Clubs

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1 Origins

The word "club" is used colloquially for social interactions. The word has a deceptively frivolous connotation, as does the word "game." But, like game theory, club theory has wide reach. The word "club" is used in economics to refer to a small group of people sharing an activity, often in a context where they care about each other's characteristics. Its usage has expanded to include such fundamental interactions among humans as production of private goods, production of services such as education, and community life. The formation of firms, choice of schools and choice of games to play are all covered by club theory, as are social arrangements like marriage.

The word entered the economics literature with a seminal (1965) paper of James Buchanan, who used the concept of a club to describe a group of people sharing a public good. The key idea he introduced was that public goods are often subject to congestion, and in that sense, exhibit some of the rivalness of private goods. As a consequence, it may be more efficient to replicate a public facility for different (small) groups of users rather than to bear the congestion cost imposed by many people using the same facility. As we will see, club theory has subsequently developed to focus more on interactions among the members of a group, in particular, firms, than on the facilities they share, but both aspects are important.

Buchanan's idea resonated with a paper of Tiebout (1956), who argued that "local public goods" would be provided optimally if agents were free to choose among jurisdictions. Tiebout's idea was that residents would sort among jurisdictions according to shared preferences for the public services that are provided there. If jurisdictions are relatively small, there should be enough jurisdictions and jurisdictional variety to satisfy most residents.

These papers led to the conjecture, pursued by a long list of scholars (see Scotchmer (2002)), that competition should provide for optimal group formation. This was essentially by analogy to other market contexts where demand and supply equilibrate at prices that support an efficient allocation, provided all the actors, including firms, are small relative to the market. Allowing for group formation is a powerful extension of competitive theory, since groups have features that do not fit easily into the general equilibrium theory of Kenneth Arrow, Gerard Debreu and their successors. Such features include externalities among agents, learning of skills, and shared consumption of private goods, whether through rental markets or informal arrangements.

The research agenda surrounding clubs has only recently produced the modifications to general equilibrium theory that accommodate group formation. Along the way, it has been necessary to sort out competing equilibrium concepts, and the difference between models of pure group formation, for which I will use the word "clubs," and models of group formation where membership in the group is coupled to occupancy of land. For the latter, I will use the term "local public goods."

The distinction between clubs and local public goods is the focus of Scotchmer (2002), so I will not focus on it here. Local public goods economies differ fundamentally from club economies in that access to local public goods is intermediated by a land market. Agents form groups by jointly choosing (i) a jurisdiction and (ii) land consumption. Residency in a jurisdiction (occupancy of land) gives access to the public goods and services provided there, including the externalities received from other members of the jurisdiction. Not only is the consumption of land bundled with local amenities, but the local public services of many different decision makers (states, counties, water districts, school districts) are also bundled together.[1]

Because of the bundling and because the land in each jurisdiction is fixed, the price of land can capitalize the value of local public goods received there and taxes paid there, in the sense that any revision of them will change the price of land. If the capitalized value of the local public goods and taxes is high (because residents value them more than those supplied elsewhere), agents will economize on their occupancy of space, which still gives them the same access to the local public goods. The price of land has two important functions: through the capitalization, it can signal the value that agents place on its local public goods policies, and through the land market, it governs the number of residents.

[1]In a trivial sense, consumption of land can be decoupled from consumption of local public amenities if one assumes that land is fungible among jurisdictions, and is either a fungible input to a "club" or a fungible private good consumed by the agent. The decoupling is unsatisfactory both because the world is not organized that way – this author cannot secede from Berkeley to join San Francisco without giving up her relatively cheap Berkeley land –and because such a model misses the implications of the second type of bundling.

In a local public goods economy, there are many possibilities for how to define a commodity space and price system, none entirely satisfying. The possibilities are more limited in the club model, where there is no land market that mediates access to groups, and there is only one set of prices. Nevertheless, there are many nuances in adapting general equilibrium theory to accommodate group formation, which I now explore.

