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Buying Fields and Marrying Daughters: An Empirical Analysis of Rosca Auctions in a South Indian Village

Stefan Klonner

Abstract:

A bidding rotating savings and credit association (Rosca) is modeled as a sequence of symmetric-independent-private-value auctions with price-proportional benefits to bidders. We estimate a structural econometric model which, by introducing an altruistic component into each bidder's utility function, allows for socially favorable deviations from the private information, non-altruistic bidding equilibrium. We find that bidding is more altruistic in groups managed by experienced organizers and in Roscas whose current members have already run through more than one Rosca cycle of the current group, implying that effective leadership and enduring relationships help mitigate the social cost of strategic behavior. When a bidder has to meet an unforeseen expenditure and this information is public, bidders act more altruistically than when information is private and the Rosca funds are used for investment, indicating reciprocal risk sharing among Rosca participants.

JEL Classification: D44; G20
Keywords: Roscas; Auctions

Introduction

The rotating savings and credit association (Rosca) is a financial institution which is observed around the world, mainly in developing countries. Roscas serve as a substitute for saving in and borrowing from more well-known financial institutions such as banks and credit co-operatives and flourish in economic settings where formal financial institutions seem to fail to meet the needs of a large fraction of the population. In general terms, a Rosca can be defined as 'a voluntary grouping of individuals who agree to contribute financially at each of a set of uniformly-spaced dates towards the creation of a fund, which will then be allotted in accordance with some prearranged principle to each member of the group in turn' (Calomiris and Rajaraman, 1998). Once a member has received a fund, also called a pot, she is excluded from the allotment of future pots until the Rosca ends. In a so-called random Rosca, a lot determines each date's 'winner' of the pot. In a bidding Rosca, an auction is staged among the members who have not yet received a pot. The highest bid wins the pot and the price the winner pays is distributed among the other bidders. In a third, empirically relevant, allocation mechanism, the decision on each period's allocation of the pot is left to the Rosca organizer.[1]

In the South-Indian state of Tamil Nadu with a population of 62 million, the turnover in registered Roscas alone equaled 100 billion Rupees, about 2.5 billion US dollars, in 2000 (Ganga-Rao, 2001), which compares to aggregate bank deposits of 66 billion Rupees (Reserve Bank of India, 2000). Given such importance of Roscas, economists' interest in this institution has been astoundingly small. In the theoretical papers by Besley et al. (1993, 1994), participants join a Rosca to finance a durable good whose costs require saving for more than one period. In

[1] In Handa and Kirton's (1999) sample, 53 percent of the Roscas operate in this way.

Kovsted and Lyk-Jensen (1999), each participant can engage in an investment project whose revenue is privately observed. In all these papers, the auctions serve as a mechanism to allocate pots earlier to participants who have a higher willingness to pay for the durable or investment project, respectively, and can therefore be advantageous if participants are not identical. The approaches to bidding Roscas taken by these authors are deterministic in the sense that all payoffs occurring during the course of the Rosca can be calculated before the beginning of the first auction. In a stochastic Rosca model, in contrast, participants receive new signals before each auction. In this connection, Klonner (forthcoming; 2001) considers risk averse individuals whose income streams are subject to idiosyncratic, privately observed shocks and shows how a bidding Rosca serves as a risk sharing device.

Empirical studies of Roscas were started by anthropologists (Geertz, 1962) and are much more numerous than the few theoretical papers cited above. All recent econometric studies of Roscas are exclusively concerned with the determinants of Rosca participation (Aliber, 2000; Anderson and Balland, 1999; Gugerty, 2000; Handa and Kirton, 1999; Levenson and Besley, 1996). None of this econometric research, however, analyzes Rosca auctions, instead treating the Rosca's allotment mechanism as a black box.

