public good.

One common pattern of community transition often described by urbanists is the process of revitalization, typically thought to be initiated by "urban pioneers."[1] New residents enter uninhabited commercial districts or (far more controversially) lower-income neighborhoods and expend considerable effort modifying the location, by making aesthetic improvements, providing cultural amenities, renewing the housing stock, and making formerly commercial areas habitable. Conventional wisdom among both urban economists and real estate investors has been that these pioneers are members of artistic and bohemian populations, who provide a public good in the form of the cultural, aesthetic, and nightlife amenities that most benefit them and, in doing so, further attract similar residents with high values for these amenities.[2] Eventually, the efforts of the new residents make the neighborhood attractive to higher-income populations, sometimes referred to as "settlers," who prefer to live in the improved neighborhood yet do not benefit as strongly from the amenities.[3] In the final step of neighborhood shift, the initial pioneers, who had been voluntarily providing a public good, typically exit once the neighborhood becomes popular. This pattern played out most famously in SoHo in the 1970s, but can also be observed in other New York City neighborhoods such as TriBeCa and the East Village, as well as those of other cities.[4]

In this paper, I use laboratory experiments to study the main forces underlying community dynamics when agents have different private values for a public good. I conduct standard linear public goods experiments in a free-mobility environment to gain insight into the basic processes of movement, community formation, and the phenomenon of one type of agent chasing another. Within this setting, I induce *heterogeneous preferences* for the public good, in the form of different monetary returns from provision, and study the dynamics of movement and voluntary local public good provision. Those subjects who receive high payoffs from public good provision are analogous to the populations typically thought to be urban pioneers, while those with weaker preferences resemble the settlers who later enter the community. In the broader context of group and team formation, those with high returns can be thought of, for instance, as members of a work group who place greater value on the team output, members of a political coalition who are more invested in the organization's goals, members of a social or information network who receive greater returns from provided content, or trendsetters who value adoption and development of new consumption goods, fads, or linguistic trends (in which case consumption of

[1] See, for instance, Hudson (1980)'s application of the invasion-succession model to urban revitalization.

[2] Florida and Melander (2007).

[3] Hudson (1988) expands the invasion-succession model to include this second wave.

[4] For instance, Cole (1987) describes the displacement of artists from New York City neighborhoods and Ley (2003) describes the movement of artists from gentrifying neighborhoods of Canadian cities.

a good constitutes group membership).[5] To the best of my knowledge, this paper is the first to study group composition dynamics in a standard voluntary contribution experiment when agents have heterogeneous returns, as well as, more broadly, the first to analyze how agents' public good returns drive their movement decisions.

Most local public goods and services are, to some extent, *congestible*, meaning that the presence of more residents diminishes the benefit that each individual may obtain. I analyze the effect of payoff congestion on movement dynamics and stability, by comparing sessions in which the public good is pure (non-rivalrous) with sessions in which the public good is congestible.

The goal of this paper is to investigate the general principles governing movement and community formation among agents with private values, which have broad applications to issues of group formation, including to the pattern the neighborhood transformation. The experiments are designed to address the following questions: (1) Is movement driven by agents' preferences for the public good? (2) Are instability and cyclical movement patterns caused primarily by congestion? and (3) Can entry fees facilitate sorting and local cooperation?

Communities often face social dilemmas, in which individual incentives diverge from the interests of the community as a whole, that may hinder the efficient provision of public goods. Since all members may consume the public good, regardless of whether they contribute to it, they have an incentive to under-contribute relative to their true demand, and equilibrium behavior results in individual free-riding and a suboptimal allocation of the public good provided in the community. Efficient provision can be even more difficult to achieve when residents have different, unobservable preferences for public good consumption, since a community cannot generally require different contributions or behavior from those who would benefit most.[6] For instance, residents not concerned with local school quality typically do not pay lower taxes, just as those who care strongly about the neighborhood's appearance cannot be required to contribute to its upkeep.

Tiebout (1956) addressed the problem of efficient public good provision with the insight that many of the public goods and services that we consume are provided by

[5] Likewise, trends similar to the cyclical pattern of neighborhood composition can be observed in other economic contexts. Karni and Schmeidler (1990) present a model of cyclical fashion trends in which consumers cycle through types of goods. In their model, members of a lower social class receive increasing utility from a good as more people consume it, while members of a higher social class receive utility that increases with the number of other high status users but decreases with the number low status users. Pesendorfer (1995) presents a model in which a monopolist introduces a redesigned good at a higher price as soon as the previous, discounted version becomes sufficiently popular. More desirable "high types" care more about matching with other high types than low types do and use the costly purchase of the new good as a means of coordinating with similar types.

[6] At a broad level, the inability of a central authority to observe individual values for a public good is at the heart of the preference revelation problem, which results in under provision (Musgrave 1939; Samuelson 1954). In the specific context of linear public goods experiments, Ledyard (1995) suggests that heterogeneous returns have a negative effect on contributions (unless information is incomplete *and* participants only interact once). Fellner et al. (2011) find that, on average, subjects contribute less when individual marginal returns cannot be linked to individual behavior and less still if they are unaware of the distribution of returns. In a public goods game in which participants are aware of each player's returns, Reuben and Riedl (2013) find that a punishment mechanism is used to enforce contributions proportional to returns.

our local communities and that non-residents may be geographically excluded from consuming them. He proposed that residents who are able to move freely between local jurisdictions would enter the community that best satisfied their preferences for the public good, along with other local non-economic features.[7] By moving in response to differences in local communities, residents reveal their true preferences and an efficient public good allocation can be achieved at the local level. The fundamental premise of Tiebout's argument has implications far beyond local public finance and public good provision and Tiebout's proposal is routinely invoked across disciplines to capture the idea that residents, workers, consumers, or coalition members who dislike their current situation can move elsewhere.

The experiments reported in this paper incorporate two fundamental features of Tiebout's framework: that public goods are spatially excludable and may be consumed only by local residents, and that residents are both fully mobile and fully informed of the differences between locations. One dynamic result emerging from the Tiebout literature is that of the poor chasing the rich, or the so-called *musical suburbs problem* (Hamilton 1975; Wilson 1998). This is commonly subverted in practice through the implementation of zoning policies, which lead to uniform tax rates, or, historically, even through restrictions placed on the mobility of the poor.[8] However, as the pattern of settlers following pioneers in the process of urban revitalization indicates, chasing patterns may also be found if residents relocate in response to a public good that is being provided voluntarily, rather than through tax revenue.

I introduce two different types of agents: those who benefit greatly from the public good (High Types), but may be highly sensitive to congestion, and those who receive very low returns from the public good but are indifferent to the presence of others (Low Types). Subjects are randomly assigned different returns from public good provision at the start of the experiment and participate in a standard linear public goods game, during which they can move between communities.[9] There are six available locations that remain fixed for the duration of the experiment, and the subjects play a dynamic game that lasts for sixty-five periods (allowing for ample time to assess the stability and long-run dynamics).

In each period, the subjects first simultaneously choose a location. They then observe the number of others who chose the same location, and make a voluntary contribution to the community's public good. They receive a payoff that depends on the total contributions made only within their own location, as well as their assigned marginal return from the public good. Finally, the subjects learn the outcomes in all

[7] For instance, Tiebout specifically references the desire of residents to have "nice" neighbors (Tiebout 1956, p. 418).

[8] Throughout U.S. history, the ubiquity of this concern may be seen in limitations on the mobility of the poor in federal legislation, ranging from the Articles of Confederation, which excluded "paupers" from those who had the right to move freely between states, to the Personal Responsibility and Work Opportunities Reconciliation Act of 1996, which prevented newcomers from receiving welfare benefits beyond what they had been receiving previously for up to a year following their move (Donahue 1997).

