The Economics of Rotating Savings and Credit Associations

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This paper analyzes the economic role and performance of a type of financial institution which is observed worldwide: rotating savings and credit associations (Roscas). Using a model in which individuals save for an indivisible durable consumption good, we study Roscas which distribute funds using random allocation and bidding. Each type of Rosca allows individuals without access to credit markets to improve their welfare, but under a reasonable assumption on preferences, random allocation is preferred when individuals have identical tastes. This conclusion need not hold when individuals are heterogeneous. We also discuss the sustainability of Roscas given the possibility of default. (*JEL* O16, O17, G20)

This paper studies rotating savings and credit associations (Roscas). These are informal financial institutions which are found all over the world.[1] They are most common in developing countries but are also used by immigrant groups in the United States (see e.g., Ivan Light, 1972; Aubrey W. Bonnett, 1981). Furthermore, many of the U.S. savings and loan associations seem to have started life as Roscas (see Edwin Symons and James White, 1984; Richard Grossman, 1992). Roscas constitute one of a number of institutions, share-cropping being another example, whose existence is pervasive in developing economies and demands some explanation. Yet while their prevalence and, to some degree, robustness has fascinated anthropologists, they have attracted surprisingly little attention from economists.[2] Our object in this paper and its companion piece (Besley et al., 1992) is therefore to initiate an analysis of their economic role and performance.

The considerable literature on Roscas reveals much variation in how they actually work in practice, but two main varieties can be identified. The first, and most prevalent, type allocates its funds randomly. In a *random Rosca*, members commit to putting a fixed sum of money into a "pot" for each

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[1]Roscas travel under many different names; *chit funds* in India, *susu* in Ghana, *tontines* in Senegal, *njangis* in Cameroon, *cheetu* in Sri Lanka, and *pasanakus* in Bolivia are just a few examples.

[2]The classic anthropological studies of Roscas are by Clifford Geertz (1962) and Shirley Ardener (1964). The latter paper is particularly recommended as an introduction to the literature; see also Donald V. Kurtz (1973) and Douglass G. Norville and James S. Wehrly (1969). Phillipe Callier (1990) provides an economic interpretation of Roscas. For informal economic analyses of Roscas in particular countries, see Dale W. Adams and Marie L. Canavesi de Sahonero (1989) on Bolivia, Robert T. Anderson (1966) and S. Radhakrishnan et al. (1975) on India, Girma Begashaw (1978) on Ethiopia, Edgar Fernando (1986) on Sri Lanka, and Adeniyi Osuntogun and Remi Adeyemo (1981) on Nigeria.

period of the life of the Rosca.[3] Lots are drawn, and the pot is randomly allocated to one of the members. In the next period, the process repeats itself, except that the previous winner is excluded from the draw for the pot. The process continues, with every past winner excluded, until each member of the Rosca has received the pot once. At this point, the Rosca is either disbanded or begins over again.

Roscas may also allocate the pot using a bidding procedure. We shall refer to this institution as a *bidding Rosca*. One individual receives the pot in an earlier period than another by bidding more, in the form of a pledge of higher contributions to the Rosca, or one-time side payments to the other Rosca members. Under a bidding Rosca, individuals may still receive the pot only once—the bidding process merely establishes priority.[4]

We take the view, documented in the extensive informal literature on Roscas, that these institutions are primarily used to save up for the purchase of indivisible durable goods.[5] Random Roscas are not particularly effective as institutions for buffering against risk, since the probability of obtaining the pot need not be related to one's immediate circumstances. Even bidding Roscas, which may allow a member to obtain the pot immediately, only permit individuals to deal with situations that cannot recur, since the pot may be obtained no more than once. Furthermore, since many kinds of risks in LDC's are covariant, individuals will have high valuations at the same instant. Roscas do play a greater role in transferring resources to meet life-cycle needs, such as financing a wedding. However, even in this context, they seem more appropriate for dealing with significant, idiosyncratic events, rather than the hump saving required for old age.

Despite its manifest importance, there has been relatively little work in the savings literature on the notion of saving up to buy an indivisible good. Yet, the existence of indivisible goods is a reason for developing institutions which mediate funds. In the absence of access to external funds, individuals must save to finance lumpy expenditures and can gain from trading with one another; the savings of some individuals can finance the purchases of others. This is not true when all goods are divisible, since gradual autarkic accumulation is efficient in the absence of heterogeneity.

Roscas provide a means of making joint savings work.[6] They also determine a rule for rationing access to the indivisible good: random allocation in a random Rosca and bidding in a bidding Rosca. We use a two-good model with indivisibilities to make precise how a group of individuals without access to credit markets may improve their welfare by forming a random or bidding Rosca. We demonstrate how these institutions work and examine their impact on savings rates. We also compare random and bidding Roscas, focusing on their relative performance in terms of their members' welfare. With homogeneous individuals, randomization is preferred to bidding as a

[3]Some forms of Roscas may require members to make in-kind contributions. An example of this form which may be familiar to the reader is that of "barn raisings," which were common among 19th-century frontier farmers in the United States. Consider a group of farmers living in the same region, each of whom wants to build a new barn. On the first Sunday in every month, the group gets together and builds a new barn for one of the farmers selected at random. They reconvene the next month and do the same, continuing until each member in the group has a barn.

[4]While bidding and drawing lots seem to be the two most common ways of allocating the pot, it is also sometimes allocated according to need or known criteria, such as age or kinship seniority. The reader is referred to Ardener (1964) for a more detailed discussion.

[5]Common examples are bicycles and tin roofs. See Fritz Bouman (1977) and Geertz (1962) for more discussion of the various uses for the pot.

[6]This was clearly recognized by Ardener (1964 p. 217). "The most obvious function of these associations is that they assist in small-scale capital formation, or more simply, they create savings. Members could save their contributions themselves at home and accumulate their own 'funds,' but this would withdraw money from circulation: in a rotating credit association capital need never be idle."

method of allocating funds within Roscas under a plausible restriction on preferences. However, with sufficient dispersion in individuals' valuations of the indivisible good, this may not be true.

For Roscas to operate successfully it is necessary that individuals keep their commitment to pay into the Rosca after they have won the pot. This may appear problematic since Rosca members are often not able to borrow in conventional credit markets precisely because they cannot be presumed to repay loans. Roscas circumvent such default problems by exploiting individuals' social connectedness. This is borne out in the anthropological literature, which reveals how the incentive to defect from a Rosca is curbed by social constraints. Roscas are thus typically formed among individuals whose circumstances and characteristics are well known to each other. Defaulters are sanctioned socially as well as being prevented from any further Rosca participation. Nonetheless, default does sometimes occur, and organizers of Roscas must be mindful of this. Thus, we discuss how concerns about default influence the design and performance of Roscas.

The remainder of this paper is organized as follows. Section I sets up the model. Section II describes how Roscas work and can improve over autarky. Section III provides comparisons of lifetime utilities and other features of the resource allocations under random and bidding Roscas. In Section IV, we extend the comparison to allow for the possibility of heterogeneous tastes. Section V discusses how considerations of sustainability may influence the design of Roscas, and Section VI concludes.

I. The Model

We use the simplest model that can capture the essential features of the problem at hand. A group of n individuals would each like to own an indivisible durable consumption good. The group is assumed to have no access to credit markets. Thus they may be villagers in a traditional society or members of an immigrant group, unfamiliar with the banking practices of their new country. Each individual lives for T years, receiving an exogenous flow of income over his lifetime of $y > 0$. We assume, at first, that individuals have identical, intertemporally additive preferences. Each individual's instantaneous utility depends on nondurable consumption, c, and on whether or not he enjoys the services of the durable. The durable does not depreciate and can be purchased at a given cost of B. Once purchased, it yields a constant flow of services for the remainder of an individual's lifetime. We also assume that the durable's services are not fungible across individuals; one must own it to benefit from its services.