Based on a case study, the goal of this paper is to improve the understanding of how bidding Roscas function in reality by shading light on the auction allotment mechanism, and, more generally, to provide a deeper understanding of the environment in which financial transactions within a village economy take place. With a dataset of 149 Rosca auctions from an agricultural South-Indian village, we show how auction outcomes respond to the distribution of information among the bidders. When, as is the case in the study village, funds from a Rosca are used to overcome indivisibilities in investment and outside credit is sufficiently costly, bidding leads to social costs arising out of strategic behavior. In this case, the efficiency of a Rosca does not only depend on the order of receipt of the pots but also on the prices obtaining in the auctions. Allowing for altruistic behavior of the bidders, our results suggest that the limited size of a Rosca group can increase the efficiency through repeated interaction among its members and effective leadership on the side of the organizer. Given the high volatility of Rosca-auction outcomes on the other hand, our findings document the trade-off between the advantages of small-scale financial intermediation and the volatility implied by such arrangements when individuals are confronted with a stochastic environment.

The rest of this paper is organized as follows. In Section 1, we describe the study village (henceforth referred to as 'E'), present the dataset on Roscas auctions, and summarize the salient features of these data together with some qualitative evidence. In Section 2.1, we develop a stochastic Rosca model, which builds on Kovsted and Lyk-Jensen's (1999) idea that participants have investment projects whose returns are independently and identically distributed and privately observed. In Section 2.3, we discuss some implications of the equilibrium of this model. Section 2.4 augments the benchmark model of Section 2.2 with altruism, whereby bidders care not only about their own, but also about the payoffs to all other bidders, and it is shown how such behavior improves the efficiency of a Rosca. In Section 3, a structural econometric model, which is derived from the augmented model, is estimated by the method of maximum likelihood. Section 4 summarizes the results and offers conclusions.

1 THE DATA AND SOME QUALITATIVE FINDINGS

1.1 The Study Village

The village E is located in a fertile river basin in the southern part of Tamil Nadu. River irrigation facilitates two paddy harvests per year, one in autumn and one in winter, whereby, according to farmers, the October-harvest is about 50% more profitable than the one in February on average.

Recently, some farmers have started banana cultivation. The village population numbers about 1000, comprising about 230 households, of which 48 belong to scheduled castes and live in a so-called colony about 500 meters away from the main village, where the caste Hindus live. The village has a post office but no bank branch. Although male literacy is as high as 57% and bus connections to two towns with several banking facilities are frequent, comparatively inexpensive and much used, financial transactions with banks play a small role for the three-fifths of village households whose primary income source is agriculture. The only regularly mentioned formal financial transaction within this group is a loan for agricultural inputs from an agricultural co-operative (see van Dillen, forthcoming).

1.2 The Data

Since the aim of this study is to investigate Rosca auctions, information from organizers is indispensable because, in E, Rosca participants could, at the very most, recall those auctions which they had won. Many participants, especially those in the colony, were not even aware of many of the modalities of the Roscas in which they participated, such as the number of participants or the amount in the pot.

Since none of the Roscas which I could observe in E is registered with the government, as Tamil state law requires, organizers were generally unwilling to admit that they administer a Rosca. I succeeded in interviewing 11 of the 19 bidding Rosca organizers whom I could find in E. I included all their Roscas which were currently going on or had ended not earlier than after the autumn harvest of 1999 and for which written records were available. This yielded information on 23 Roscas and 149 auctions. For each auction in the sample, I recorded the winning bid, the winner's use of the pot, and whether this purpose was his private information during the auction. Moreover, for each Rosca in the sample, I reported the contribution of each member in each round, the number of participants in the Rosca, the number of Roscas the organizer had completed before starting the one from which the observation stems, and the number of Roscas he had completed with the same group from which the observation stems. Some summary statistics are provided in Table 1. Note that each observation in this dataset refers to the outcome of one auction. Thus, for example, if at the time of the interview, in a Rosca with 10 participants, 6 auctions had taken place, this Rosca contributes 6 observations to the dataset. Of course, the Rosca-specific variables take the same respective values in all of these six observations.