[9] In the typical public goods experiment, subjects receive an endowment in each period and, without discussion, choose how much to keep for private consumption and how much to contribute anonymously to the group. The total amount contributed is multiplied by a factor less than 1 and each subject receives this amount in addition to the portion of his endowment he kept for himself.

locations before making their next move. Consistent with the difficulty in observing public goods preferences of other households, which is at the root of the problem of inefficient public good provision, the subjects do not receive any information on the returns from the public good received by fellow participants.

This paper analyzes the extent to which community instability may be driven by payoff congestion, by directly comparing experimental sessions with a congestible public good to sessions with a pure public good. When the public good is congestible, High Types receive lower returns from public good provision in more populated communities. In the absence of congestion, the most efficient outcome occurs when the population pools its resources into a single community and, in this case, there is no set of residents who may increase their payoffs by collectively relocating.

Each location is associated with an entry fee. These fees capture the cost that a household incurs by moving, but also vary between locations, capturing the existence of communities that are less easily accessible, for instance due to geographical location, higher real estate prices, or substantial joining fees or requirements for initiation. Movement into three of the six locations carries a very low cost (equivalent to twenty percent of the subject's per-period endowment), while movement into the other three locations carries a much higher cost (equivalent to sixty percent of the subject's endowment). Since the Low Types benefit little from public good provision, these entry fees are relatively higher for them, and imply that provision in another community must be far greater than in their own in order for them to gain by moving. Such fees can therefore serve as a mechanism that coordinates separation by type and allows the High Types to avoid congestion.

I find, first, that subjects' behavior varies greatly by their assigned public good preferences. While the Low Types contribute little and, over time, learn not to contribute anything at all, the High Types do contribute, and they sustain these contributions for the duration of the experiment. But, although the High Types tend to contribute consistently, the locations themselves experience vast, cyclical fluctuations in public good provision. Local provision peaks immediately after the community is formed and then declines steadily over the life of the community. This is reminiscent of the pattern of urban revitalization in which the most substantial contributions are made by the early entrants, making the community attractive to others.

Consistent with the fundamental premise of Tiebout's model, the subjects do, in fact, move in response to these differences in local public good provision. Perhaps more importantly, this movement is greatly shaped by the subjects' exogenously assigned returns from the public good. The High Types are far more responsive to differences in local provision. While neither type remains in communities with low provision, the High Types have a significantly lower threshold for movement, and are typically in the community with the highest provision level. Thus, taken statically, or without consideration of the changes in communities over time, there is some evidence of sorting by type.

Congestion seems to play an important role in community dynamics. Communities tend to be highly unstable when the public good is congestible, and there is a clear pattern of the Low Types chasing the High Types through locations. The High Types frequently exit populated communities with declining provision levels in favor of previously unoccupied locations and at an immediate cost to themselves. They make

substantial contributions to the public good and are quickly joined by other High Types. Once their community becomes competitive, they are followed by the Low Types, provision deteriorates, and the cycle starts once again. Movement is frequent, with at least one subject typically moving in each period, and never subsides over the course of a sixty-five period experiment.

Although movement is less frequent in sessions without congestion, the chasing dynamic and community instability persist. The heterogeneous population of subjects is often able to co-exist in a single location for many periods. However, less than half of the overall movement appears to be driven by congestion and the High Types continue to exit even when the presence of Low Types does not diminish their payoffs. In addition, frequent movement is associated with lower payoffs. This suggests that the chasing phenomenon is not driven purely by payoff-based incentives, but that people may also have intrinsic preferences for the composition of their community and that movement is partially driven by an unwillingness to be around those who do not contribute to the community.

With respect to entry fees, I find that local fees can facilitate the High Types' coordinated avoidance of the Low Types but do not promote long-term community stability. The existence of locations with differing entry fees allows the High Types to coordinate on a community and to avoid congestion caused by the Low Types. Locations associated with high fees are entered primarily by High Types and the subjects contribute more while they are there. However, even when High Types segregate, provision is not sustained and these communities are ultimately no more stable than those with low entry fees.

Even in this simple environment, we observe clear, general patterns of movement driven by subjects' assigned preferences for public good provision that strongly resemble those observed in neighborhood transitions. Those subjects who benefit most from public good provision often enter previously unoccupied locations and make substantial contributions to the public good. They are joined, first, by those with similar preferences, and, eventually, by those who benefit little and do not contribute, before exiting once again. Further, the continual exit of the pioneering subjects is only partially driven by local crowding, suggesting that community instability may be partially attributed to an intrinsic unwillingness to provide for those who do not contribute.

1.1 Related literature

Experimental studies have consistently shown that voluntary contributions in fixed-group, linear public goods games begin midway between optimal and one-shot equilibrium levels but decline with repetition, typically approaching the theoretical equilibrium unless supported by institutions, such as sanctions or taxes for those who contribute too little (Ledyard 1995; Ostrom 2000).

However, it is rarely the case that individuals are assigned to a fixed community or group. Individuals typically enter communities voluntarily, with some expectations of the group outcome based on the local history or norms, and with the understanding that they can move elsewhere should they disapprove of the behavior of their neighbors. Therefore, a practical approach is to study the public goods problem at the local level, where association is voluntary and movement is possible.

Despite the abundance of applications, only recently has experimental research jointly considered voluntary public goods contributions and endogenous group formation. The results thus far suggest that mobility in itself is not sufficient to solve the public goods problem without the implementation of formal boundary rules that restrict group entry. When individuals have complete freedom to move between groups then free-riders will continuously chase contributors between societies.

Ehrhart and Keser (1999), the first to conduct such experiments, study a congestible linear public goods game. They find a group-level dynamic in which groups with high contributions grow, contributions in large groups decline, and groups with declining contributions shrink, and an individual-level correlation suggesting that higher contributors exit larger groups in favor of smaller ones. A pair of studies compared treatments in which subjects can freely move between groups, can enter only with their new group's consent, or can exit only with their former group's consent (Ahn et al. 2008, 2009). They find that subjects often vote to deny entry or approve exit, even in a pure public good environment when groups benefit from having more members. Thus, while restricted entry serves to increase contributions, earnings are lower for cooperators when the public good is pure.

Several other experimental studies have found that high contributions can be sustained in voluntary contribution public goods games when subjects are provided with a mechanism to build their groups and control membership composition (Page et al. 2005; Cinyabugma et al. 2005; Charness and Yang 2014). Chaudhuri (2011) provides a recent review of the literature on cooperation in sorted groups.

There is evidence that declining contributions may be at least partially explained by the existence of conditional cooperators: subjects who are willing to cooperate only if their partners do as well (Fischbacher et al. 2001). Faced only with the choice of how much to contribute, conditional cooperators who are locked into fixed groups, with no other means of retaliation against free-riders, quickly learn to cease attempts at cooperation. Several experimental studies have tested conditional cooperation by sorting subjects based on the propensity for cooperation that they exhibit in earlier periods or games, and nearly all find that contribution is sustained at a higher level when cooperators only ever encounter other cooperators.[10]

Experiments allowing subjects to buy entry into separate games designed to be more attractive to cooperators typically find moderate but incomplete sorting (Bohnet and Kübler 2005; Brekke et al. 2011). Finally, when subjects may "vote with their feet" for local institutions and choose between groups with or without punishment mechanisms, they initially separate, with only the most cooperative joining the punishment community. However, the entire population eventually gathers in the community with punishment and achieves high levels of efficiency (Gürerk et al. 2006).