2 Clubs (Groups) in General Equilibrium

Key features of a competitive equilibrium are that (i) the commodity space is defined independently of the set of agents, (ii) the price system is complete with respect to the set of commodities, (iii) prices are anonymous, and (iv) agents optimize with respect to the price system, but not by observing other agents' preferences or endowments.[2] A convincing general theory should not put unreasonable restrictions on agents' tastes or consumption sets, should allow that memberships in groups affect demand for private goods and vice versa, and should allow agents to belong to several groups simultaneously.[3] For example, if schools and firms are both modeled as groups, then an agent might have to belong to a school as a student, in order to later belong to a firm as a worker with the requisite skills.

There have been two approaches to putting clubs into general equilibrium theory, which I will refer to as the EGSSZ approach[4] and the CPPT approach.[5] To be concrete, I will mainly use the EGSSZ model, and then show how it relates to the

[2]Early discussions of price-taking equilibrium missed various of these requirements. For example, in analyses that use the "core" equilibrium concept from game theory, following Pauly (1967), the commodity space is often defined as the set of groups (coalitions) that are feasible in the economy, even when decentralizing with prices. The commodity space then depends on who is in the economy.

[3]Three restrictive assumptions of earlier papers discussed in Scotchmer (2002) are that there is a single private good, that agents' tastes come from a finite set of "types" (sometimes one type), and that agents can belong to only one group. The trading of private goods is key because the demand for group memberships may depend on private-goods prices (and vice versa). Restricting agents to a single membership is a legacy of the discarded analogy with local public goods economies. That restriction was convenient for constructing equilibrium prices based on willingness to pay, but is discarded in the work referenced here, since it is very cumbersome where agents can have several memberships. The work referenced here relies on fixed points.

[4]Ellickson, Grodal, Scotchmer and Zame (1999, 2001, 2005), which I will refer to as EGSZ, Scotchmer (2005), Zame (2005), Scotchmer and Shannon (2006).

[5]Cole and Prescott (1997) and Prescott and Townsend (2006).

CPPT model.

Following, in particular, EGSZ (1999,2005), the commodity space begins with an exogenously given set of *group types.* A group type specifies a finite set of memberships, activities that the members engage in, and an input/output vector of private goods. The memberships may have requirements attached to them, such as to be smart or brawny, or to have skills such as the ability to write computer code. These are called by EGSZ (2005) *membership characteristics.* A given membership may or may not be available to an agent in his consumption set, and if it is, qualification for the membership may be innate or require investments.

More formally, let $\mathbf{G}$ be a finite set of group types, and for each $g \in \mathbf{G}$, let $\mathbf{M}(g)$ be a set of memberships. Each membership has attached to it a membership characteristic, but we do not need notation for this characteristic, which can be identified with the membership itself, $m \in \mathbf{M}(g)$.[6] The definition of the group type also specifies its activities, and an input/output vector, say $h(g) \in \mathbf{R}^N$.[7] Some group types do not require any inputs or produce any outputs; some require only inputs; and some (firms) may require inputs to produce outputs. Labor in a firm is not modeled as an input, but rather as a group membership for which skills or other characteristics may be required.

It is convenient to assume that a group's required input/output vector is distributed among members of the group. Thus, each group also has associated to it a transfer function $t_g : \mathbf{M}(g) \rightarrow \mathbf{R}^N$ such that $\sum_{m \in \mathbf{M}(g)} t_g(m) = h(g)$. This specifies the member's share of h, which may have positive and negative elements. Unless used for incentive purposes as in the papers referenced in section 4 below, the transfer

[6] Characteristics are defined as part of the membership, and not necessarily attached to the agent. Whether the agent can choose a given membership depends on whether he is innately endowed with the characteristic required for it, or alternatively whether he can acquire it. EGSZ (1999,2001) assumed that each agent is or is not innately equipped for any given membership, but if not, cannot become so. The same theorems and proofs apply to the generalization in EGSZ (2005), followed in this section.

[7] In EGSZ (1999, 2001, 2005), the characteristics are elements of a set Ω, and the group type specifies how many members with each characteristic are present. The activity of the group is defined by some element γ in a finite set Γ. The simpler notation used here is equivalent, although less descriptive. If the group needs several members with the same characteristic, then the same characteristic can be embodied in several distinct memberships, rather than, as in the EGSZ papers, allowing several memberships of the same description.

function t can largely be arbitrary, since any maldistribution can be remedied through membership prices, which are endogenous.