1.3 Stylized Facts about Harvest-Bidding Roscas in E

We now combine the evidence from the data with some qualitative observations to summarize some key features of harvest-bidding Roscas which are important to set up a theoretical model that will serve as a benchmark for explaining Rosca auction outcomes in E:

1. Rosca funds are almost never used for consumption or domestic purposes (2 of 128 auctions where the organizer recalled what an auction's winner used the pot for). Instead Rosca funds are mostly used for productive investment (80 of 128 cases), e.g. buying a field plot or starting banana cultivation, or what villagers call "emergencies" (31 cases), which are marriages or the ritual puberty function of a daughter or a close relative. Less frequent uses are buying jewelry, settling debt, medical treatment and children's education, which may also be regarded as investments since they increase or consolidate a household's net wealth and human capital, respectively.[2]
2. When there is no 'emergency', information on a winner's purpose is mostly private before the beginning of an auction (102 out of 118 cases). This means that if someone intends to

[2] Organizers were sure that, when the purpose is unknown, it is not an 'emergency'. Moreover, in those 21 cases, the winner always kept his purpose secret, with one exception where,

obtain a pot to buy a field plot, for example, he does not tell other bidders about his intention before the auction. Organizers and participants say that it is advantageous to keep a potential investment use of Rosca funds secret.

3. When information on the purpose of an auction's winner is public, it is mostly an 'emergency' (24 out of 40 cases). Marriage arrangements are usually known throughout the village well in advance so that, in these cases, it is not a bidder's decision whether to reveal this information public or not. Organizers and participants say that bidding is less competitive in such cases. It is claimed, instead, that other bidders understand the need in question and that bidding does not go as high.
4. Lying about the use of Rosca funds (e.g. pretending a marriage when there is none) is virtually impossible because, ex post, the use of the funds is obvious to anybody in the village and dishonest people are excluded from future Roscas. Such an exclusion was considered a prohibitively severe sanction by all participants interviewed.
5. Defaulting on contributions also results in exclusion from future Roscas. Out of the 11 organizers who responded, only one mentioned problems with outstanding contributions.[3] If somebody pays a contribution late, the organizer has to step in.
6. Participants say that it is crucial to be able to obtain a pot when there is an unforeseen opportunity or 'emergency', and that, for this reason, random Roscas are useless.
7. In a different sample of 21 participants in harvest bidding Roscas in the village E, in 10 out of 14 cases where the respondents had already obtained a pot of an ongoing Rosca, the winner used the pot for a different purpose than he had been planning when he had joined

according to the organizer, the winner said before the auction that he needed money without further specifying why.

the Rosca, or he did not have a particular idea what to use the funds for when he had joined the Rosca. In three other cases where the participants knew in advance what to use the funds for (purchase of a field plot or marriage of a daughter), the timing (in which round to take the pot) was not determined at the beginning. The only case in which a winner knew when he wanted to take the pot and what to use it for, was someone who took the first pot to repair his house.

8. In the sample obtained from Rosca organizers, the observed winning bid fluctuates in 15 of 16 Roscas where at least five auctions were recorded, i.e. there exists a t, such that, in the t-th round, a higher winning bid is observed than in the $(t-1)$-th round, even when the funds are used for the same purpose.
9. Both organizers of and participants in bidding Roscas pointed out that unrestrained bidding is bad for the welfare of the group. It is considered advantageous if, in each round, a Rosca allocates as much money as possible to the winner and does not favour losing bidders through a high winning bid, which is equally distributed among the losers of an auction.

Since investment use of Rosca funds is the most frequent case in E (see observation 1 of the list above), a model where each bidder's desire to finance an investment project determines his bid seems appropriate as a benchmark. From 2 and 4 we conclude that, in such a model, the kind of investment project to which a bidder has access is his private information. Observations 6, 7 and 8 can be interpreted as clear evidence against a deterministic Rosca model because, to apply such a model, participants would have to know the purpose for which to use the funds from the Rosca in advance, which contradicts 7. Moreover, in the deterministic model of Kovsted and Lyk-

[3] He was, however, the only organizer in the sample who was incapable of keeping proper records of his Roscas and made a somewhat confused impression during the interviews.

Jensen (1999), the winning bid decreases monotonically from auction to auction during the course of the Rosca, which contradicts 8. Observation 5 implies that we can neglect any problems of defaulting on contributions. Observation 9 implies that the marginal disutility to an auction's winner from receiving less money due to bidding in the auction is higher than the sum of the marginal utilities to that same auction's losers from receiving more money through the distribution of the winning bid.

2 Theory

2.1 A Model of Rosca Auctions in E

In this section, we use the observations from the previous section to formalize the course of a harvest-bidding Rosca in E. Note that, throughout this paper, we take each Rosca participation as given and set the problem of an optimal Rosca portfolio aside. Problems of defaulting on Rosca contributions are also set aside, an assumption, which is supported by observation 5 cited in the previous section.