For simplicity, there is no discounting, which precludes any motive for saving or borrowing apart from the desire to acquire the durable. An individual's instantaneous utility with nondurable consumption c is $v(1,c)$ if he owns the durable, and $v(0,c)$ otherwise. We assume that $v(0,\cdot)$ and $v(1,\cdot)$ are increasing, strictly concave, and three times continuously differentiable in their second argument, using $v'(i,c)$, $v''(i,c)$, and so forth to denote differentiation of $v(i,\cdot)$ with respect to c, for $i=0$ or 1. Given c, we define $\Delta v(c) \equiv v(1,c) - v(0,c)$ to be the instantaneous gain in utility from owning the durable, and $v(\alpha,c) \equiv \alpha v(1,c) + (1-\alpha)v(0,c)$, for $0 \leq \alpha \leq 1$, as the expected instantaneous utility when α is the probability of owning the durable.

Our results require some further structure on preferences. The first, innocuous, condition is that $\Delta v(c) > 0$ for all $c \geq 0$, which says only that individuals like the durable. We will also assume that $\Delta v'(c) \geq 0$ (i.e., that the marginal utility of nondurable consumption is not decreased by owning the durable). This is critical for much of our analysis and can be interpreted as saying that durable services and nondurable consumption are complements. We regard the assumption as reasonable for many of the uses to which Rosca funds are put—purchasing a bicycle, a household appliance, or a tin roof for one's house. We will, however, indicate how the assumption affects our analysis as we proceed.

Under *autarky*, individuals save up on their own. Our assumptions imply that it is optimal for each individual to save B at a constant rate $y-c$, over an interval $[0,t]$.[7] Thus, lifetime utility maximization involves each individual choosing c and t to:

$$(1)\quad \text{maximize}\{t\cdot v(0,c)+(T-t)\cdot v(1,y)\}$$

subject to $t(y-c)=B$, and $0\le c\le y$. Let (t_a,c_a) be the solution to (1) and let W_a be the maximal value of lifetime utility.

We exploit a simple way of writing W_a. First, substitute for t using the constraint in (1). This yields a one-variable maximization problem involving c, and the maximand can be written as

$$T\cdot v(1,y)-B\left[\frac{v(1,y)-v(0,c)}{y-c}\right].$$

Next, define

$$(2)\quad \mu(\alpha)\equiv\min_{0\le c\le y}\left[\frac{v(1,y)-v(\alpha,c)}{y-c}\right]\qquad 0\le\alpha\le 1.$$

Setting $\alpha=0$ in (2), lifetime utility under autarky can be written as

$$(3)\qquad W_a=T\cdot v(1,y)-B\cdot\mu(0).$$

Expression (3) has an appealing interpretation, paralleled in our analysis of Roscas. The first term represents lifetime utility if the durable were free, while the second term is the minimal utility cost of saving up for the durable. This minimization trades off the benefit of a shorter accumulation period against the benefit of higher consumption during this period. Letting, $c^*(\alpha)$ be the consumption level which solves (2), the optimal autarkic consumption rate, c_a, is $c^*(0)$.

[7]Note that accumulation for purchase of the durable is not desirable at all for some parameter values. It follows from our analysis of (1) that an individual would choose to save up on his own to purchase the durable only if $T\cdot\Delta v(y)/B$ is sufficiently large. Here we shall consider only such cases where this condition holds.

Under autarky, no individual has the durable good before date t_a, at which time all n individuals receive it. Thus the expected fraction of time that an individual will enjoy the services of the durable during the accumulation period is zero. This explains why autarky is represented by $\alpha=0$ in (2). Autarky is inefficient; each person saves at rate $y-c_a=B/t_a$ and after an interval of t_a/n, there are enough savings to buy a durable which could be given to one of the group members. Roscas remedy this inefficiency, with the cost function $\mu(\cdot)$ measuring the extent of welfare improvement.

Before considering Roscas, we establish some technical properties of $\mu(\cdot)$ and $c^*(\cdot)$, which prove useful later. The proof of the lemma is in the Appendix.

LEMMA: *Under the assumptions on preferences set out above, the minimized cost $\mu(\cdot)$ in (2) is a decreasing, concave function of α, and the cost-minimizing consumption rate $c^*(\cdot)$ is an increasing function of α. Both are twice continuously differentiable on* $[0,1]$, *where they satisfy the identity $\mu(\alpha)\equiv v'(\alpha,c^*(\alpha))$. Moreover, if $v'''(i,c)>0$ for $i=0$ and 1, and if $\Delta v''(c)\ge 0$, then $c^*(\cdot)$ is strictly convex.*

II. Roscas

This section examines how members of a group may improve their welfare by forming either a random or a bidding Rosca. As well as examining how Roscas operate and raise lifetime utilities over autarky, we also consider their effect on savings rates. We begin with random Roscas.

A. *Random Roscas*

Imagine that our n-person group forms a random Rosca which meets at equally spaced dates up to t_a (i.e., $\{t_a/n, 2t_a/n, \dots, t_a\}$, with contributions of B/n at each meeting). Each time the Rosca meets, an individual is randomly selected to receive the pot of B, allowing him to buy the durable. Each individual continues to save at rate B/t_a over the interval $[0,t_a]$, as under autarky, but can now expect to receive the durable $t_a(n-1)/2n$ sooner. Risk aversion is not an issue here, since from each individual's *ex ante* viewpoint, the random Rosca does as well as autarky in every state of the world, and strictly better in all but one.[8]

A random Rosca which lasts until t_a is only one possibility. For example, the group could also have met until $t_a/2$ with contributions of B/n and a durable being bought after each interval of length $t_a/2n$. Given the uniform spacing of meeting dates and the constant contribution rate, the duration of the Rosca will be inversely proportional to the rate at which the group saves and accumulates the durable.

It seems natural to suppose that the group would agree on a length for the Rosca which maximizes the (*ex ante* expected) utility of the representative group member.[9] To characterize this length and the implied savings rate, consider a "general" random Rosca of length t, meeting at the dates $\{t/n, 2t/n, \dots, t\}$, with members contributing B/n at each meeting date. A representative member of the Rosca views his receipt date for the pot (and hence the durable) as a random variable, $\tilde{\tau}$, distributed uniformly on the set $\{t/n, 2t/n, \dots, t\}$. Each member saves at rate B/t over the life of the Rosca, and nondurable consumption is thus $c = y - B/t$ during this period. Given c, each member's lifetime utility is the random variable: $\tilde{\tau} \cdot v(0,c) + (t - \tilde{\tau}) \cdot v(1,c) + (T - t) \cdot v(1,y)$, where $t = B/(y-c)$. Lifetime expected utility in this random Rosca is the expected value of the expression above, and since $E(\tilde{\tau}) = [(n+1)/2n]t$, each member's *ex ante* welfare is

$$(4) \quad W(c) \equiv t\left[\left(\frac{n+1}{2n}\right)v(0,c) + \left(\frac{n-1}{2n}\right)v(1,c)\right] + (T-t)v(1,y)$$

where $t = B/(y-c)$.

The group's problem is now to choose t (or equivalently c), to maximize (4). Let t_r denote the optimal length, c_r the associated consumption rate, and W_r the maximal value of expected utility. This problem is similar to that encountered under autarky. Indeed, defining $\bar{\alpha} = (n-1)/2n$, (4) may be rearranged as follows:

$$W(c) = T \cdot v(1,y) - B\left[\frac{v(1,y) - v(\bar{\alpha},c)}{y-c}\right].$$

By analogy with the reasoning leading to (3), we obtain

$$(5) \quad W_r = T \cdot v(1,y) - B \cdot \mu(\bar{\alpha})$$

with $c_r = c^*(\bar{\alpha})$.

The interpretation is the same as that of (3): welfare is the difference between what lifetime utility would be were the durable a free good and the minimal (expected) utility cost of saving up for its purchase. This cost is lower under the random Rosca than under autarky because each member expects to enjoy the durable's services for a fraction $\bar{\alpha}$ of the time in which he is saving up for the durable. It is now easy to establish the following proposition.