Many important aspects of this problem remain unexplored. In addition to having different preferences for contributing or free-riding, as these studies suggest, individuals in a society typically obtain varying benefits from public good consumption. These

[10] Experimental studies that have found sustained cooperation in groups formed of previously cooperative subjects include: Gunnthorsdottir et al. 2007; Rigdon et al. 2007; Gunnthorsdottir et al. 2010; Yang et al. 2007; Cabrera et al. 2012; Burlando and Guala 2005; Ones and Putterman 2007; and Gächter and Thöni 2005. An exception is Ockenfels and Weimann (1999).

differences are at the core of the preference revelation problem and the inability of a central government to efficiently provide public goods. While there have been several fixed-group linear public goods experiments considering heterogeneous returns, there has not been any prior experimental work that incorporates such differences into the local public goods framework, and, to my knowledge, this is the first experimental study to address how agents' public goods returns drive movement and the dynamics of group composition. This paper uses a linear public goods game, in line with the body of previous work; the experiment lasts for 65 periods, allowing for sufficient time for the cyclical nature of community dynamics to play out; and the paper studies the effect of congestion and entry fees on community stability. The finding in this paper that individuals often refuse to remain in a location where others are contributing less than they are, even when the presence of free-riders does not harm the payoffs of contributors, suggests that community stability may depend on a punishment mechanism to support contributions, as in Gürerk et al. (2006), or a local tax that all members are required to pay, as in Robbett (2014). The latter experiment used non-linear payoff functions to generate single-peaked preferences over tax rates, finding that tax institutions could allow agents to sort by their preferred tax rate and, when taxes could be voted on, achieve optimal provision levels within sorted groups. The baseline condition of that paper allowed for voluntary contributions and, consistent with the broad outcomes of this paper, finds that voluntary contribution communities are far less stable.

2 Experimental design

2.1 Setting

The experiment in this paper considers a local, linear public good that is provided by voluntary contributions from community members. There are nine agents in the population and six available locations. In each period, agents first simultaneously choose their locations from among the six places.[11] There is no limit on the number of agents who can form a single community. Next, they learn the number of community members in their chosen location and choose how much to contribute to the local public good. Finally, each agent receives a return from the public good provided in his own community (there are no spillovers). Two conditions were conducted: In Congestible Public Goods (CPG) sessions, agents receive lower returns from the public good as the community grows; in Pure Public Goods (PPG) sessions, more community members are weakly beneficial.

[11] The number of agents in the population is in line with the previous work on endogenous group formation reviewed in the previous section, which typically includes 9 or 12 agents. The limited number of locations used here is more restrictive than in these previous studies, which typically allow all participants to be in groups by themselves. However, all six locations are rarely used in this experiment (less than 1 % of observations) and thus the ability to form more communities likely would not have a large effect on the outcomes. Given the monetary incentives to form fewer groups, the availability of more locations could lead to more extreme results, in the form of lower efficiency and less stability.

All agents have the same per-period endowment of 25 units each and differ only in their *marginal per-capita return (MPCR)*, which is the increase in payoffs that the agent receives from someone in his community contributing an additional unit to the public good. Agents whose payoffs are sensitive to congestion experience declining MPCR over the number of members in their community. Agents are aware of the heterogeneity but not the distribution of types, consistent with both the basic problem of demand revelation and previous experimental work on heterogeneous MPCRs (e.g. Fisher et al. 1995).

In each population of nine agents, there are five "High Types" whose MPCR is very high, such that they greatly benefit from local public good provision. In the congestible public good sessions, the MPCR of the High Types declines sharply with the number of other members in their community, thus making them very sensitive to the presence of free-riders. In the pure public good sessions, their MPCR remains high regardless of the community size. In both pure public good and congestible public good sessions, the MPCR is set at 1 when a High Type is in a community by himself, to ensure that behavior in singleton groups does not drive any between-condition differences. The remaining four agents in the population are "Low Types" who have a very low marginal per-capita return, which is constant across the number of members. The extreme values of MPCR were chosen to separate the motivations of those who benefit greatly from community provision from those who do not.[12] Entry fees are the same for all agents and vary by location entered: three of the six locations have an entry fee of 5 units and the other three locations have an entry fee of 15 units.

Let L_t^i be the location that agent i chooses in period t. In each period, each agent i receives a payoff that depends on his personal contribution, c_t^i, the total contributions made at his location, the total number of members at his location, $n(L_t^i)$, and any entry fees he may have incurred by selecting a different location than in the previous period, $f(L_t^i)$.

In each period t, agent i's payoff is equal to:

$$\pi_t^i = 25 - c_t^i + MPCR^i(n(L_t^i)) * \sum_{j|L_t^j = L_t^i} c_t^j - f(L_t^i) * 1_{L_t^i \neq L_{t-1}^i} \quad (1)$$

where MPCR is equal to:

	Congestible Public Good Sessions	*Pure Public Good Sessions*
Low Types	$MPCR = 0.15$	$MPCR = 0.15$
High Types	$MPCR = 1 - 0.08(n(L^i) - 1)$	$MPCR = 0.8$ if $n(L^i) > 1$
		$MPCR = 1$ if $n(L^i) = 1$

[12] The ratio of High and Low Types is held constant across all sessions and was chosen to be a (near) equal split, consistent with public goods experiments in fixed, heterogeneous groups. Populations that are homogeneous or that have a more extreme ratio of types might experience greater stability, as the incentives for "chasing" would be muted. However, this is not a question addressed by the current investigation, which focuses on populations with heterogeneous returns.

When the public good is congestible, the most efficient outcome occurs when all High Types and two Low Types locate within a single location and contribute their entire endowment of 25 units each, while avoiding the other two Low Types who locate elsewhere and contribute nothing. When the public good is pure, the most efficient outcome has all High Types and Low Types in a single location, contributing their full endowments. Note that in both the CPG and PPG conditions, no agent has myopic incentive to unilaterally exit a large group in favor of moving to a new location. This is because the payoff an agent receives in a singleton community is equal to 25, which is the same as the minimum payoff that an individual can always achieve by simply retaining his entire endowment, and movement carries a cost. In the CPG condition, however, moving to a new location could pay off in the long-term if other contributors follow. In other words, high contributors could do better by collectively relocating to a group without free-riders. This motivation is eliminated in the PPG condition. Free-riders do not harm the payoffs of their group members and thus no set of agents could do better by collectively exiting the efficient, 9-person group.

The entry fees capture the costs that households face in moving and reinforce the dynamic nature of the game. Further, these costs assume greater importance when agents differ in their public goods returns: Since the Low Types benefit little from public good provision compared to High Types, the entry fees are relatively higher for them, and imply that provision in another community must be far greater than in their own in order for a move to be profitable. More specifically, a Low Type who is considering moving to a low entry fee (5 units) community will recoup the fee only if contributions in the new community exceed those in the current location by 33 units. In contrast, the contributions required for a High Type to recoup the 5 unit fee is 6.25 units in the PPG sessions and between 5 and 14 units in the CPG sessions. The high entry fee locations triple the contributions necessary for agents to recoup the cost of entry, which further widens the gap between High Types and Low Types. Thus the entry fees, and high entry fees in particular, could enable the High Types to avoid the presence of Low Types. Without the existence of entry fees, the inertia in the game would be eliminated and we would expect greater instability.

Finally, we note that the exogenously-assigned MPCR values are not intended to replace subjects' intrinsic or homegrown preferences for cooperation. A large body of experimental work has found that subjects in public goods games differ in their intrinsic willingness to contribute, both unconditionally and in response to the contributions of others. For instance, Fischbacher et al. (2001) use the strategy method to identify approximately half of their participants as "conditional cooperators" who respond positively to contributions of their group members and a third of participants as "free riders" who always contribute nothing. Burlando and Guala (2005) combine this method with three other classification methods and are able to classify roughly a third of participants as free-riders, a third as reciprocators, and a fifth as pure cooperators. In addition to these differences in intrinsic motivation, subjects' contributions are also responsive to MPCR. For instance, Goeree et al. (2002) find that participants tend to respond both to changes in the return that they receive from the public good (suggesting that they are responsive to the cost of contribution) and the returns that others receive (suggesting that they are responsive to the social benefits). Fischbacher et al. (2014) provide a systematic study of heterogeneous responses to heterogeneity

in returns. They find that the conditional contributions of those classified as "conditional cooperators" respond positively to small increases in own MPCR (which varies between 0.3 and 0.5) while those classified as "selfish" tend to contribute nothing over all possible contributions of other members regardless of MPCR or heterogeneity in returns. While the MPCR values of High and Low Types in the current experiment are extreme, and thus expected to substantially influence subjects' behavior, it is important to note that they do not replace or eliminate this intrinsic heterogeneity—just as community members who benefit from a public good may still prefer to free ride and community members who benefit little may still be willing to contribute. The persistent heterogeneity within assigned types could work to dampen observed differences in behavior of types.