For simplicity, consider a bidding Rosca with 2 participants. At the beginning of each meeting, each participant contributes m Rupees. Consequently, the pot amounts to $2m$. In the first round, an oral ascending bid auction takes place. In such an auction, the bid b is increased continuously. The winner receives the pot minus his last bid, b^w say, in total $2m - b^w$, and the loser, in turn, b^w. In the second round, that participant who did not win the auction in the first round receives the pot without a discount.

To formalize the ideas developed in the previous section, suppose that each individual is risk neutral and that, in period t, his preferences can be described by the intertemporally separable von-Neumann-Morgenstern utility function

$$U_t = q_t + \delta q_{t+1},$$

where q_τ denotes consumption measured in Rupees in period τ and $\delta \leq 1$ is a discount factor for future consumption. Each period covers one paddy crop cycle so that there are two periods per agricultural year. Suppose that, after every harvest, each Rosca participant has access to an investment project which costs $2m$ and that each Rosca participant participates in only one bidding Rosca at a time. In each period, the profit which the investment project yields is determined by a random variable, R say, which is independently and identically distributed over the participants with the smooth parametric cumulative distribution function (cdf) $F(r;\boldsymbol{\theta}, \lambda)$, where $\boldsymbol{\theta}$ and λ, the former a vector, are parameters. λ marks the lower bound of the support of R. The profit from an investment creates an instantaneous utility equivalent to consuming $2mr$, where r is the realization of R. Further assume that each individual privately observes his realization of R in period 1 before the auction in period 1. We assume that investing $2m$ is always preferred to consuming $2m$, i.e. $\lambda > 1$ and that the winner of an auction has to consume or invest the funds obtained from the Rosca instantaneously. Outside credit is available to finance the gap between the funds received from the Rosca, $2m - b^w$, and the cost of the investment project. Of course this gap is equal to b^w. Every Rupee borrowed creates an instantaneous disutility of $c > 1$. To insure that b^w has to be financed completely by outside credit, which is essential to keep the analysis tractable, we will assume that saving outside the Rosca is not possible.

It should also be said that we have not explicitly incorporated inflation into the model, which may play a role in our application, where Roscas have a lifetime of five to eight years. Unfortunately, a price index for investment goods of the kind Rosca funds are used for in E is not available. The consumer price index for agricultural laborers in the state of Tamil Nadu, however, rose from 725 in December 1989 to 1752 in December of 1999 (base year: 1960/61, source: Central Statistical Organization), which implies an average annual rate of inflation of 9.2 percent. For the rest of this paper, we will assume that the nominal price of the investment project as well as the realized and expected rate of inflation remain constant over the lifetime of the Rosca, which implies that the discount factor δ will capture any effect of inflation that would affect participants' actions in the Rosca.

We now turn to the Rosca auction which, in E, is invariably of the oral ascending bid (OA) form, i.e. those participants who have not yet received a pot meet and submit successive oral bids until only one bidder, the winner, remains. Since we have to refer to standard auctions at several stages of the theoretical and econometric analysis, we briefly sketch the setting of what will be referred to as a 'standard auction'. There is one seller, who owns a single, indivisible item and K buyers. Each bidder knows K and his own valuation (or value, in short) for the item, which is the maximum amount he would be willing to pay for the item, but none of the other bidders' values. The values are identically and independently distributed (see Matthews, 1990). It is further assumed that the seller cannot set a minimum price.

We model an OA-Rosca auction as a so-called button auction, where each bidder presses a button as the standing bid continuously increases. A bidder drops out of the bidding process once he releases his button. The auction is over once there is only one bidder still pressing his button. He receives the pot at a price equal to the standing bid at the moment the other bidder dropped out, b^w.