PROPOSITION 1: *By forming a random Rosca, group members raise their expected lifetime utilities. The optimal random Rosca involves members saving at a lower rate over a longer interval than under autarky. Nevertheless, if* $v'''(i,c) > 0$ *for* $i = 0$ *and* 1, *and if*

[8] This is also noted by Callier (1990 p. 274). "The creation of a tontine is one of the most obvious Pareto improvements that people who save in order to purchase a bulky asset can create for themselves in a society with fragmented capital markets.... The pooling of resources reduces the time of 'waiting' before the purchase for all participants except the one who is last collecting the kitty (who nevertheless does not have to wait more than if he had saved alone)."

[9] In Cameroon the typical length of njangis is two years (see James Brooke, 1987). The cundina in Mexico last between one and two years according to Kurtz (1973). These lengths seem to be broadly in line with many other studies of Roscas that we have found. The literature reveals considerable variation in the size of Roscas. Most seem to range from 10 to 20 members although Osuntogun and Adeyemo (1981) report Roscas as large as 100 members in southwestern Nigeria.

$\Delta v''(c) \geq 0$, then individuals expect to receive the durable good sooner in the optimal random Rosca than under autarky (i.e., $t_r > t_a > (n+1)t_r/2n$).

PROOF:

Equations (5) and (3) imply that $W_r - W_a = B[\mu(0) - \mu(\bar{\alpha})]$. This is positive since, as stated in the lemma, $\mu(\cdot)$ is a decreasing function; so group members' expected utility is higher in the random Rosca than under autarky. The lemma also established that $c^*(\cdot)$ is increasing. Therefore consumption is greater as well, since $c_r = c^*(\bar{\alpha}) > c^*(0) = c_a$. However, the constraint $t(y-c) = B$ applies under both autarky and the random Rosca. Hence $t_r > t_a$, and the optimal random Rosca involves members saving at a lower rate over a longer interval than under autarky.

To prove that the expected receipt date under the optimal random Rosca is sooner than that under autarky we have to show that $t_a > (n+1)t_r/2n = (1-\bar{\alpha})t_r$. Since $t_a = B/[y - c^*(0)]$ and $t_r = B/[y - c^*(\bar{\alpha})]$, it will suffice to show that $y - c^*(\bar{\alpha}) > (1-\bar{\alpha})[y - c^*(0)]$. Now, in view of the assumed concavity of $v(1,\cdot)$, inspection of (2) reveals that $y = c^*(1)$. Therefore, we need to show that $\bar{\alpha}c^*(1) + (1-\bar{\alpha})c^*(0) > c^*(\bar{\alpha})$. This follows from Jensen's inequality and the convexity of $c^*(\cdot)$ established under these hypotheses in the lemma.

Welfare is raised by forming a Rosca because some financial intermediation reduces everyone's utility cost of saving up. This conclusion is independent of any restrictions we imposed on preferences other than individuals' liking the durable. Showing that nondurable consumption is higher and the accumulation period is longer under the random Rosca does require the assumption that durable services and nondurable consumption are complements. The result that individuals receive the durable earlier on average under the random Rosca is less general, requiring the assumptions of positive third derivatives stated in Proposition 1.

The ranking of random Roscas and autarky does not hold *ex post* since, though individuals have the same prospects *ex ante*, their circumstances differ once the order of receipt has been determined. Using the index i to denote the person who wins the pot at the ith meeting, at date $t_r(i/n)$, *ex post* utilities under the random Rosca are given by

$$(6) \quad u_r^i = t_r\left[\left(\frac{i}{n}\right)v(0,c_r) + \left(1-\frac{i}{n}\right)v(1,c_r)\right] + (T - t_r)v(1,c_r) \qquad i = 1,\ldots,n.$$

Since his consumption/receipt-date pair (c_r, t_r) is feasible, but not optimal, under autarky, the individual receiving the pot at the final meeting date ($i = n$) has been made strictly worse off (*ex post*) by joining the random Rosca.

B. *Bidding Roscas*

Suppose now that individuals bid for the right to receive the pot at a certain date (i.e., they form a bidding Rosca). We assume that Rosca members determine the order of receipt for the pot when the Rosca is initially organized at time zero.[10] Since there is no uncertainty, this does not seem unreasonable. By a "bid" we mean a pledge to contribute a certain amount to the Rosca at a constant rate over its life, in exchange for the right to receive the pot at a certain meeting date. A higher bid would naturally entitle an individual to an earlier receipt date.

Of the many auction protocols that could be imagined, all must result in individuals being indifferent among bid/receipt-date pairs, since individuals have identical preferences and complete information. Moreover, any efficient auction procedure must be structured so that total contributions committed through bids are just adequate to finance acquisition of the durable by the recipient of the pot at each meeting date.

[10]The literature reveals considerable variation in the bidding procedures used in practice. See Ardener (1964) and Fernando (1986) for discussions of particular cases.

This precludes both redundant savings within the Rosca and the necessity to save outside of the Rosca.

The two requirements that individuals are indifferent among bid/receipt pairs and that the sum of the contributions equals the cost of the durable completely determine the outcome of the bidding procedure. Thus it is unnecessary to commit to a particular auction protocol. However, to provide a concrete example, fix the duration t of the bidding Rosca and suppose that a series of $n-1$ oral, ascending-bid auctions are held at date zero among n group members, determining in sequence who receives the pot at each meeting date except the last, with each winner excluded from participation in subsequent auctions. The last remaining individual has his contribution set so that the sum of all commitments just equals the durable's cost, B. It is easy to see, using a backward-induction argument, that every (subgame-perfect) equilibrium of this bidding mechanism leaves all individuals at the same level of lifetime utility. Moreover, by construction, the winning bids (plus the last recipient's contribution) will sum to the cost of the durable. We now show how to characterize these equilibrium bids.

If the bidding Rosca lasts until time t, bidding determines who receives the durable at each of the meeting dates $\{t/n, 2t/n,\dots,t\}$. Let b_i denote the promised contribution of individual i, defined to be the one who wins the pot at time $(i/n)t$. A set of bids $\{b_i\}_{i=1}^{n}$ constitutes an equilibrium if (i) no individual could do better by outbidding another for his place in the queue and (ii) contributions are sufficient to allow each participant to acquire the durable upon receiving the pot.

If Rosca member i bids b_i, he will have nondurable consumption $c_i = y-(n/t)b_i$ at each moment during the Rosca's life. Thus, we can characterize the Rosca in terms of the consumption rates: $\{c_i\}_{i=1}^{n}$. Condition (ii) implies that individual i's equilibrium utility level is

$$t\left[\left(\frac{i}{n}\right)\cdot v(0,c_i)+\left(\frac{n-i}{n}\right)\cdot v(1,c_i)\right]$$
$$+(T-t)\cdot v(1,y)$$

in a bidding Rosca of length t. Letting α_i equal $(n-i)/n$, condition (i) implies, for all individuals i and some number x, that

$$(7)\qquad v(\alpha_i,c_i)=x \qquad i=1,\dots,n.$$

The number x represents the members' common average utility during the life of a bidding Rosca of length t, in a bidding equilibrium.

Now define $\bar{c}$ to be the average nondurable consumption rate of members during the life of the Rosca [i.e., $\bar{c}\equiv(1/n)\sum_{i=1}^{n}c_i$]. Then condition (ii) is equivalent to

$$(8)\qquad t(y-\bar{c})=B.$$

Given the Rosca's length t, the relations (7) and (8) uniquely determine members' nondurable consumption rates and their average utility over the life of the Rosca, consistent with bidding equilibrium. Equivalently, one could take as given the equilibrium average utility level for the duration of the Rosca, x. Then (7) gives individuals' equilibrium consumption levels, $\{c_i\}_{i=1}^{n}$; and these, via (8), can be used to find the Rosca's length, t.