2.2 Experimental procedure

Experiments were conducted using the experimental software z-Tree (Fischbacher 2007) in the Laboratory for Experimental Economics and Political Science (EEPS) and the Social Science Experimental Laboratory (SSEL) at the California Institute of Technology and in the Harvard Decision Science Laboratory at the Harvard Kennedy School of Government. Nine subjects interacted in each session, and were paid based on their performance in the game. Nine sessions were conducted in which the public good was pure (non-rivalrous) and nine sessions were conducted in which the public good was congestible. Thus there were 81 subjects in each condition. This paper reports sessions that lasted for 65 periods and so the dataset contains a total of 10,503 subject-periods.[13] It is important to note that, because the subjects interact with the eight others in their session, receive feedback on other players' behavior over the course of the experiment, and experience group sizes that depend on the decisions of others, each subject's behavior cannot be viewed independently. To address this concern, robustness checks are provided, such that every comparison of means reported at the individual-level is also reported at the session-level and regression models are replicated with session-level controls.[14]

In the initial period of each session, the subjects were randomly assigned to three communities of three members each and chose how to allocate their endowment between private and public consumption. In subsequent periods, all six locations were available, and the participants made their decisions in two stages.

[13] One CPG session was dropped because of a technical error, which caused no data to be recorded after the 27th period. One pilot CPG session was conducted that lasted 30 periods. Neither of these are included in the results reported in this paper, but are included in the data set. All of the pure sessions were conducted at Caltech, while the congestion sessions were conducted at both Caltech and Harvard. Every figure and table is reproduced with Caltech-only data in an appendix, available on request, which reveals no substantive changes or loss of significance.

[14] The number of sessions, or populations of interacting participants, in each treatment compares favorably with other work on public goods games with endogenous group formation (e.g. Charness and Yang (2014); Ahn et al. (2008, 2009); Gunnthorsdottir et al. (2007) and Page et al. (2005) have three to seven sessions of interacting subjects per treatment).

Table 1 Summary statistics by condition and type

	Congestible		Pure	
	High Types	Low Types	High Types	Low Types
Observations	45	36	45	36
Contribution	10.89 (0.88)	2.45 (0.57)	10.63 (0.86)	3.21 (0.54)
Proportion moves	0.23 (0.017)	0.15 (0.016)	0.11 (0.014)	0.10 (0.013)
Community size	4.32 (0.11)	4.17 (0.17)	7.15 (0.22)	7.07 (0.27)
Percent efficient relative to Nash	18.7 %		21.2 %	

The individual subject is taken as the unit of observation. Standard errors reported in parentheses

First, the subjects chose whether to stay in their current location or to move to a different location for a fee. While making this choice, they were able to observe the total contributions and number of community members in all locations, as well as their own contributions and returns, in each of the previous three periods.[15] Movement into one of the three original locations incurred the low fee (5 units: equivalent to 20 % of their per-period endowment) while movement into one of the other three locations incurred a much higher fee (15 units: 60 % of their endowment). As shown in Eq. 1, entry fees were subtracted from their payoffs at the end of the period and thus did not restrict contributions.

Once they made their location decisions, the subjects then observed how many others were in their chosen location and made a contribution to that community's public good. Subjects were able to observe only the number of people and the total contributions in the locations, and did not receive any information regarding the location of specific subjects or individual contribution levels.

3 Summary of data and the role of congestion in community stability

In this section, I summarize the role of congestion in community formation, stability, and efficiency. The subsequent sections will consider the voluntary provision of the local public good, movement in response to local provision, and the effect of entry fees. All of the results are presented separately for the CPG and PPG sessions. Table 1 summarizes the data for the two conditions. It provides the average contribution for each of the two types of subjects, the proportion of observations in which the subject moved to a different group, and the average group size experienced by each of the types. It also displays the average efficiency with and without congestion, where efficiency is defined as percent efficiency beyond the myopic Nash outcome in which all players retain their endowment, i.e.: (Realized Payoffs−Nash Payoffs)/(Efficient Payoffs−Nash Payoffs).

[15] Through pilot experiments it was determined that subjects who were provided with the full history never looked back more than two to three periods while choosing their location. Thus the available history was restricted to three periods to reduce clutter and confusion.

First, we see that there is a pronounced difference in how much the two types contribute to the public good. Although contributing nothing is the dominant myopic strategy for both types, the High Types do contribute. The average contribution per period is 10.76 for High Types compared to only 2.83 for Low Types and the difference in contributions of the two types is significant at any reasonable level.[16] This is consistent with previous results showing that MPCR affects contributions.[17] However, there are no significant differences in average contributions between the pure public good and congestible public good sessions ($Z = -0.044$ for High Types and $Z = 1.11$ for Low Types).

While congestion does not appear to influence contributions, it does play an important role in community stability. Movement is frequent in the congestible public good sessions—occurring in over three-quarters of all periods—and does not cease over the course of the experiment. Movement is significantly less common when the public good is pure. Across both types, subjects move in 19.5 % of opportunities in the CPG sessions compared to 10.5 % of opportunities in PPG sessions, suggesting that approximately 46 % of the movement is driven by congestion.[18]

There is also a significant difference in the size of communities that form in the two conditions.[19] Participants in the CPG sessions disperse across locations and there are most commonly three communities in existence. The entire population of subjects resides in a single community during these sessions in less than 4 % of all periods. This contrasts sharply with the pure public good sessions, during which subjects are *most frequently* in a single community.

Despite the incentive in the PPG condition to form a single group, the average community size experienced is significantly less than 9.[20] Further, efficiency is only slightly higher in the PPG sessions than the CPG sessions. While direct comparisons to other studies cannot be made, the low levels of efficiency suggest that free-mobility is less successful than other mechanisms, such as punishment or pre-play communication, in promoting public goods contributions. A session-level inspection of the data reveals that there is a clear dichotomy in the PPG sessions. In roughly half of the PPG sessions (4 out of 9), subjects move more than 15 % of the time (and on average movement is similar to the congestion sessions). In the other sessions, they move as infrequently as 1 % of all opportunities and are in a single community in 74 % of observations.

[16] Taking each subject as the unit of observation, the difference in contributions between the High and Low Types is significant at less than the 0.01 level in both conditions using Wilcoxon rank-sum tests ($Z = 6.39$ for CPG and $Z = 5.91$ for PPG). The differences remain significant at less than the 0.01 level if the session is taken as the unit of observation ($Z = 3.49$ and $Z = 3.4$.)

[17] See for instance: Isaac et al. (1984).

[18] The difference in movement is significant if the unit of observation is the subject ($Z = -5.101$, $p < 0.01$) or the session ($Z = -2.252$, $p = 0.024$).

[19] The average community size experienced by participants in the PPG condition is significantly higher if the subject is taken as the unit of observation ($Z = 9.43$) or if the session is the unit of observation ($Z = 3.4$). The average community sizes of 4 (CPG) or 7 (PPG) group members indicates that the groups formed are, on average, of similar size to those usually formed by experimenters in VCM experiments.

[20] If either the individual or the session is taken as the unit of observation, $p < 0.01$.