For the derivation of a bidding equilibrium in the Rosca button auction, it is useful to consider a second-price, sealed bid (SPS)-Rosca auction. In such an auction, the active participants submit their bids in sealed envelopes. The highest bid wins and the winner pays a price equal to the second highest bid submitted. Although, at least in the context of Roscas, this type of auction is empirically irrelevant, we shall argue that, under certain assumptions, its equilibrium is also an equilibrium of the OA-Rosca auction. We will assume that in the button auction, at each level of the standing bid, each bidder only observes whether the auction is still going on or not, i.e. he cannot observe how many other bidders are still holding down their buttons or at which level of the standing bid other bidders have quit the auction. Thus each bidder's problem is to decide when to release his button. Suppose that each bidder releases his button at a standing bid equal to his bid in the SPS-Rosca auction. If all bidders follow this rule, the payoffs to all participants are equal in the SPS and the OA-Rosca auction. Further, since, during the button auction, by assumption, a bidder does not obtain any further information than a bidder of a SPS-Rosca auction has, the reduced normal form games corresponding to the second-price sealed bid and the oral ascending bid Rosca auction are identical. Thus they are strategically equivalent, which implies that the equilibrium of the SPS-Rosca auction is also an equilibrium of the OA-Rosca auction.

Even when there are more than two bidders in a Rosca auction, the assumption that, in the course of the bidding, a bidder of an OA-Rosca auction does not obtain any further information than a bidder of a SPS-Rosca auction can be justified by the observation that, in the former auction, at any level of the standing bid, it is usually not clear how many bidders are still in the auction and whether any of the bidders has already quit the bidding process because Rosca auction records show that often a bidder raises the standing bid for the first time after the auction has already gone on for many thousands of Rupees. The problem that, in contrast to a button auction, bidding increments in an OA auction are of a discrete nature, should be negligible since auction records indicate that, before the bidding stops, bidding increments are usually as small as 0.1 to 0.2% of the amount in the pot.

2.2 Non-altruistic Bidding Equilibrium

Before the auction in the first round, each bidder observes the revenue of his investment project, r_k, $k = 1, 2$. Let us consider bidder 1, say, who is confronted with the other participant bidding according to the function $b(r_2)$, which is strictly increasing in r_2. Suppose bidder 1 also adopts the bidding function $b(\cdot)$, but that he has the option to pretend not to have observed r_1 but ρ, say.

If he submits $b(\rho)$ and wins the auction, then, provided he invests the funds obtained from the Rosca, his expected utility is $U^w(\rho \mid r) \equiv 2mr - cE[b(R) \mid R < \rho]$, where, for notational convenience, we have written r instead of r_1. $2mr$ is his utility from engaging in the investment project with profit r. $E[b(R) \mid R < \rho]$ is the expected value of the bid submitted by bidder 2 conditional on the event that bidder 2 bids higher than $b(\rho)$. Of course, if $b(\cdot)$ is strictly increasing, as we have assumed, the events $b(R) \le b(\rho)$ and $R \le \rho$ are identical. Since, in expectation, bidder 1 has to take a loan of $E[b(R) \mid R \le \rho]$ to finance the costs of the investment, we have to subtract $cE[b(R) \mid R \le \rho]$ from the profit of the investment project. If bidder 1 wins the auction then, in the second round, he cannot receive the pot and thus, in this case, his expected utility from the second Rosca round is zero. The probability of winning the auction is $P^w(\rho) \equiv P(R \le \rho)$. Note that, strictly speaking, we would also have to subtract m, the contribution each participant has to pay at the beginning of each meeting, from $U^w(\rho \mid r)$. Since, however, after joining the Rosca, each participant has to pay m at every meeting irrespective of the auction outcome, this is not relevant for the strategic analysis.

At this stage, we have assumed that, in a symmetric bidding equilibrium, it is always advantageous for the winner to invest the funds obtained from the Rosca instead of consuming them. Note that, in our sample, consumption is never cited as the purpose Rosca funds are used for. Since it is also essential for solving the model that winners never consume these funds, we will now formally rule out the possibility that, after an auction, a winner prefers to consume. Towards this end, we first define the vector of parameters $\beta \equiv (\theta, \lambda, c, \delta, m)$. Assuming symmetric bidding, in this notation, a preference for investing the funds over consuming them for all possible realizations of R, requires that

(1) $$2mr - cb(r) > 2m - b(r) \text{ for all } r > \lambda.$$

Rearranging (1), we can now define

$$B(b(\cdot)) \equiv \{\beta\text{: } b(r) < 2m(r\text{-}1)/(c\text{-}1) \text{ for all } r > \lambda\}.$$

In words, given $b(\cdot)$, B is the subset of parameters which ensure that (1) holds.