As in the random Rosca, it is natural to assume that the length of the bidding Rosca is chosen to maximize the common utility level of its members. The foregoing discussion and (7) imply that this common welfare is

$$T\cdot v(1,y)-B\big\{[v(1,y)-x]/[y-\bar{c}]\big\}.$$

Now let $\hat{c}(\alpha,x)$ be the function satisfying $v(\alpha,\hat{c})\equiv x$, and define

$$\bar{c}(x)\equiv\left(\frac{1}{n}\right)\sum_{i=1}^{n}\hat{c}(\alpha_i,x).$$

Then, when the equilibrium average utility during a bidding Rosca is x, $\hat{c}(\alpha_i,x)$ is individual i's nondurable consumption rate during the Rosca, and $B/[y-\bar{c}(x)]$ is the Rosca's length. Denote by t_{b} and W_{b}, respectively, the duration and common utility level of the optimal bidding Rosca. Then, using by now familiar arguments, we may write the following:[11]

$$(9) \qquad W_{\mathrm{b}} = T \cdot v(1, y) - B \cdot \mu_{\mathrm{b}}$$

where

$$(10) \qquad \mu_{\mathrm{b}} \equiv \min_{x} \left[\frac{v(1, y) - x}{y - \bar{c}(x)} \right].$$

Letting x^* give the minimum in (10), then $t_{\mathrm{b}} = B/[y - \bar{c}(x^*)]$ is the length of the optimal bidding Rosca.

Lifetime utility expressed in (9) admits the same interpretation noted for autarky and the random Rosca; it is the difference between lifetime utility if the durable were free and the minimal cost of saving up. The latter, determined in (10), again trades off higher welfare during the Rosca versus faster acquisition of the durable. We may now establish the following proposition.

PROPOSITION 2: *By forming a bidding Rosca, group members raise their lifetime utilities relative to autarky. Moreover if $1/v'(0, \cdot)$ is concave, the optimal bidding Rosca involves group members saving at a lower average rate and over a longer interval than under autarky.*

PROOF:

Equations (9) and (3) together imply that $W_{\mathrm{b}} - W_{\mathrm{a}} = B[\mu(0) - \mu_{\mathrm{b}}]$, which is positive if and only if $\mu(0) > \mu_{\mathrm{b}}$. Since $v(\alpha, c)$ increases with both α and c, $\hat{c}(\alpha, x)$ decreases with α; so,

$$\bar{c}(v(0,c)) = \left(\frac{1}{n}\right) \sum_{i=1}^{n} \hat{c}(\alpha_i, v(0,c))$$

$$< \left(\frac{1}{n}\right) \sum_{i=1}^{n} \hat{c}(0, v(0,c)) = c$$

for $0 \leq c \leq y$. Therefore $\bar{c}(v(0, c_{\mathrm{a}})) < c_{\mathrm{a}}$; but then, setting $x = v(0, c_{\mathrm{a}})$ in (10) and comparing the value of the right-hand side with the minimized value in (2), we see that $\mu(0) > \mu_{\mathrm{b}}$. Thus, by forming a bidding Rosca, group members raise their lifetime utilities. The proof of the second part of the proposition is given in the Appendix.

Again, the welfare dominance of the Rosca over autarky requires no assumption on preferences other than individuals' liking the durable good. The greater complexity of the bidding Rosca is reflected in the need to make an assumption on the curvature of the inverse of the marginal utility of income function in order to compare the Rosca's savings rate to that under autarky. Concavity of this function does not follow from any well-known property of utility functions, though it is satisfied for many cases. For example, for isoelastic utility functions with $v(0, c) = c^{1-\rho}/(1-\rho)$, $1/v'(0, c)$ is convex if $\rho > 1$ and concave if $\rho < 1$.

Unlike autarky or the random Rosca, the bidding Rosca leaves each individual with a different rate of nondurable consumption during the accumulation period. Earlier acquirers of the durable bid a higher contribution to the Rosca and consume less of the nondurable; $(c_1 < \cdots < c_n)$. Proposition 2 also reveals that the last individual to acquire the durable in a bidding Rosca must have greater nondurable consumption during accumulation than under autarky $(c_n > c_{\mathrm{a}})$. These higher contributions of earlier recipients resemble interest payments, and in this sense the bidding Rosca can be likened to a market.[12]

III. Bidding versus Random Roscas

While we have already established that either type of Rosca allows a group to use its savings more effectively than under autarky, they do not yield identical outcomes. We observed above that bidding results in recipients of early pots forgoing consumption. The optimal savings rate may also dif-

[11] In this minimization x is restricted to a range defined by the requirement that the consumption levels $c_i = \hat{c}(\alpha_i, x)$ must be no less than zero and no greater than y, $i = 1, \ldots, n$.

[12] Our companion paper (Besley et al., 1992) makes the comparison exact.

fer between the two institutions. Comparison of these savings rates and welfare levels is the object of this section. In particular, understanding the latter may yield insight into the circumstances when we would expect to observe one or the other of the Rosca types in practice. Our main result for a homogeneous group is stated in the following proposition.

PROPOSITION 3: *Group members' expected utility will be higher if they use a random rather than a bidding Rosca. If the value of the durable is independent of the nondurable consumption rate [i.e., $\Delta v'(c) \equiv 0$], and if $1/v'(0,\cdot)$ is a convex function, then the optimal random Rosca involves members saving at a lower rate over a longer interval than the optimal bidding Rosca.*

PROOF:

From (5) and (9) we see that $W_{\mathrm{r}} - W_{\mathrm{b}} = B[\mu_{\mathrm{b}} - \mu(\bar{\alpha})]$, so we need to show that $\mu_{\mathrm{b}} > \mu(\bar{\alpha})$. The proof is simple. Using (2), the definition of $\hat{c}(\alpha, x)$, and the change of variables $x = v(\bar{\alpha}, c)$, we can write

$$\mu(\bar{\alpha}) = \min_{x}\left[\frac{v(1,y) - x}{y - \hat{c}(\bar{\alpha}, x)}\right]. \tag{11}$$

Comparing (11) with (10) we conclude: $\mu(\bar{\alpha}) < \mu_{\mathrm{b}}$ if $\hat{c}(\bar{\alpha}, x) < \bar{c}(x)$, for all x; but $\hat{c}(\bar{\alpha}, x)$ is $\hat{c}(\cdot, x)$ evaluated at the average of α_i, while $\bar{c}(x)$ is the average of the values $\hat{c}(\alpha_i, x)$. Hence, by Jensen's inequality, our conclusion holds if $\hat{c}(\cdot, x)$ is strictly convex. A bit of calculus shows

$$\partial \hat{c}/\partial \alpha = -[\Delta v(\hat{c})/v'(\bar{\alpha}, \hat{c})] < 0.$$

A bit more reveals

$$\partial^2 \hat{c}/\partial \alpha^2 = [-\partial \hat{c}/\partial \alpha]\left[\frac{\Delta v'(\hat{c})}{v'(\bar{\alpha}, \hat{c})} + \frac{d}{dc}\left(\frac{\Delta v(\hat{c})}{v'(\bar{\alpha}, \hat{c})}\right)\right]$$

which is positive provided that $\Delta v'(c) \geq 0$. This proves the first claim of the proposition. The proof of the second claim is given in the Appendix.

Thus according to Proposition 3 our assumptions imply that individuals are better off using a savings association that allocates access to funds by lot. This may explain why randomization is so widely used in practice. Though this finding is at first sight counterintuitive, a natural explanation is available. As will emerge in the next section, however, the assumption of identical preferences is crucial to the result; when individuals' preferences differ, bidding permits them to sort themselves.