There is a continuum of agents, say, $a \in [0,1]$. Agents have utility functions, endowments of private goods and consumption sets. The utility functions can be written $u_a(x_a, \mu_a)$, where $x \in \mathbf{R}_+^N$ is consumption of private goods and μ_a is a list of memberships, $\mu_a : \cup_{g \in \mathbf{G}} \mathbf{M}(g) \to \{0,1\}$, where $\mu_a(m) = 1$ if the agent chooses membership m, hence belongs to the group g such that $m \in \mathbf{M}(g)$. Agents' consumption sets determine which memberships are available to them. For example, an agent's consumption set would presumably not permit both a membership in a sumo wrestling club and a membership in a ballet club, since those require different innate characteristics. Consumption sets play a much larger role in club theory than in private-goods economies. Some memberships may not be available to a given agent at all, regardless of what other memberships he chooses or what private goods he invests.

Informally, an equilibrium consists of private-goods prices $p \in \mathbf{R}_+^N$ and membership prices $q : \cup_{g \in \mathbf{G}} \mathbf{M}(g) \to \mathbf{R}$ such that each agent is in his budget set and optimizing, supply equals demand for private goods, and group membership choices are consistent in a sense we will make clear.[8] Group membership prices are constrained to satisfy budget balance within each group type $g \in \mathbf{G}$:[9]

$$\sum_{m \in \mathbf{M}(g)} q(m) = 0$$

The prices q facilitate transfers among agents according to scarcities. Some members (those who choose memberships with positive prices) pay others (those with negative prices). Intuitively, some members are paid because they create positive externalities or production opportunities for the members who pay. If, for example, there is a

[8]All the nuances of general equilibrium theory appear here, such as the distinction between quasi-equilibrium and equilibrium. The technical difficulties in going from quasi-equilibrium to equilibrium are exacerbated by group formation, since, for example, the group can exhaust the private goods available to the members, who are then in the zero-wealth position. See Gilles and Scotchmer (1997), example 3.

[9]The prices for memberships are determined in equilibrium, whereas the internal transfers t are fixed, and part of the definition of the group. In examples with no uncertainty in the input/output vector, which is what we have so far considered, the prices q could equally well sum to the value of the input/output vector, and transfers t would be unnecessary. However the papers referenced in section 4 need particular internal transfers for incentive purposes.

membership that only a few agents are equipped to fill, or if it is costly to acquire the required skills (membership characteristics), then that membership price may be negative; the member will be paid to belong to the group.

A continuum of agents is necessary to ensure that membership choices are consistent in the sense that there are (almost) no partially filled groups. Membership choices are *consistent* if there exist nonnegative real numbers $\alpha(g)$, $g \in \mathbf{G}$, such that for every $m \in \mathbf{M}(g)$

$$\int_A \mu_a(m) = \alpha(g)$$

Due to the continuum, each group has measure zero in the economy. Without the continuum, consistent choices might be impossible. The fixed point in the EGSZ (1999) proof of existence delivers prices such that membership choices are consistent. There is no analogous consistency condition for private-goods exchange economies. Consistency of memberships is the main technical difficulty in accommodating groups in general equilibrium theory.

I now give two informal examples of how club theory expands the reach of general equilibrium theory.

First, let the group type be a firm that uses inputs to produce outputs. The required labor, with its required skills, is modeled through the group memberships. If a worker needs to acquire the skills to fulfill the membership, he may make collateral investments to do so, for example, by joining a school in a student membership. The negative elements of $h(g)$ are private goods inputs (for example, intermediate goods), and the positive elements are the firm's output. The input/output vector is divided up among the workers (members) according to the transfer function t_g, and ultimately sold in the market. Transfers of value are made among the members of the firm through the prices q. Of course, whether a given firm type is used in equilibrium depends on the prices of private goods, the opportunity costs of workers, and "externalities" created by the firm type. Agents might avoid very profitable technologies because they dislike the production process or because they dislike the characteristics exhibited by the other workers (members) required to use that production process.

The firm makes zero profit even though there is no concept of linearity in production. The firm has measure zero in the economy, since it is finite, so there is no fudging with respect to the competitive foundations of the model. The only constant returns to scale is that many copies of a given firm type may form, each producing the same output from the same inputs. However, each copy of the group type is a separate profit-maximizing entity.