If bidder 1 submits $b(\rho)$ and this turns out to be the second highest bid submitted, his expected utility is $U^l(\rho) \equiv b(\rho) + EU^l$. In this case, his bid is the price the winner pays and this price is paid to him, bidder 1, as the loser of the auction. EU_t^l is the expected utility from receiving the pot in the second round without a discount, $2\delta E[R]$. The probability of submitting the second highest bid, if bidder 1 pretends to have observed ρ, is $P^l(\rho) \equiv P(R > \rho)$.

Consequently, the expected utility of bidder 1 before submitting his bid is given by

(2) $$U(\rho \mid r) \equiv U^w(\rho \mid r) P^w(\rho) + U^l(\rho) P^l(\rho).$$

To derive the symmetric Bayes-Nash equilibrium of such an auction, we determine how an infinitesimal change in the pretended return ρ affects expected utility. To this end, we take the derivative of (2) w.r.t. ρ to obtain

(3) $$\frac{dU(\rho \mid r)}{d\rho} = \left(1 - F(\rho)\right) b'(\rho) + f(\rho)\left(2mr - EU^l - (1+c)b(\rho)\right).$$

For notional convenience, we have dropped the parameters θ and λ, on which F depends. In equilibrium, nothing can be gained from pretending a different return than the one actually observed. Formally, we equate the RHS of (3) with r substituted for ρ to zero. This gives a first-order differential equation,

$$(4) \qquad b'(r)\big(1-F(r)\big) = f(r)\big((1+c)b(r) + EU^l - 2mr\big),$$

whose solution is

$$(5) \qquad b^e(r) \equiv \left(2mr - EU^l + 2m\int_r^{\bar{r}} \left(\frac{1-F(t)}{1-F(r)} \right)^{1+c} dt \right) / (1+c),$$

where $\bar{r}$ marks the upper bound of R's support. The symmetric bidding equilibrium is summarized in

Proposition 1

For parameters $\boldsymbol{\beta} \in B(b^e(\cdot))$, a Rosca with second-price auctions has a symmetric bidding equilibrium in which each bidder determines his bid according to the function $b^e(\cdot)$.

A more detailed discussion of $b_t^e(\cdot)$ follows in the next subsection.

In equilibrium, ex ante expected utility from joining a Rosca, $EU(b^e)$ say, is obtained as $E[U(R\,|\,R)]$, where $U(\cdot|\cdot)$ is given in (2). This can be written as

$$(6) \qquad \begin{aligned} EU(b^e) &= \frac{1}{2}\big(2mE[R_{2:2}] - cE[b^e(R_{1:2})]\big) + \frac{1}{2}\big(E[b^e(R_{1:2})] + EU^l\big) \\ &= \big(E[R_{2:2}] + \delta E[R]\big)m - (c-1)E[b^e(R_{1:2})]/2, \end{aligned}$$

where $R_{i:n}$ denotes the i'th lowest order statistic in a sample of size n. Ex ante, winning and losing the auction in the first round is equally likely and the winner's profitability is distributed as the higher order statistic of an iid sample of 2 random variables drawn from F. The price obtaining in the auction, in contrast, is determined by the lower order statistic of that sample. The term

$(c-1)E[b^e(R_{1:2})]/2$ represents the strategic costs which bidding entails when outside credit is costly.

2.3 The Notion of Overbidding in Rosca Auctions

It is well known that, in a standard SIPV second-price sealed bid auction, each bidder submits his maximum willingness to pay for the item auctioned. For obvious reasons, this dominant strategy is also referred to as 'truth-telling'. For the bidding equilibrium of an OA-Rosca auction, in contrast, Klonner (forthcoming) has shown that, when participants are risk averse and use Rosca funds for consumption, bidders overbid relative to their maximum willingness to pay. We will now analyze this point in the context of the present model. To this end, we first need to determine a bidder's maximum willingness to pay in a Rosca auction as a function of his observed profit r, $b^0(r)$ say. First consider a standard SIPV auction and a bidder whose valuation for the item auctioned is υ. By definition, this bidder's maximum willingness to pay for the item is found by equating the utility from winning the item at a standing bid of b^0, $U^w(b^0|\upsilon) \equiv \upsilon - b^0$, with the utility from losing the auction at the standing bid b^0, $U^l(b^0|\upsilon) \equiv 0$, which gives the well-known result $b^0(\upsilon) = \upsilon$. Applying the same reasoning to a Rosca auction gives $2mr\text{-}cb^0 = b^0 + EU^l$ and thus

$$(7) \qquad b^0(r) = \left(2mr - EU^l\right)/(1+c) = b^e(r) - 2m\int_r^{\bar{r}} \left(\frac{1-F(t)}{1-F(r)}\right)^{1+c} dt/(1+c).$$