The assumption that the durable and nondurable goods are complements is key to proving that random allocation dominates bidding from an *ex ante* viewpoint. To see why, consider two Roscas of the same duration. Bidding requires members to have the same average utility over the life of the Rosca; random allocation requires them to have the same nondurable consumption rates. Each of these requirements constitutes a constraint on the more general scheme which randomly assigns members an order of receipt i, $1 \leq i \leq n$, and a consumption rate c_i, $0 \leq c_i \leq y$, but which requires neither equal consumption rates nor equal *ex post* utilities.[13] Were such a scheme designed to maximize *ex ante* expected welfare, it would equate individuals' marginal utilities: $v'(\alpha_i, c_i) = v'(\alpha_j, c_j)$, $1 \leq i, j \leq n$.[14]

When $\Delta v'(c) \geq 0$, random assignment with equal nondurable consumption more closely approximates this condition than does bidding. In a bidding equilibrium, earlier recipients of the pot contribute more to the Rosca (lower c_i) in exchange for greater access to the durable during the Rosca (higher α_i). However, with $\Delta v'(c) \geq 0$, they also have higher marginal utilities than those

[13] Hybrid Roscas of this sort seem not to be observed in practice. This may be due to problems of implementation, since losers in this lottery might prefer to join another Rosca than to continue in the original one.

[14] Otherwise it would be possible to increase *ex ante* expected utility by increasing contributions to the Rosca by an individual with lower marginal utility and reducing them for an individual with higher marginal utility, keeping total contributions at each meeting just equal to B.

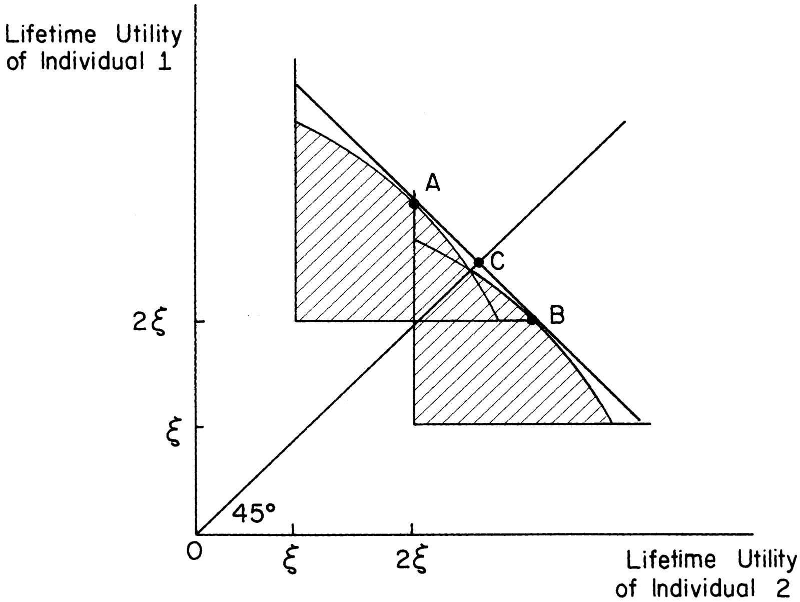

FIGURE 1. LIFETIME UTILITY POSSIBILITIES FOR A TWO-PERSON GROUP WITH TIME HORIZON $T = 3$ YEARS AND ROSCA LENGTH $t = 2$ YEARS

Note: $\xi \equiv \Delta v(c) > 0$ is a constant.

receiving the pot later. This divergence of marginal utilities is mitigated in the random Rosca, which sets $c_i = c_r$, for all i. Thus, when the two goods are complements, the equal-consumption-rate constraint of random allocation is less inhibiting than is the equal-average-utility constraint of bidding, and the random Rosca performs better than the bidding Rosca in this case.[15] This is particularly clear when $\Delta v' \equiv 0$, since equality of consumption rates during the Rosca implies equality of marginal utilities. However, equality of lifetime utilities constrains consumption so that the marginal utility is higher among those who receive the pot earlier.

Figure 1 illustrates the latter case graphically. We depict lifetime utility possibilities for a two-person group with time horizon $T = 3$ years, and Rosca length $t = 2$ years. The value of the durable's services, $\Delta v(c) \equiv \xi > 0$, is a constant. Since total annual contributions to the Rosca must equal the durable's cost, total annual consumption for the individuals equals $2y - B$ during the life of the Rosca. By considering alternative nondurable consumption levels for the two individuals satisfying this constraint, we trace out two utility possibility frontiers. Which is relevant depends upon who gets the durable first. If individual 1 does, the relevant utility possibility frontier is located

[15]Conversely, if durable and nondurable consumption are sufficiently strong substitutes, then the equal-average-utility constraint, by forcing c_i and α_i to covary negatively in the group, can produce less inequality of marginal utilities than the equal-consumption-rate constraint. For example, one can easily show that, if $v(0,c) = 1 - \exp(-c)$ and $v(1,c) = v(0, c + \xi)$, for some $\xi > 0$, then the optimal bidding Rosca achieves the maximal *ex ante* expected utility among the more general schemes of the sort discussed in the text. Less obvious, but also true, is that this exponential form is necessary for the bidding Rosca to attain the more general maximum.

to the northwest in the figure, while if individual 2 gets the durable first, the relevant frontier is the one to the southeast. The indivisibility of the durable good causes the overall utility possibility set to be nonconvex.

Because a random Rosca yields equal nondurable consumptions, its utility allocation is either at point A (if individual 1 wins the first pot) or at point B (if individual 2 does). Note that, because $\Delta v' = 0$, the slope of the relevant utility possibility frontier is -1 at points A and B; the line containing A and B is tangent to the two frontiers at those points. Since these utility allocations have equal probability, each individual's *ex ante* expected utility is at point C. The sum of expected utilities at point C is maximal among all feasible expected utility allocations. A bidding Rosca, by making utilities equal, produces a utility allocation at the intersection of the two frontiers. The dominance of the random Rosca is now obvious.[16]

Proposition 3 also compares the savings rates in random and bidding Roscas, but it requires that $\Delta v'(c) = 0$ and imposes a restriction on the curvature of $1/v'(0,\cdot)$. No general result appears to be available. Combining Propositions 2 and 3, in the case of separable logarithmic utility [i.e., where $v(0,c) = \ln(c)$ and $v(1,c) = v(0,c) + \xi, \xi > 0$], then, since $1/v'(0,c)$ is linear, $t_a < t_b < t_r$. Thus, in this case institutions with higher *ex ante* welfare are also those with lower savings rates and longer accumulation periods.

IV. Roscas with Heterogeneous Individuals

While there is some evidence that Roscas are formed among relatively homogeneous groups (see e.g., Thomas Cope and Kurtz, 1980), there is no good reason to suppose that the individuals in any particular group have identical preferences for the durable and, hence, for receipt of the pot. In this section we show how allowing for such differences may reverse the ranking of the bidding and random Roscas from an *ex ante* viewpoint. With heterogeneous tastes, bids can be used to order individuals, with those who value the pot more acquiring it sooner. This is true whether or not information about tastes is private. Even if valuations are public information, individuals can use bidding to realize "gains from trade" within the Rosca, as members who value the pot more exchange greater contributions for earlier access to the pot. When valuations are not commonly known, bidding plays the additional role of inducing individuals to reveal this information. We restrict attention here to the case in which preferences are common knowledge.

We consider the operation of a two-person bidding Rosca.[17] The preferences of these two individuals are as above, except that individual 1's utility when he has the durable is increased by a constant, with individual 2's utility being reduced by the same constant. Thus, prior to acquiring the durable good, utility for both individuals is $v(0,c)$; after acquiring it, individual 1 has utility $v^1(1,c) \equiv v(1,c) + \xi$, and individual 2 has utility $v^2(1,c) \equiv v(1,c) - \xi$, for $\xi \geq 0$. The parameter ξ measures the difference in the individuals' tastes. Note that $\xi = 0$ is the case of homogeneous individuals considered above and that an increase in ξ yields a mean-preserving spread in the dispersion of the individuals' valuations. The key assumption is that the *difference* in individuals' valuations of the durable is independent of the level of nondurable consumption. Relaxing this would complicate the analysis without adding new insights. As before, $v^i(\alpha,c)$ denotes individual i's expected utility flow at an instant when α is the probabil-

[16] The failure of bidding to achieve maximal expected utility parallels results obtained in other literatures where indivisibilities are important. See, for example, the model of conscription in Theodore Bergstrom (1986), the location models of James A. Mirrlees (1972) and Richard Arnott and John Riley (1977), and the club membership model of Arye Hillman and Peter Swan (1983).