There are clearly observable patterns in how these differences arise. At the beginning of each session, subjects typically attempt to create one all-inclusive community, and most participants move into the same location by the sixth or seventh period. In the CPG sessions, contributions decline, subjects exit the community, and after the fifteenth period there are typically at least three populated communities in any period. Occasional renewed attempts to establish larger communities also quickly disintegrate. In the PPG sessions, subjects also exit the all-inclusive community, despite the fact that a strong Nash partition has already been reached and even forward-looking subjects have no incentive to coordinate on a new location. In the frequent-movement PPG sessions, this pioneering participant contributes more (23 in frequent movement sessions vs. 15 in infrequent movement sessions, $p = 0.06$) and is typically followed by others. In the PPG sessions not characterized by frequent movement, this individual typically returns to the original community and the all-inclusive group endures over most periods. Interestingly, this process of exit and re-entry is associated with a spike in contributions in the community. The average community provision level is 49 in the final period before the all-inclusive community breaks up and is 66.5 in the first period in which it has been re-formed.[21] This suggests that temporary exit may be used as a tool to sustain provision. This effect resembles the well-known and robust "restart effect" pattern, in which contributions increase dramatically following a surprise announcement that participants will be playing a new set of periods with the same group members (Andreoni 1988; Croson 1996; Burlando and Hey 1997). The pattern is also consistent with the experimental punishment literature, which finds that subjects are often willing to sacrifice their own payoffs in order to harm those who are not contributing and that subjects who have been punished respond by increasing their contributions.

4 Provision of the public good

First, we consider overall provision of the public good at the local, community level. Table 2 reports estimates of a regression of community provision (*total contributions* made by all residents) on the number of residents of each type along with the number of periods that the community has been continuously populated (unpopulated locations are not included).[22] Regressions are run separately for the congestible public goods and pure public goods sessions. We see that the presence of High Types has a large positive effect on community provision. This is the case in both the congestible and pure public goods sessions. The presence of Low Types has a smaller effect, which is insignificantly positive in the PPG sessions and actually negative in the CPG sessions. We also see that provision declines over the length of time that the community has been populated in both the CPG and PPG sessions. At the local level, total contributions therefore exhibit the same classic decline found in fixed-group public goods experiments (Ledyard 1995).

The difference in contribution behavior for the two types extends beyond the magnitude of contribution, to *when* they contribute. Figure 1 shows the average contribution

[21] This difference is significant at $p < 0.05$ ($Z = -1.977$).

[22] Neither the sign nor significance of any estimates change if session-level random effects are included.

Table 2 Regression of provision on community features

	(1) CPG	(2) PPG
Number of High Types	9.388*** (0.353)	12.06*** (0.454)
Number of Low Types	−0.978** (0.475)	0.759 (0.643)
Time populated	−0.315*** (0.0245)	−0.0956** (0.0402)
Constant	14.51*** (0.776)	3.712*** (1.031)
Observations	1826	1057
Adjusted R^2	0.446	0.559

Standard errors in parentheses. Dependent variable is the total contributions in the community
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

over time for each type. First, we see that the contributions of Low Types decline significantly over the course of the experiment and, in the CPG sessions, approach zero.[23] In contrast, the contributions of the High Types are sustained for the duration of the experiment. In fact, in both conditions, 42 % of High Types actually increase their contributions from the initial periods to the final periods.

We next look at how subjects' contributions vary over community size. While community size is not randomly assigned and we cannot conclude that group size affects contribution level, learning how individuals contribute in different communities is still an essential piece of the community dynamics story. First, the contributions of High Types decline over community size when the public good is congestible. This is not surprising, since the High Types in these sessions receive lower returns from public good provision in larger communities and we have already observed that the subjects' contributions are responsive to MPCR. However, communities may also experience *behavioral* congestion: Collective action problems would cause both types of agents, in both conditions, to contribute less in larger communities. In fact, High Types' contributions also decline over community size in the PPG sessions, when MPCR is constant. High Types' contributions are negatively correlated with community size in both types of sessions ($p = 0.01$ for each treatment including individual fixed effects). In contrast, contributions of Low Types actually *increase* over community size.[24] Low Type contributions are positively correlated with community size in both the congestion and pure public good sessions, and both are significant at the 0.01 level.

5 Movement in response to public good provision

I next analyze the extent to which movement is influenced by local public good provision for each of the two types of agents. While the voluntary contribution mechanism differs from the environment considered by Tiebout and the incentives for location

[23] The decrease in contribution over time is significant for Low Types with individual fixed effects in both the CPG ($p < 0.01$) and PPG ($p = 0.06$) sessions.

[24] These patterns are broadly consistent with the findings of Isaac et al. (1994) that participants with low MPCR (in homogeneous groups) respond positively to group size.

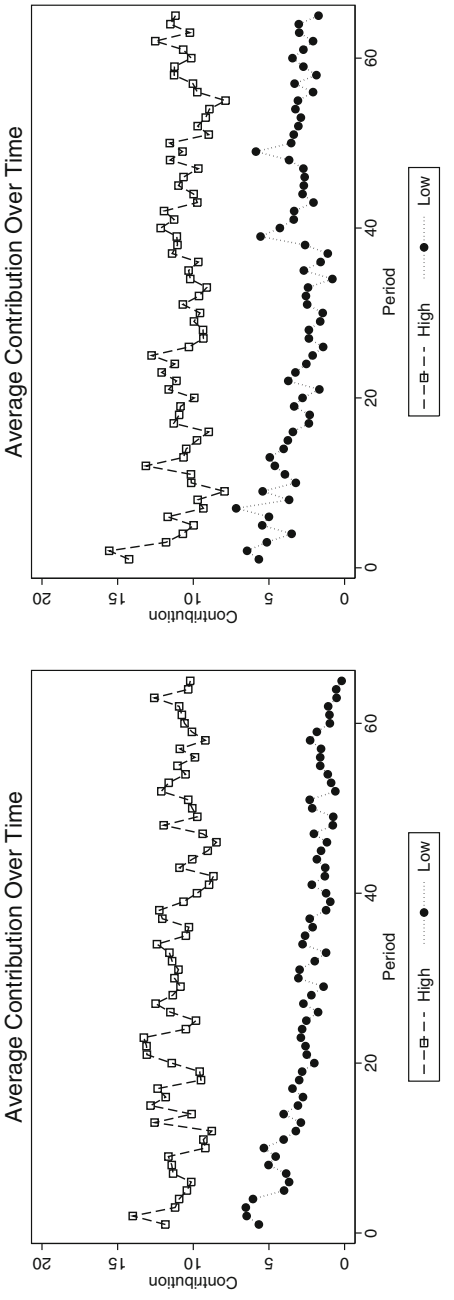

Fig. 1 Average contribution over time in congestible (*left*) and pure (*right*) sessions

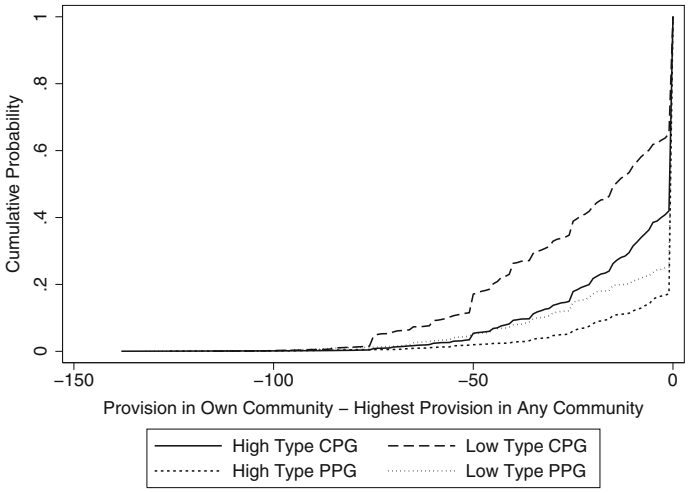

Fig. 2 Probability that subjects are in a community with inferior provision levels

choice are very different in this game, movement in response to variation in local provision history does provide support for Tiebout's fundamental premise. The results described in this section strongly suggest that subjects move in response to provision and, further, that this movement is greatly shaped by their returns from provision.