That is, in the bidding equilibrium defined in Proposition 1, a bidder observing r adds $2m\int_r^{\bar{r}} \left(\frac{1-F(t)}{1-F(r)}\right)^{1+c} dt/(1+c)$ to his maximum willingness to pay to determine his bid. In this sense, Rosca bidders 'overbid' (like bidders in a standard SIPV first-price auction underbid).[4] In accordance with the literature on standard auctions, we will refer to bidding $b^0(r)$ as 'truthful bidding' throughout the rest of this paper.

The extent of overbidding is decreasing in c because high costs of outside finance make winning at a price higher than $b^0(r)$ more painful. Another implication of overbidding is that a bidder may win the auction at a price at which he would ex post prefer not to have won, which can be interpreted as a winner's curse from overbidding. This happens whenever $b^e(r_{1:2}) > b^0(r_{2:2})$, which is always the case when $r_{2:2}$ is sufficiently close to $r_{1:2}$. This feature of the model is in line with casual evidence from the field study, where organizers reported more than once that, after the end of an auction, the winner wanted to renegotiate the auction outcome saying he had not meant to bid so high and actually had no use for the money in that period.

Notice that, in the light of (6), overbidding as implied by the Nash Equilibrium increases the expected winning bid and thus the strategic cost of bidding, which reduces participants' ex ante expected payoff from the Rosca.

2.4 Bidding Equilibrium with Altruism

In the environment in which our sample Roscas operate, there are good reasons to expect departures from the just derived private information, one-shot bidding equilibrium. As described in Section 1, in these Roscas, information may be – at least in part – public, bidders interact repeatedly as documented by the number of Rosca cycles a given group has completed before the Rosca that is in the dataset, organizers have a concern that bidding in their groups is not excessive, and individual behavior in Rosca auctions likely affects a participant's reputation

[4] Outside the Rosca context, second-price auctions where the winning bid is distributed among the losers of the auction have first been investigated by Engelbrecht-Wiggans (1994). He does

outside the Rosca within the village. Such factors may mitigate the strategic costs of bidding and thus increase the expected utility from Rosca participation. A natural way to incorporate such considerations is to add a notion of altruism to the bidding model of Section 2.2.

To this end, we modify equation (2) to

$$(8) \qquad U^A(\rho\,|\,r) \equiv \left(\left[U^w(\rho\,|\,r) + \mu E[\tilde{U}^l(\rho)]\right]P^w(\rho) + \left[U^l(\rho) + \mu E[\tilde{U}^w(\rho)]\right]P^l(\rho)\right)/(1+\mu),$$

where $E[\tilde{U}^l(\rho)] = E[b(R)\,|\,R<\rho] + EU^l$ and $E[\tilde{U}^w(\rho)] = 2mE[R\,|\,R>\rho] - cb(\rho)$ is the expected utility of the other bidder in case he loses or wins the auction, respectively. In the sequel, we will refer to both positive and negative values of μ as 'the altruistic case', although the latter in fact implies a higher utility when the other bidder is made worse off.

Now the first order condition can be written as

$$(9) \qquad (1-\phi)b'(r)\big(1-F(r)\big) = f(r)\big((1+c)b(r) + EU^l - 2mr\big),$$

where $\phi = (c-1)\dfrac{\mu}{1-\mu}$. Even without deriving the solution to this differential equation, it can be seen from (9) how altruism affects bidding. Obviously, for $\mu = 0$, that is in the absence of altruism, (9) is equivalent to (4), the first order condition derived in Subsection 2.2. More interestingly, for ϕ equal to unity, that is for $\mu = 1/c$, (9) degenerates to an algebraic equation with solution $b(r) = \big(2mr - EU^l\big)/(1+c)$, which is equivalent to the bidder's maximum willingness to pay for the pot, $b^0(r)$. Thus, for μ reciprocal to the cost of outside funds, truthful bidding is the Nash Equilibrium. The reason is that, in this case, the marginal gain from overbidding through a higher side payment when losing the auction, $b'(r)$, is just equal to the

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not address the issue of overbidding, however.

marginal disutility caused by the marginal cost which the other, winning, bidder has to incur, $\mu c\, b'(r)$.