[17] This restriction is for notational simplicity only. The extension to many members is straightforward.

ity of owning the durable. Hence, $v^1(\alpha,c) = v(\alpha,c)+\alpha\xi$; and $v^2(\alpha,c) = v(\alpha,c)-\alpha\xi$.

Consider a bidding Rosca of length t, meeting at dates $t/2$ and t. Let b_i be individual i's bid, and let c_i be his nondurable consumption rate during the Rosca. Then $c_i = y - 2b_i/t$. We will adopt the auction protocol described in Subsection II-B: an oral, ascending-bid auction where the winner gets the first pot and the loser's contribution is set to yield a total payment of B at each meeting date. To understand the outcome of such an auction, note that individual 1 will always exceed the bid b, if

$$(12)\quad v^1\left(\tfrac{1}{2}, y-2\frac{b}{t}\right) > v^1\left(0, y-2\left[\frac{B-b}{t}\right]\right).$$

The left-hand side of (12) is individual 1's average utility during the Rosca if he wins with bid b, and the right-hand side is his average utility if individual 2 wins with the same bid. As long as (12) holds then, by bidding a little more than b, individual 1 raises his welfare if his bid prevails. Since tastes are common knowledge, individual 2 will exceed any bid satisfying (12) knowing that 1 will go higher. In this way, 2 can reduce the size of his own contribution. Thus the outcome of the auction will be that individual 1 wins with a bid for which (12) is an equality.

In bidding equilibrium, therefore, individual 1 will be indifferent between consumption/receipt-date pairs (c_2, t) and $(c_1, t/2)$. Furthermore, consumption rates will satisfy $B = (t/2)(2y - c_1 - c_2)$. These two conditions uniquely determine the equilibrium consumption (and hence, bids) in a bidding Rosca of length t.[18] We now consider the optimal length for such a Rosca.

[18] In the natural extension of this analysis to the case of n individuals, equilibrium consumptions will be determined by the equations:

(i) $v^i(\alpha_i, c_i) = v^i(\alpha_{i+1}, c_{i+1}) \qquad i = 1,\dots,n-1$

(ii) $\sum_{i=1}^{n} c_i = n\left[y - \frac{B}{t}\right].$

To facilitate comparison with our previous analysis, suppose that the Rosca is utilitarian, its length being chosen to maximize the average utility of its members. Given length t, let x be the average of the members' utility during the Rosca. In bidding equilibrium

$$x \equiv \left(\tfrac{1}{2}\right)\left[v^1\left(\tfrac{1}{2}, c_1\right) + v^2(0, c_2)\right].$$

Since bidding equilibrium requires $v^1(0,c_2) = v^1(1/2, c_1)$, we conclude that $x = v(0, c_2)$. Using the function $\hat{c}(\alpha, x)$ defined in Subsection II-B by the identity $v(\alpha, \hat{c}) \equiv x$, write equilibrium consumption rates as $c_1 = \hat{c}(1/2, x - \xi/2)$ and $c_2 = \hat{c}(0, x)$. Letting $\tilde{c}(x, \xi)$ denote the average equilibrium consumption rate, we have

$$\tilde{c}(x,\xi) \equiv \left[\hat{c}\left(\tfrac{1}{2}, x - \xi/2\right) + \hat{c}(0, x)\right]\big/2.$$

Then the average welfare in bidding equilibrium is

$$(13)\quad \overline{W} \equiv T\cdot v(1,y) - B\left[\frac{v(1,y) - x}{y - \tilde{c}(x,\xi)}\right].$$

Denote by $\tilde{W}_{\mathrm{b}}$ the level of average welfare in the optimal bidding Rosca with heterogeneous preferences. Then (13) implies the following familiar relationship:

$$(14)\quad \tilde{W}_{\mathrm{b}} = T\cdot v(1,y) - B\tilde{\mu}_{\mathrm{b}}$$

where

$$(15)\quad \tilde{\mu}_{\mathrm{b}} \equiv \min_x \left[\frac{v(1,y) - x}{y - \tilde{c}(x,\xi)}\right].$$

We can interpret (14) and (15) as before. Mean welfare in the optimal bidding Rosca is the difference between what it would be if the durable were free and the minimal cost of saving-up. This cost, $\tilde{\mu}_{\mathrm{b}}$, is the value of a minimization problem.

It is revealing to compare the expressions above with the analogous equations (9) and (10) which apply to the homogeneous bidding Rosca. Mean welfare in the heterogeneous case differs from that in the homogeneous case only because the corresponding average consumption rates, $\tilde{c}(x,\xi)$ and $\bar{c}(x)$, differ. In the homogeneous case

$$\bar{c}(x) \equiv \left[\hat{c}\left(\tfrac{1}{2},x\right)+\hat{c}(0,x)\right]/2.$$

Hence $\tilde{c}(x,0)=\bar{c}(x)$, and so as individuals' tastes become more similar, the outcome with heterogeneity converges to the outcome in the homogeneous bidding Rosca. Moreover, since $\hat{c}(\alpha,x)$ is increasing in x, we know that $\tilde{c}(x,\xi)$ is decreasing in ξ. So, *a mean-preserving increase in the dispersion of members' valuations of the durable good reduces the mean utility cost of saving up to a bidding Rosca and, hence, increases the individuals' mean welfare in bidding equilibrium.*

To see why intuitively, let individual 1's valuation of the durable rise and let individual 2's fall by an equal amount, holding fixed nondurable consumption rates. The change in valuations has no impact on mean welfare when both individuals have the durable, and it increases mean welfare when only individual 1 has it. Thus, as long as individual 1 has priority of access, increasing the dispersion of valuations holding consumption fixed raises mean welfare. Allowing consumption rates to move to their equilibrium levels only reinforces this effect.

In a random Rosca, individuals 1 and 2 consume the nondurable good at the same rate, and both have an even chance of acquiring the durable on either of the same two dates. It follows that the average of the two individuals' expected utilities in a random Rosca is independent of ξ. Setting $\xi=0$ and using (5), we conclude that average expected utility in the optimal random Rosca with diverse tastes, denoted $\tilde{W}_{\mathrm{r}}$, is given by: $\tilde{W}_{\mathrm{r}} \equiv T\cdot v(1,y)-B\cdot\mu(1/4)$. (Since $n=2, \bar{\alpha}=1/4$.) We now have the following proposition.

PROPOSITION 4: *The average of individuals' expected lifetime utilities in the optimal bidding Rosca exceeds that in the optimal random Rosca if the dispersion of individuals' valuations is sufficiently large.*

PROOF:

The above discussion implies that $\tilde{W}_{\mathrm{b}} > \tilde{W}_{\mathrm{r}}$ if and only if $\tilde{\mu}_{\mathrm{b}} < \mu(1/4)$. Comparing (15) with (11) we see that $\tilde{\mu}_{\mathrm{b}} < \mu(1/4)$ if $\tilde{c}(x^*,\xi) < \hat{c}(1/4,x^*)$, where x^* gives the minimum in (11) for $\bar{\alpha}=1/4$. Writing this out, we have: $\tilde{\mu}_{\mathrm{b}} < \mu(1/4)$ if $\hat{c}(1/2,x^*-\xi/2) < 2\hat{c}(1/4,x^*)-\hat{c}(0,x^*)$. Hence, to conclude that $\tilde{W}_{\mathrm{b}} > \tilde{W}_{\mathrm{r}}$ it suffices to know that

$$x^*-\xi/2 < v\left(\tfrac{1}{2}, 2\hat{c}\left(\tfrac{1}{4},x^*\right)-\hat{c}(0,x^*)\right)$$

or

$$\frac{\xi}{2} > x^* - v\left(\tfrac{1}{2}, 2\hat{c}\left(\tfrac{1}{4},x^*\right)-\hat{c}(0,x^*)\right).$$

Thus, bidding dominates for high enough ξ, since the left-hand side of the above inequality increases with ξ and the right-hand side is independent of ξ. Note that the right-hand side of the inequality is positive since

$$\hat{c}\left(\tfrac{1}{4},x^*\right) < \tfrac{1}{2}\left\{\hat{c}(0,x^*)+\hat{c}\left(\tfrac{1}{2},x^*\right)\right\}$$

from the proof of Proposition 3. This implies that

$$v\left(\tfrac{1}{2}, 2\hat{c}\left(\tfrac{1}{4},x^*\right)-\hat{c}(0,x^*)\right) < x^*.$$

The reason for the result should be clear. The bidding Rosca gives the pot to the individual with the highest valuation first, while a random Rosca does not respect individuals' valuations. If the gain from doing this is large enough, it outweighs that from randomization which we demonstrated in the previous section. Since our welfare criterion is mean expected utility, the interpretation of this result is as follows: given sufficient heterogeneity, individuals choosing "behind the veil of ignorance" (i.e., before they know their tastes) would opt for a bidding Rosca rather than a random Rosca.