First, subjects are most frequently in the community with the highest provision level and typically move if there is a community with vastly higher public good provision than in their own. Figure 2 presents cumulative distribution functions for subjects of each type in both the CPG and PPG sessions. The horizontal axis shows the discrepancy between the total contributions in the subject's location and those in the location with the highest total contributions.

The likelihood that subjects are in an inferior community depends on the magnitude of the difference in provision levels. Subjects are in the community with the highest total provision 47.8 % of the time in the congestion sessions and 79.2 % of the time in the no congestion sessions. This suggests that multiple populated communities can persist only if they offer similar provision levels. High Types have a much lower threshold for exit than Low Types and, though in similarly sized communities, High Types experience higher provision levels than Low Types. Figure 2 clearly shows that High Types are more likely to be in the community with the highest provision level than the Low Types are, suggesting that the entry fees do generate some sorting.

Figure 3 presents the provision levels and sizes of the communities entered and exited for each preference type and each condition. The darker gray bars show the average provision and population size in the community *exited* (not including the subjects themselves or their own personal contributions) and the lighter gray bars show the average provision and population size in the community *entered* (based on the outcomes in the previous period, which is the information the subjects had while making their movement decisions).

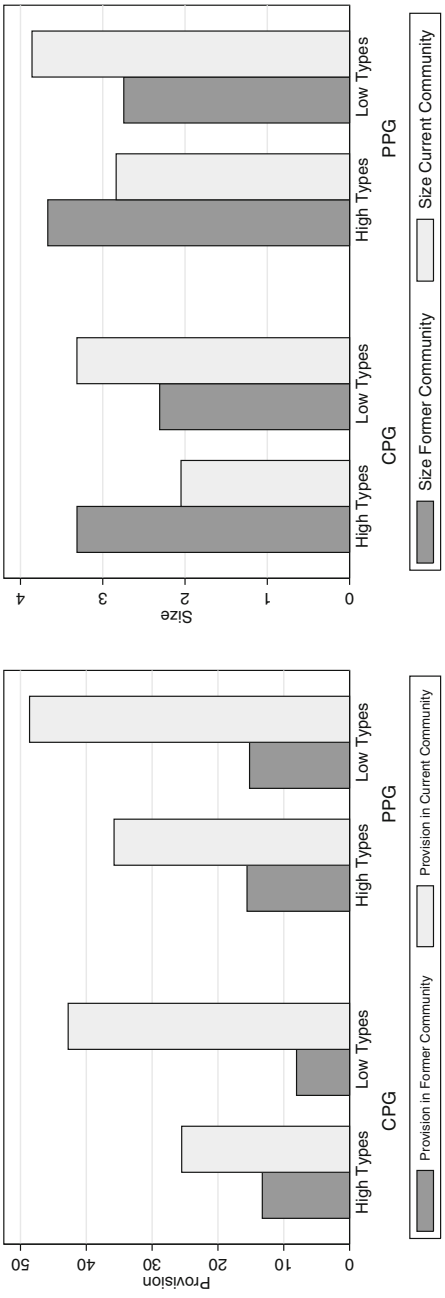

Fig. 3 Features of communities entered and exited

While both High Types and Low Types tend to exit communities where the others are contributing little in favor of communities with much higher provision levels, the average provision in the community entered is much greater for the Low Types. This is shown in the left panel of Fig. 3. The first thing to note is that the provision level in the exited community is significantly lower than in the entered community for both types in both conditions. Second, this difference is smaller for the High Types, further suggesting that they have a lower threshold for movement. In the CPG sessions, the High Types who move enter communities with a previous provision of 25.5 while Low Types move into communities with a previous provision of 42.7. This difference is similar in the PPG sessions: The communities entered by High Types have an average previous provision of 35.8 while the communities entered by Low Types have an average previous provision of 48.6.[25] This suggests that entry fees do deter Low Types from moving into higher performing communities unless these communities offer substantially greater provision.

In addition to differing in their responsiveness to public good provision, the two types also respond very differently to community size and membership. The right panel of Fig. 3 shows that the two preference types exhibit opposing patterns of movement based on community size. While Low Types exit smaller communities in favor of larger ones, High Types actually tend to exit very large communities and enter small communities. This pattern holds in both the congestible and the pure public goods sessions, in which the presence of others does not diminish the payoffs of the High Types.[26]

The High Types are also much more likely to *pioneer* communities, by moving into previously empty locations. In the congestion sessions, 128 of the 145 pioneers are High Types and, in the pure public goods sessions, 54 of the 73 pioneers are High Types. Given that we observe High Types entering smaller communities than the Low Types do, it is important to note that this difference in community size is not driving the result that High Types have lower thresholds for movement (by dragging down the average provision of the community entered). The pattern depicted in the left panel of Fig. 3 holds even if we exclude those subjects who move into previously empty locations or locations with provision lower than in their former community.

In summary, we have thus far seen that the High Types provide the public good and that they are more responsive to differences in local provision, but they also respond to differences in per-capita provision and are willing to exit populated communities in favor of previously empty locations. When these results are considered together,

[25] The difference between types in the provision of the community entered is significant at $p < 0.01$ in both the CPG and PPG sessions in Wilcoxon rank-sum tests, taking the individual subject's average outcome over the session as the unit of observation. If session-level random effects are included the PPG sessions are different only at the $p = 0.03$ level and, if the session is taken as the unit of observation, $p = 0.14$. The difference remains significant at $p < 0.01$ in the CPG sessions.

[26] The individual subject is the unit of observation and the variable considered is the difference in the size of the community entered vs. exited (not including the individual moving). The difference between types is significant at the $p < 0.01$ level in the CPG ($Z = -5.36$) and PPG ($Z = -3.38$) conditions. The difference is significant at the $p < 0.01$ in both conditions if session-level random effects are included. If the session-type is the unit of observation, the difference is significant at the $p < 0.01$ level in the CPG condition ($Z = -3.57$) and at the $p = 0.07$ level in the PPG condition ($Z = -1.81$).

a clear dynamic emerges in which the Low Types continually chase the High Types through locations, a pattern that never ceases or slows over the course of experimental sessions. The High Types enter previously empty locations at an immediate cost to themselves and contribute once they are there. They are then joined by fellow High Types and provision peaks. The Low Types follow as soon as this new community greatly surpasses their own, provision levels decline, and the High Types exit once again.

The dynamics of community composition are shown in the probit regressions presented in Tables 3 (for High Types) and 4 (for Low Types). These models estimate the likelihood that a subject resides in a location using the number of (other) High Types present in the previous period, the number of (other) Low Types present in the previous period, the change in the number of (other) High Types in the previous period, and the change in the number of (other) Low Types in the previous period, along with dummy variables for whether the subject was in that location in the previous period and whether the location has a high entry fee. These results show that both High and Low Types are more likely to be in a community where High Types resided in the previous period, as well as where there was a previous *influx* of High Types. Additionally, the presence and, especially, influx of Low Types have negative effects on the likelihood of High Types being in the community in the subsequent period. These patterns are remarkably similar for both the congestible and the pure public good sessions.

Finally, I consider whether movement in the congestible and pure public goods sessions may be considered a best response. Subjects who move tend to select the community in which they would have done the best in the previous period. However, the question remains whether such movement is, in fact, profitable. Though it is impossible to construct a perfect counterfactual for their continuation payoffs had they not moved, this question may be analyzed through a couple of other approaches.