Substitution in the production process is modeled through different firm types. If it is possible, for example, to produce the same outputs with more labor that is less skilled, but that would be modeled as a different firm type. The firm types that materialize in equilibrium typically depend on the prices for private goods.

Second, let the group type be a school. Some membership characteristics are called "teacher", and others are called "student." The same person is typically not equipped for both roles. In fact, suppose that some student memberships require the membership characteristic "advantaged student" and others "disadvantaged student." Presumably the student's status in this regard is constrained in his consumption set. Suppose for simplicity that there are no private-goods inputs or outputs to the group, and no internal transfers. Since the membership fees sum to zero, the teacher will presumably be paid, and the students will pay. However, if the advantaged students confer high enough positive externalities on disadvantaged students, and if they are in the position of having to choose between mixed schools and schools where everyone is advantaged, the advantaged students may also have to be paid. Essentially, the disadvantaged students pay the advantaged students for the externalities conferred. If these externalities are not large enough relative to what the advantaged students give up to be in the mixed school, such schools will not materialize in equilibrium.

3 Randomized Memberships

In the model described above, agents choose clubs deterministically; there is no randomness in the resulting state of the economy. However, the premise behind the CPPT branch of the clubs literature is that randomness can be utility enhancing. This depends on the premise that utility functions can be interpreted as von Neumann/Morgenstern utility functions (not assumed in the previous model), and is illustrated by the following example.

Suppose there are two firms types, $g_1, g_2 \in \mathbf{G}$. The firm type g_1 has a single worker and g_2 has a worker and supervisor. The club memberships are $\mathbf{M}(g_1) = \{m_{w1}\}$, $\mathbf{M}(g_2) = \{m_s, m_{w2}\}$. Suppose that each agent can choose a single membership, that a third of the agents have consumption sets that permit supervisor job memberships, m_s, and two-thirds of the agents have consumption sets that permit worker memberships, m_{w1} or m_{w2}. There is a single private good, of which each agent has an endowment e. The utility of supervisors is equal to their consumption of the private good, regardless of memberships, whereas the utility of each worker is the following, where c is his consumption of the private good

$$u(c, \mu) = \begin{array}{ll} \frac{1}{2} f(c) & \text{if } \mu = 0 \\ f(c) & \text{if } \mu(m_{w1}) = 1 \\ f(c) + 1 & \text{if } \mu(m_{w2}) = 1 \end{array}$$

In an EGSZ-type equilibrium, the prices of memberships are $q(m_{w1}) = 0$ and $q(m_{w2}) = \hat{q}$, $q(m_s) = -\hat{q}$, together with price $p = 1$ for the private good, where $f(e - \hat{q}) + 1 = f(e)$.Workers receive utility $f(e) = f(e - \hat{q}) + 1$ and supervisors receive utility $e + \hat{q}$. The supervisors are paid by the workers because they are the relatively scarce, but very valuable because they facilitate the creation of high value in supervised firms.

The basic idea of the clubs model of Cole and Prescott (1997) can be seen in the example. If the workers' utility function can be interpreted as a von Neumann/Morgenstern utility function, and if f is concave, the equilibrium is not efficient. The expected utility of workers can be increased without decreasing the utility of supervisors by equalizing the workers' consumption in the two memberships m_{w1}, m_{w2}, and letting them randomize on which membership they take. The equalized consumption is $\hat{c} = (1/2)(2e - \hat{q})$. Then the ex post utility of workers who end up in m_{w1} is less than the ex post utility of workers who end up with m_{w2}, but their ex ante expected utility is the same, namely, $(1/2) f(\hat{c}) + (1/2)(f(\hat{c}) + 1) = f(\hat{c}) + (1/2)$, and larger than $f(e)$.