This analysis of heterogeneity is limited by our assumption that individuals' valuations are commonly known. To relax this assumption would be of interest but would take us far afield from the concerns of the present paper. It is clear, however, that the main insight from the simplest case, that bidding can serve a useful sorting function, will be robust in the face of further analysis.

V. The Sustainability of Roscas

We premised our analysis on an assumption that the group of potential Rosca members had no access to external credit markets. This is not unreasonable for most situations where Roscas are prevalent, whether among an ethnic group within the United States or in less developed countries. There are various reasons why particular groups may have difficulty in obtaining credit in formal markets. First, immigrant groups or rural villagers may be intimidated by banks, which require their customers to be literate and to be familiar with certain banking practices. Second, groups may be discriminated against, and thus unable to obtain access to credit from regular sources. Third, and perhaps most importantly, banks may perceive the default risk of lending to certain groups to be too high. Default may occur either because borrowers face unreliable income streams, and thus are *unable* to repay, or because they are *unwilling* to repay, with the bank having insufficient sanctions against them to make them do so. Typically, individuals who join Roscas tend to lack reliable forms of collateral which can be used to assuage banks' fears of nonrepayment.

Since those who receive the pot early are effectively in debt to the other group members, Roscas too would seem vulnerable to problems of nonrepayment, with individuals refusing to honor their membership commitment after winning the pot. However, there are good reasons why Roscas do not fall victim to the problem of deliberate default which banks might face. The key to understanding Roscas is noting that, unlike markets, they are not anonymous institutions. They use preexisting social connections between individuals to help circumvent problems of imperfect information and enforceability. The rules of Roscas reflect concerns of this kind. For example, individuals must be appropriately vetted before being allowed to join.

A typical scenario for a Rosca is a group of individuals from the same village or, in an urban setting, from the same office.[19] In the United States, as we have noted, Roscas are most often formed from among an ethnic group. Thus individuals are likely to have good information about the reliability of their neighbors and co-workers and can enforce sanctions—social and economic—on those who are delinquent without good reason. It seems central to understanding the sustainability of Roscas that there be some kind of "social collateral" among a group which can be harnessed in this way.

All this explains very well why Roscas tend to avoid large-scale default in practice, and the anthropological literature on Roscas is replete with examples to illustrate this point. Summing up these, Ardener (1964 p. 216) observes that "a member may go to great lengths, such as stealing or selling a daughter into prostitution in order to fulfill his obligations to his association; failure to meet obligations can even lead to suicide." Reporting on Roscas in Cameroon, a recent *New York Times* article noted that "bankers complain of loan delinquency rates as high as 50%. But [Rosca] payments are taken so seriously that borrowers faced with delinquency have been known to commit suicide" (Brooke, 1987 p. 30). Perhaps ironically, the inability of Rosca members to enter credit markets actually strengthens the value of social sanctions, since individuals with bad reputations earned in Roscas may expect little other credit-market access.[20]

[19]Adams and Canavesi de Sahonero (1989) conduct a detailed analysis of Roscas based in offices in urban Bolivia.

[20]This may help to explain why Roscas become less important in the process of economic development, however, since as individuals' market opportunities expand, the value of social sanctions declines, and the sustainability of Roscas becomes more problematic.

All of this notwithstanding, it would be misleading to ignore default entirely. Here, we shall examine how such considerations may influence the design and performance of Roscas. We do this within our model by supposing that a defaulting individual is subjected to social sanctions inflicted by other group members with an exogenously given utility cost of K.[21] This cost might represent the discomfort, loss of face, and other social costs associated with having to confront the other Rosca members each day or, in the extreme, the costs of finding a new job or place to live. In a more general model, it might also represent the loss from being excluded from Rosca participation in the future.

Suppose now that individuals choose whether or not to meet their Rosca obligations. Then a Rosca will be established only if it satisfies a *sustainability constraint*, ensuring that each individual prefers to maintain his contribution to the Rosca after he has won the pot. With identical preferences, this constraint takes a very simple form: it holds for every Rosca member if it holds for the first one to win the pot, the latter having the greatest incentive to default.

Consider a random Rosca among n identical individuals, as defined in Subsection II-A. If the consumption rate during the Rosca is c, then it lasts until date t and meets at $\{t/n, 2t/n, \ldots, t\}$, where $t = B/(y-c)$. Then, the benefit to the first recipient of defaulting is

$$\left(\frac{n-1}{n}\right)B\left[\frac{v(1,y)-v(1,c)}{y-c}\right]$$

(i.e., the gain from avoiding the $n-1$ remaining contributions to the Rosca). The Rosca is sustainable if this benefit does not exceed the default cost K. Letting

$$g(c,\alpha)\equiv\alpha\left[\frac{v(1,y)-v(1,c)}{y-c}\right]$$

and with $\bar{\alpha}=(n-1)/2n$ as before, the sustainability constraint becomes $g(c,\bar{\alpha})\leq K/2B$. The analysis of Section II implicitly assumed K to be large enough for this constraint to be satisfied at the optimal nondurable consumption rate, $c^*(\bar{\alpha})$.

If the constraint were not satisfied, the allocation that we described for the random Rosca would not be sustainable. Fixing n, we can ask how the demands of sustainability would affect the design of the Rosca. Since utility is concave in c, $g(c,\alpha)$ decreases in c, for $c\leq y$. Thus, for a given number of members, the sustainability constraint can be accommodated only by increasing c above c_r or, equivalently, increasing t above t_r. Thus, deterring default requires increasing the duration of the Rosca. Holding the duration of the Rosca fixed, the benefit of default could be reduced by lowering n. Fewer meetings implies a shorter period over which the first recipient of the pot might enjoy the benefits of default. Obviously, either of these adjustments will reduce the welfare gain from forming a Rosca, since the original allocation is being further constrained.[22,23]

[21] It would be theoretically more satisfying to have K determined endogenously, arising from rational behavior by the individuals in some extended version of the model. A natural way of doing this would be to posit a sequence of Roscas through time, supposing that failure to perform in the past results in future exclusion from Rosca participation. Then K would depend positively on the benefit of Rosca participation relative to autarky, and negatively on individuals' discount rates.

[22] Referring to the sustainability constraint, it is also clear that a larger pot also may create problems of sustainability. This is borne out in Stephen Haggblade's (1978) discussions of the njangis in Cameroon. However, he does report that some Roscas with \$40,000 pots are found there (p. 43). One imagines that the severity of the social sanctions associated with default would also be great in Roscas of this magnitude. As we have seen, it is the ratio of default cost to pot size, K/B, which matters.

[23] This discussion suggests the following reformulation of the Rosca design problem:

$$\mu^*\equiv\min_{\alpha,c}\left[\frac{v(1,y)-v(\alpha,c)}{y-c}\right]$$

subject to $g(\alpha,c)\leq K/2B$, where (α,c) must also satisfy $0\leq c\leq y$, and $\alpha\in\{(n-1)/2n;\ n=2,3,\ldots\}$. It is easy to show, by writing out the first-order conditions for this constrained minimization, that when the optimal random Rosca discussed earlier is not sustainable, a solution involves $c>c_r$.