First, I consider the immediate effect of movement on subjects' earnings. Table 5 gives fixed effect regression estimates of each subject's public good returns on the decision to move, along with the size of the community entered, and the subject's personal contribution. The first two columns show that movement is associated with slightly higher public good returns in the period that the subject moves. The third and fourth columns present estimates of the same model with the entry fee subtracted from public good returns. We see that, once the entry fees are accounted for, movement is associated with an immediate loss of 5.7 units in the CPG sessions and 5.1 units in the PPG sessions. Thus, while the subjects tend to better their location by moving, the difference is not great enough to immediately recoup the entry fees.

This, however, does not necessarily imply that the move does not increase the subject's payoffs over multiple periods, and so it is important to also consider the effect of movement on overall earnings for the experiment. Table 6 gives regression estimates of each subject's total profits on the total number of times he moves during the experiment as well as his average contribution. When the public good is congestible, frequent movement is associated with only slightly higher earnings for both types. Additionally, there is only a small, statistically insignificant earnings advantage for those who "chase" rather than pioneer and develop new communities, controlling for contributions. Conversely, frequent movers of both types tend to earn *lower* payoffs in the pure public good setting. This effect is particularly large for the High Types: a single

Table 3 Community composition dynamics: probit of High Type currently in community on the previous community composition (marginal effects reported)

	(1) CPG	(2) CPG	(3) PPG	(4) PPG
Number of other highs (t−1)	0.322*** (0.0449)	0.292*** (0.0412)	0.579*** (0.0788)	0.440*** (0.0534)
Number of lows (t−1)	−0.157** (0.0722)	−0.101* (0.0548)	−0.211*** (0.0561)	−0.0593 (0.0453)
High entry fee location	−0.363*** (0.110)	−0.322*** (0.111)	−0.536*** (0.0765)	−0.453*** (0.0926)
In Community (t−1)	2.139*** (0.150)	2.182*** (0.145)	2.330*** (0.121)	2.424*** (0.104)
Number of other highs (t−1) − number of other highs (t−2)		0.142*** (0.0415)		0.404*** (0.0905)
Number of lows (t−1)− number of lows (t-2)		−0.165*** (0.0567)		−0.284*** (0.0687)
Constant	−1.638*** (0.0549)	−1.685*** (0.0550)	−2.013*** (0.138)	−2.083*** (0.131)
Observations	17280	17010	17280	17010
Pseudo R^2	0.483	0.487	0.737	0.748

Standard errors in parentheses. Standard errors clustered at session level
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4 Community composition dynamics: probit of Low Type currently in community on the previous community composition (marginal effects reported)

	(1) CPG	(2) CPG	(3) PPG	(4) PPG
Number of highs (t−1)	0.310*** (0.0540)	0.212*** (0.0589)	0.495*** (0.0607)	0.388*** (0.0517)
Number of other lows (t−1)	−0.0539 (0.146)	0.0287 (0.143)	−0.152*** (0.0403)	−0.0470 (0.0402)
High entry fee location	−0.548*** (0.123)	−0.493*** (0.118)	−0.650*** (0.0528)	−0.604*** (0.0436)
In community (t−1)	2.711*** (0.242)	2.900*** (0.262)	2.364*** (0.207)	2.601*** (0.268)
Number of Highs (t−1)− number of highs (t−2)		0.317*** (0.0515)		0.282*** (0.0935)
Number of Other Lows (t−1)− number of other lows (t−2)		0.0386 (0.0689)		0.00484 (0.104)
Constant	−2.000*** (0.0996)	−2.032*** (0.113)	−2.183*** (0.137)	−2.219*** (0.146)
Observations	13824	13608	13824	13608
Pseudo R^2	0.650	0.665	0.790	0.802

Standard errors in parentheses. Standard errors clustered at session level
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5 Fixed effects regressions of public good returns on movement and features of the new community

	(1) CPG	(2) PPG	(3) CPG	(4) PPG
Move	1.672*** (0.329)	1.175* (0.624)	−5.739*** (0.330)	−5.089*** (0.624)
Community size	0.758*** (0.0622)	3.172*** (0.0884)	0.797*** (0.0625)	3.214*** (0.0884)
Contribution	0.957*** (0.0188)	0.753*** (0.0274)	0.941*** (0.0189)	0.749*** (0.0274)
Constant	3.704*** (0.347)	−1.531** (0.710)	3.632*** (0.349)	−1.806** (0.710)
Observations	5265	5265	5265	5265
Adjusted R^2	0.332	0.252	0.326	0.271

Standard errors in parentheses. Includes subject fixed effects. Dependent variable in (1) and (2) is return from public good. Dependent variable in (3) and (4) is return from public good less entry fee
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 OLS Regression of total profits on number of moves

	(1) CPG High Type	(2) CPG Low Type	(3) PPG High Type	(4) PPG Low Type
Moves	6.127 (5.790)	3.119 (2.450)	−92.17*** (14.39)	−26.75*** (5.648)
Average contribution	4.071 (7.656)	−50.99*** (3.310)	−20.62 (17.76)	−38.45*** (7.982)
Constant	2147.9*** (96.24)	1711.8*** (28.41)	4527.0*** (301.9)	2151.0*** (60.11)
Observations	45	36	45	36
Adjusted R^2	−0.000	0.785	0.346	0.530

Standard errors in parentheses. Dependent variable is the participant's total earnings
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

additional move is associated with a lower payoff of 92 units—nearly quadruple the subject's single period endowment and double the typical per-period earnings. This is strong evidence that movement is not a successful strategy for achieving higher provision when the public good is pure, and that frequent movement is not driven by payoff-based incentives.

6 Entry fees

Finally, I consider the extent to which entry fees promote separation by type and local provision. Locations with differing entry fees can facilitate coordinated congestion avoidance. Since Low Types receive only a 15 % return from the public good, best responders should move into a low entry fee community only if the difference in expected contributions between the new community and their current community is greater than 33. However, when the cost of entering is three times as great, the difference in contributions must be greater than 100 units for the Low Types to recoup the entry fee.

In CPG sessions, high entry fee locations are entered primarily by High Types and average contribution levels are much higher there. High Types account for approximately 75 % of the movement into the high entry fee locations. Contributions in these communities are more than double the contributions in the low entry fee locations and total provision is also higher.[27]

However, these communities are no more stable than the low entry fee communities and neither their population nor their provision levels are sustained for any longer. Thus, even when the High Types are able to successfully coordinate and separate, provision levels cannot be maintained and the free-riding and chronic relocation problems persist.

In the PPG sessions, high entry fee locations are entered less frequently. The Low Types are just as likely to enter as are the High Types and, while average contributions are higher in the high entry fee locations, total provision levels are lower. While subjects are in high entry fee locations 22.2 % of the time in the CPG sessions, they are in these locations only 6.7 % of the time when the public good is pure. Although average contributions in PPG sessions are slightly higher in the high entry fee locations, the average population is less than half that in other populated communities, and the total provision levels do not rival those in the low entry fee locations.

7 Conclusion

The pattern of those who impose negative externalities perpetually chasing those who impose positive externalities is a fundamental dynamic of community development and group formation.

This dynamic is borne out in the local neighborhoods of many cities, as artists and others with strong preferences for cultural and aesthetic amenities enter and rejuvenate commercial or depressed areas, only to attract further gentrification and eventually find themselves priced out of their new homes. Similarly, trendsetters are forever on the run from both conformists and marketers. Karni and Schmeidler (1990), for instance, show that social consumption preferences can lead to the cyclical nature of fads. Finally, the dynamic of chasing has also been observed in social dilemmas games, in which cooperators tend to be the first to exit uncooperative groups or partnerships and will be followed by free-riders in the absence of strict boundary rules (Ehrhart and Keser 1999; Ahn et al. 2008, 2009).