Cole and Prescott argue that the randomized outcome can be achieved in two ways. The agents can buy lotteries on club memberships directly, or the agents can buy randomizations on wealth, and then choose their club memberships deterministically as in the EGSZ model. In the first implementation, prices are on probability units of consumption bundles. In the example, consumption bundles would be elements $(c, m) \in \mathbf{L}$, where c is (for mathematical convenience) in a finite set of points in $\mathbf{R}_+$ and $m \in \{m_s, m_{w2}, m_{w1}, m_o\}$, where m_o is a null membership that means no group membership is chosen. The prices are $\{p(c, m) \in \mathbf{R}_+ : (c, m) \in \mathbf{L}\}$. If an agent chooses a consumption bundle (c, m) with probability one, he pays $p(c, m)$. More generally, an agent can choose probabilities (a "lottery") $\left\{x(c, m) \in \mathbf{R}_+ : \sum_{(c,m)\in\mathbf{L}} x(c, m) = 1\right\}$. It is then natural to define the utility function on the vectors x, so that the agent receives utility $u(x)$ and pays $p \cdot x$.

This transformation, also used by Prescott and Townsend (2006), gives the group-formation model a structure that is similar to an exchange economy. However, for analytical tractability, some desirable features are given up along the way, such as that the authors restrict to a finite set of preference types, and restrict each agent to a single membership.

Moreover, there is a single profit-maximizing "intermediary" on the supply side, which offers a combination of lotteries that maximize profits, and creates firms from the outcome of agents' (independent) randomizations. To do this, the intermediary must serve a continuum of agents. It is therefore a different type of firm than the group types in the EGSSZ model and the firms of the CPPT model, such as g_1, g_2.

An important role of the intermediary in the CPPT model is to make transfers of value among the groups it creates as the outcome of randomizations. In the example above, there is a single private good, whose price can be taken as 1. The single membership in the firm type g_1 is coupled with consumption $\hat{c} < e$. The value of the member's consumption is therefore less than the value of his endowment; he has budget left over. Since the total value of consumption must equal the total value of endowment in the example (there is no production), the value of consumption in the group type g_2 must be greater than the value of their endowment. Thus, from an ex post point of view, there is a transfer of value from g_1 to g_2. The intermediary absorbs both sides of this transfer, which sum to zero.

Scotchmer and Shannon (2006) show how lotteries on memberships can be introduced to the EGSSZ model through *lottery group types,* which are finite and are formally treated the same as ordinary group types. There is no need for a distinguished firm called an intermediary that serves a continuum of agents.

A lottery group type is composed of several constituent group types in **G.** A feasible lottery must have the same number of members as in the constituent group types, since the lottery members will be assigned to the memberships in the constituent group types. The probability distribution is uniform on all assignments that are consistent with the memberships.

In the example, a lottery group type is constructed from one copy of g_1 and one copy of g_2, and has three memberships. Worker memberships are such that the member can be assigned to m_{w1} or m_{w2}, and a supervisor membership is such that the member will only be assigned to m_s. There are two ways to make this assignment, each with probability one-half. Each worker has probability one-half of being assigned each worker membership, as required. As part of the definition of the lottery group type, there is an internal transfer function designating that each worker must give up a transfer $e - \hat{c}$ to the supervisor. The membership prices for joining this lottery group are zero, so there are no transfers between this lottery group and any other, but there is a transfer of value between the two group types within the lottery.

With this structure, each lottery is a group type with finite members, and, as such, fits directly into the EGSZ model with no modification. Transfers of value among constituent groups take place within the lottery group. (In the basic EGSZ (1999) model described above, there cannot be transfers of value between groups due to the zero-profit constraint within groups.)

A caveat, however, is that not all lotteries can be accommodated with a finite number of group types. Each lottery group defines fixed probabilities on wealths and memberships. Different probabilities are provided by different lottery groups. Since there are continuously many possible lotteries, a complete lottery space would require a continuum of lottery group types, some very large. Thus, as in the CPPT approach, there is some loss in the technical convenience of restricting to a finite number of group types.

4 Unverifiable Characteristics

In game theory, the game is primitive. An agent either finds himself in the game or he does not, but there is generally no explanation for which game he finds himself in. Club theory makes a contribution in allowing agents to choose among games. However, to interpret a game as a finite group type, the theory must accommodate strategies and characteristics that are not verifiable. Such an extension is made by Prescott and Townsend (2006), who use the CPPT approach to discuss how the market chooses among firm types that are subject to moral hazard. Equilibrium will weed out the contractual arrangements that are inefficient, where that may depend on the prices at which private goods trade. The same idea is taken up and extended by Zame (2005) and Scotchmer and Shannon (2006). These papers build on EGSZ (1999, 2005), but differ in emphasis, and in the way group formation is formalized.