Equation (5) reveals that the expected utility in a random Rosca of given length increases with n. Hence, absent considerations of sustainability, welfare is higher with a larger Rosca membership. In practice, however, we do not often observe Roscas of more than a few score members, and sustainability considerations would seem key to understanding this fact. This is especially so if one considers the determinants of the default cost, K. In larger groups it becomes more difficult to keep track of defecting members (the evidence [e.g., Haggblade, 1978] seems to be that larger Roscas face bigger default problems). This effect is likely to outweigh the intermediation benefits of a larger membership in groups above a certain size, since the marginal benefit of another member declines with the size of the group, while marginal monitoring and enforcement costs could be expected to increase.

The issues of sustainability are broadly similar for bidding Roscas. We should emphasize, however, that, because bidding for priority forces a heavier obligation upon earlier recipients, the incentive issues are more serious. Moreover, there is an interesting complication if individuals differ with respect to their susceptibility to social sanctions and if this difference is private information. Those individuals who care little about such sanctions would have a further incentive to bid in order to get the pot early, knowing that they need not continue paying into the Rosca after winning the pot. Thus, bidding brings along its own adverse-selection problem.

Our discussion of sustainability has so far focused exclusively on the problem of willingness to continue making payments into the Rosca, rather than ability to do so. The latter might also be a problem if individuals' incomes are stochastic, since then they might sometimes be unable to contribute. The anthropological literature indicates that on some occasions Roscas serve a risk-sharing role, with one or more members paying the contributions of another. Problems of moral hazard and adverse selection seem less likely to pervade such "insurance" schemes than in other contexts, because of the social connectedness of Rosca members.

VI. Concluding Remarks

This paper has investigated the economic role and performance of Roscas. We have sought their rationale in the fact that some goods are indivisible, a fact which makes autarkic saving inefficient. We have argued here that Roscas can be understood as a response by a socially connected group to credit-market exclusion. This seems broadly consistent with what we see in practice. We have made precise how Roscas improve over autarky and have compared random and bidding Roscas. We found that the indivisibilities which might motivate the existence of Roscas can explain why random allocation is so widely used. However, with sufficient dispersion of the valuations of the durable goods, bidding may be preferred as a means of allocating rights to the pot.

Our analysis also discussed the problem of sustainability, and we pointed out some of the constraints that this might impose. In general it may necessitate operating Roscas with fewer members and longer durations than would otherwise be desirable. Sustainability seems likely to be more of a problem in bidding than random Roscas, since the gains from early default are greater, and individuals with the lowest disutility from social disapproval and sanctions have a stronger incentive to bid in order to obtain the pot early.

The analysis suggests a number of interesting avenues for empirical investigation. While there are many studies of Roscas, few have tried to test concrete theoretical hypotheses. Our analysis suggests at least three directions in which this might go. First, there are questions about Rosca memberships: do the groups appear to be homogeneous, and what social connections between group members circumvent the problem of default? Second, there are questions of Rosca design—their length, their savings rates, and whether bidding or random allocation is used. On the last issue our model gives predictions in terms of the structure of preferences and the heterogeneity of the group. Third, there are questions of what Rosca winnings are used for. Our theory predicts their use for the purchase of durable goods.

A number of theoretical issues remain outstanding. This paper has compared the allocations achieved by random and bidding Roscas to the autarkic allocation and to each other. It is also interesting to ask how the allocations attained by Roscas compare with those that are, in principle, feasible for the group. For example, are Roscas efficient? Furthermore, would the group formation of a credit market result in the same allocation as a bidding Rosca? These and other questions are pursued in our companion paper (Besley et al., 1992). We show there that, in general, Roscas do not produce efficient allocations and that bidding Roscas are inferior to credit markets. Nonetheless, the element of chance offered by random Roscas is still of value. Indeed, we present an example in which an *ex post* efficient market allocation is dominated (under the *ex ante* expected-utility criterion) by a random Rosca.

APPENDIX

PROOF OF LEMMA:

It is easy to see that, as long as acquiring the durable good is desirable under autarky, a unique interior solution to (2) exists. The first-order condition for this problem implies

$$v'(\alpha,c^*)=[v(1,y)-v(\alpha,c^*)]/[y-c^*]$$
$$=\mu(\alpha).$$

This is the identity claimed in the lemma. Since $v(\alpha,c)$ is increasing in α, $\mu(\cdot)$ must be decreasing. Moreover, since $\mu(\cdot)$ is the value of a minimand linear in the parameter α, elementary duality theory implies that $\mu(\cdot)$ is a concave function of α. By the envelope theorem,

$$\mu'(\alpha)=-\Delta v(c^*)/[y-c^*].$$

These relations, the assumed three-times continuous differentiability of the utility function, and the implicit-function theorem establish the extent of differentiability of $\mu(\cdot)$ and $c^*(\cdot)$ asserted in the lemma. Now differentiate $v'(\alpha,c^*)\equiv\mu(\alpha)$ with respect to α, and use the envelope result to get

$$\frac{dc^*}{d\alpha}=-[v''(\alpha,c^*)]^{-1}\left[\Delta v'(c^*)+\frac{\Delta v(c^*)}{y-c^*}\right]>0$$

given concavity of the utility functions $v(i,\cdot)$, and the assumption that $\Delta v'\geq 0$. Differentiate the identity $v'(\alpha,c^*)\equiv\mu(\alpha)$ twice with respect to α to get

$$\frac{d^2c^*}{d\alpha^2}=[v''(\alpha,c^*)]^{-1}\times\left[\mu''(\alpha)-2\Delta v''(c^*)\cdot\left(\frac{dc^*}{d\alpha}\right)-v'''(\alpha,c^*)\cdot\left(\frac{dc^*}{d\alpha}\right)^2\right]$$
$$>0$$

using the assumptions that $\Delta v''(c^*)\geq 0$ and $v'''(i,c^*)>0$, for $i=0$ and 1.

COMPLETION OF PROOF OF PROPOSITION 2:

We need to show that if $1/v'(0,\cdot)$ is concave then $t_b>t_a$. It is sufficient to show that $c_a<\bar{c}(x^*)$ to establish the result. By the lemma, the first-order condition for the minimization in (10), and the fact that $\mu_b<\mu(0)$, we have that

$$v'(0,c_a)=\mu(0)>\mu_b$$
$$=\left\{\left(\frac{1}{n}\right)\sum_{i=1}^{n}[v'(\alpha_i,\hat{c}(\alpha_i,x^*))]^{-1}\right\}^{-1}$$

However, because $\Delta v'(c)\geq 0$, we have that $v'(\alpha,c)\geq v'(0,c)$. Therefore, using Jensen's inequality and the assumed concavity of $1/v'(0,\cdot)$,

$$v'(0,c_a)>\left\{\left(\frac{1}{n}\right)\sum_{i=1}^{n}[1/v'(0,\hat{c}(\alpha_i,x^*))]\right\}^{-1}$$
$$\geq v'(0,\bar{c}(x^*)).$$

The result now follows from the fact that $v''(0,c)<0$.

COMPLETION OF PROOF OF PROPOSITION 3:

We need to show that $\Delta v' \equiv 0$ and $1/v'(0, \cdot)$ convex imply $t_r > t_b$. It suffices to deduce that $c_r > \bar{c}(x^*)$. By the same reasoning as employed in the completion of the proof of Proposition 2, the fact that $\mu(\bar{\alpha}) < \mu_b$ (proved in the text) and the assumption that $v'(\alpha, c)$ is independent of α, we have

$$v'(\bar{\alpha}, c_r) < \left\{ \left(\frac{1}{n} \right) \sum_{i=1}^{n} [v'(\bar{\alpha}, \hat{c}(\alpha_i, x^*))]^{-1} \right\}^{-1}$$

$$\leq v'(\bar{\alpha}, \bar{c}(x^*))$$

using Jensen's inequality and the convexity hypothesis. The result follows at once.

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