In the experiments reported in this paper, I find clear evidence of this pattern in a population of agents with heterogeneous returns from public good consumption, even when those responsible for the congestion receive little benefit from movement and locating near others, and when there are significant barriers to entry. Further, while sensitivity to congestion does drive a portion of the flight from crowded locations, the dynamic often persists in the absence of payoff congestion. Movement continues even

[27] At the individual level, the average contribution made by a participant in a high entry fee location is 11.7, compared to 5.8 in low fee locations. The effect of entry fee type on average contribution is significant at the $p < 0.01$ level (with each individual as the unit of observation and accounting for session effects) and holds even controlling for type. At the community level, average provision is 31 in populated high fee locations compared to 17.2 in other populated locations ($p < 0.01$ with session-level controls).

after a strong Nash stable partition has been reached and forward-looking agents have no incentive to coordinate on another location.

This suggests that this chasing dynamic is fundamental and intrinsic, rather than driven purely by congestion or payoff-based incentives. Even when efficiency would have a society pooling its resources into a single community, resentment or unwillingness to be around free-riders suggests that achieving stable groups and communities may be dependent on requiring equal contributions from all members.

The experiments reported in this paper demonstrate patterns of movement driven by subjects' assigned returns from public good provision that resemble those observed in real neighborhoods. Subjects with high values for public goods enter unoccupied locations and provide a local public good. They are joined by others with high values, and, eventually, by those who benefit little and do not contribute. The high value residents then exit once again in favor of less populated locations. The perpetual movement of the pioneering subjects is only partially driven by crowding, suggesting that community instability may also be attributed to an intrinsic unwillingness to provide for those who do not contribute themselves.

References

Ahn TK, Issac RM, Salmon T (2008) Endogenous group formation. J Public Econ Theory 10(2):171–194

Ahn TK, Issac RM, Salmon T (2009) Coming and going: experiments on endogenous group size for excludable public goods. J Public Econ 93:336–351

Andreoni J (1988) Why free ride? Strategies and learning in public goods experiments. J Public Econ 37:291–304

Bohnet I, Kübler D (2005) Compensating the cooperators: is sorting in the prisoner's dilemma possible? J Econ Behav Organ 56(1):61–76

Brekke KA, Hauge KE, Lind JT, Nyborg K (2011) Playing with the good guys: a public good game with endogenous group formation. J Public Econ 95(9):1111–1118

Burlando R, Guala F (2005) Heterogeneous agents in public goods experiments. Exp Econ 8(1):35–54

Burlando R, Hey JD (1997) Do Anglo-Saxons free-ride more? J Public Econ 64:41–60

Cabrera S, Fatas E, Lacomba J, Neugebauer T (2012) Splitting leagues: promotion and demotion in contribution-based regrouping experiments. Exp Econ 16(3):1–16

Chaudhuri A (2011) Sustaining cooperation in laboratory public goods experiments: a selective survey of the literature. Exp Econ 14(1):47–83

Charness G, Yang C-L (2014) Starting small toward voluntary formation of efficient large groups in public goods provision. J Econ Behav Organ 102:119–132

Cinyabugma M, Page T, Putterman L (2005) Cooperation under the threat of expulsion in a public goods experiment. J Public Econ 89(8):1421–1435

Cole DB (1987) Artists and urban redevelopment. Geogr Rev 77(4):391–407

Croson R (1996) Partners and strangers revisited. Econ Lett 53:25–32

Donahue J (1997) Tiebout? Or not tiebout? The market metaphor and America's devolution debate. J Econ Perspect 11(4):73–81

Ehrhart K-M, Keser C (1999) Mobility and cooperation: on the run. Working Paper

Fisher J, Isaac RM, Schatzberg JW, Walker JM (1995) Heterogeneous demand for public goods: effects on the voluntary contributions mechanism. Public Choice 85:249–266

Fischbacher U (2007) z-Tree: Zurich toolbox for ready-made economic experiments. Exp Econ 10(2):171–178

Fischbacher U, Gächter S, Fehr E (2001) Are people conditionally cooperative? Evidence from a public goods experiment. Econ Lett 71:397–404

Fischbacher U, Schudy S, Teyssier S (2014) Heterogeneous reactions to heterogeneity in returns from public goods. Social Choice Welf 43:195–217

Fellner G, Iida Y, Kröger S, Seki E (2011) Heterogeneous productivity in voluntary public good provision: an experimental analysis. IZA Discussion Paper, 5556
Florida R, Melander C (2007) There goes the metro: How and Why Bohemians, Artists, and Gays Affect Regional Housing Values. J Econ Geogr 10(2):167–188
Gächter S, Thöni C (2005) Social learning and voluntary cooperation among like-minded people. J Eur Econ Assoc 3(2–3):303–314
Goeree JK, Holt CA, Laury SK (2002) Private costs and public benefits: unraveling the effects of altruism and noisy behavior. J Public Econ 83:255–276
Gunnthorsdottir A, Houser D, McCabe K (2007) Disposition, history and contributions in public goods experiments. J Econ Behav Organ 62:304–315
Gunnthorsdottir A, Vragov R, Seifert S, McCabe K (2010) Near-efficient equilibria in contribution-based competitive grouping. J Public Econ 94:987–994
Gürerk Ö, Irlenbusch B, Rockenbach B (2006) The competitive advantage of sanctioning institutions. Science 312:108–111
Hamilton BW (1975) Zoning and property taxation in a system of local governments. Urban Stud 12:205–211
Hudson JR (1980) Revitalization of inner-city neighborhoods: an ecological approach. Urban Aff Rev 15(4):397–408
Hudson JR (1988) Pioneer artists and middle class settlers: lifestyle variables and neighborhood succession. J Family Econ Issues 9(3):250–267
Isaac RM, Walker JM, Thomas S (1984) Divergent evidence on free riding: an experimental examination of some possible explanations. Public Choice 43(2):113–149
Isaac RM, Walker J, Williams AW (1994) Group size and the voluntary provision of public goods: experimental evidence utilizing large groups. J Public Econ 54:1–36
Karni E, Schmeidler D (1990) Fixed preferences and changing tastes. Am Econ Rev 20:262–267
Ledyard J (1995) Public Goods: A Survey of Experimental Research. In: Roth AE, Kagel J (eds) The Handbook of Experimental Economics. Princeton University Press, Princeton
Ley D (2003) Artists, aestheticisation and the field of gentrification. Urban Stud 40:2527–2544
Musgrave RA (1939) The voluntary exchange theory of public economy. Q J Econ 53:213–237
Ockenfels A, Weimann J (1999) Types and patterns: an experimental east-west-german comparison of cooperation and solidarity. J Public Econ 71:275–287
Ones U, Putterman L (2007) The ecology of collective action: a public goods and sanctions experiment with controlled group formation. J Econ Behav Organ 62:495–521
Ostrom E (2000) Collective action and the evolution of social norms. J Econ Perspect 14(3):137–158
Page T, Putterman L, Unel B (2005) Voluntary association in public goods experiments: reciprocity, mimicry and efficiency. Econ J, Royal Econ Soc 115(506):1032–1053
Pesendorfer W (1995) Design innovations and fashion cycles. Am Econ Rev 85(4):771–792
Reuben E, Riedl A (2013) Enforcement of contribution norms in public good games with heterogeneous populations. Games Econ Behav 77:122–137
Rigdon M, McCabe K, Smith V (2007) Sustaining cooperation in trust games. Econ J 117:991–1007
Robbett A (2014) Local institutions and the dynamics of community sorting. Am Econ J: Microecon 6:1–22
Samuelson PA (1954) The pure theory of public expenditure. Rev Econ Stat 36:387–389
Tiebout CM (1956) A pure theory of local expenditures. J Political Econ 64:416–424
Wilson JD (1998) Imperfect solutions to the musical suburbs problem. In: Pines D, Sadka E, Zilcha I (eds) Topics in public economics: theoretical and applied analysis. Cambridge University Press, Cambridge, UK
Yang C-L, Yu C-SJ, Yue I-T (2007) The rise of cooperation in correlated matching prisoners dilemma: an experiment. Exp Econ 10:3–20