The name "strategy" is a good description for unverifiable characteristics that are chosen by the agent, while the name "unverifiable characteristic" is more descriptive when the characteristic is innate. Both play the same role in the model. A group type could be, for example, a normal-form game, where the membership indicates row player or column player, and the unverifiable strategy indicates the play. If the equilibrium is unique, all agents with the same membership will choose the same strategy. In contrast, a job characteristic such as proficiency at writing computer code may be innate, and may vary in an unverifiable way across agents.

The groups that materialize from a member's choices will have a random component, namely, the unverifiable characteristics of other members. For the random realizations of groups, I will use the term "augmented" group types. For conceptual clarity, one can think of the agents first choosing their verifiable memberships and unverifiable strategies, then being randomly matched into augmented groups consistent with their choices, and then choosing private goods consumptions. Choices of private goods may depend on the matching into augmented groups. The unverifiable characteristics of other members in a group may affect each member's demand for private goods directly, and if the group type is a firm, may affect his income. Agents have von Neumann/Morgenstern utility functions, and the optimization at the stage of choosing memberships and strategies is on expected utility. (It is because agents maximize expected utility that lotteries should be considered in the model, as discussed above.)

If the unverifiable characteristics are distinguished according to something verifiable like output, then agents can be made to screen optimally into groups, just as if the characteristics themselves were verifiable. (See example 2 in Scotchmer and Shannon.) No such ploy is available if the unverifiable characteristics affect utility directly, since utility is also unverifiable.

Since each agent's demand for private goods depends on the random matching of agents into their chosen group types, there is no conceptual reason to think that private-goods prices should be the same for all matchings, and Scotchmer and Shannon do not assume it. There may be two sources of uncertainty in an agent's consumption of private goods: Uncertainty about the augmented group types he will find himself in, which affect demand, and uncertainty as to the prices at which he will trade private goods. Both sources of uncertainty may reduce welfare.

If the set of agents were finite, a random matching into groups would not have the feature that each agent's random match (hence demand for private goods) could be understood as independent of any other agent's random match (demand for private goods). Duffie and Sun (2004) prove a sense in which the uncertainty faced by any two agents can be understood as independent if the population is a continuum. This provides an easy way to prove existence of equilibrium despite the randomness caused by unverifiable characteristics. If one restricts to constant prices for private goods (prices that are the same at every random matching), aggregate demand can be treated as constant for all random matchings, which allows a proof of existence based on EGSZ (1999). But this should not lead us to believe that constant prices are natural. There is no reason that the same equilibrium price vector should be selected at each random matching – constant prices are an assumption, not a conclusion.[10]

[10] This is an important difference between the treatments of Zame (2005) and Scotchmer and Shannon (2006). The latter paper models the random matching process, and explores the consequences, especially for efficiency, when prices are not restricted to be constant.

Prescott and Townsend (2006) prove the first welfare theorem for the economies with moral hazard that they consider. In contrast, Zame (2005) and Scotchmer and Shannon (2006) show many senses in which equilibrium will be inefficient. The difference lies partly in the classes of economies considered, and partly in the definition of "efficiency," which is only defined relative to the trading opportunities in the economy.[11] There are two broad classes of inefficiencies. First, there are belief-driven coordination problems, well known in game theory, that are not solved by embedding games in general equilibrium. There may be multiple equilibria, including efficient ones and inefficient ones, each supported by beliefs that are correct in equilibrium. Second, there are inefficiencies in the trading of private goods. Trades in private goods are always efficient from an ex post point of view (conditional on the random matching) but not necessarily from an ex ante point of view. Depending on what is observable, the latter inefficiency may be remediable through insurance markets.

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[11] For example, Scotchmer and Shannon point out that inefficiency in teams would vanish if agents could choose a game with a residual claimant. Prescott and Townsend prove efficiency in a model that does not give agents that option. At best the equilibrium is efficient with respect to the (arbitrary) set of games allowed in the model.

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