The solution to (9) is

$$b^A(r) \equiv \left(2mr - EU^l + 2m\int_r^{\bar{r}} \left(\frac{1-F(t)}{1-F(r)} \right)^{\frac{1+c}{1-\phi}} dt \right) / (1+c). \tag{10}$$

Defining $\beta_\phi \equiv (\theta, \lambda, c, \delta, m, \phi)$ and $B_\phi(b(\cdot)) \equiv \{\beta_\phi: b(r) < 2m(r\text{-}1)/(c\text{-}1)$ for all $r > \lambda\}$, this bidding equilibrium is summarized in

Proposition 2

For parameters $\beta \in B(b^A(\cdot))$ *and* $\phi \geq 0$,

(i) *a Rosca with altruistic bidders and second-price auctions has a symmetric bidding equilibrium in which each bidder determines his bid according to the function* $b^A(\cdot)$.

(ii) *bids are strictly decreasing in the extent of altruism,* $\partial b^A(r)/\partial\phi < 0$ *for all* $r < \bar{r}$.

The way interim utility in (8) is normalized, ex ante expected utility in the presence of altruism is completely analogous to the non-altruistic case (eq. (6)) with only b^A substituted for b^e. We thus have

Proposition 3

For $c > 1$ *and* $\phi \geq 0$, *ex ante expected utility from Rosca participation is strictly increasing in the extent of altruism,* $\partial EU(b^A)/\partial\phi > 0$.

3 STRUCTURAL ESTIMATION OF ROSCA AUCTIONS

In this section, we first derive a structural econometric model from the theoretical benchmark model that was developed in Section 2.4. Although the literature has recently made considerable progress in the field of nonparametric identification of auction models, structural estimation seems inevitable in the present case because, in our dataset, not any two observations are identically distributed, flawing any attempt to conduct reduced form inference. Subsection 3.2 discusses some issues of econometric methodology relevant for the structural estimation of Rosca auctions while the third subsection presents the results. The whole section is organized such that readers who are less concerned with the econometric details may skip Subsection 3.2.

3.1 Estimation Strategy

The goal of the empirical exercise is to identify which factors influence the welfare participants derive from participating in a Rosca. As outlined above, bidding involves a social cost from an ex ante perspective whenever *c*, the cost of funds from outside the Rosca, is bigger then unity. While a framework that defines a unique bidding equilibrium for each Rosca auction, such as the private information, non-altruistic model of Section 2.2, does not have room for identifying such factors, the altruistic model of Section 2.4 with a continuum of equilibria, which can be unambiguously welfare-ranked, does.

For the estimation, we first need to specify a distribution function *F*. For the exponential distribution with shift parameter λ and scale parameter θ, $F(r) = 1\text{-Exp}[-(r-\lambda)/\theta]$ with $r > \lambda$, the equilibrium bid function b^A given in (10) is linear in *r*, in particular

$$b^A(r) \equiv \frac{1}{1+c}\left(2mr - EU^I\right) + (1-\phi)\frac{2m\theta}{(1+c)^2}. \qquad (11)$$

Notice that, as in the general case, $b^A = b^e$ when $\phi = 0$ and $b^A = b^0$ when $\phi = 1$. In words, ϕ equal to zero represents the non-altruistic Nash Equilibrium, ϕ equal to one truthful bidding, and, as stated in Proposition 3, the higher ϕ, the higher the welfare from Rosca participation.

The estimation has to deal with auctions with varying numbers of bidders. Consider a Rosca with n participants and the auction in the t'th round with $\nu_t + 1$ bidders, say. One could think of a variety of ways how the payoffs to the other bidders in such an auction enter a given bidder's utility. We consider the case where the average of the payoffs to the other bidders weighted by a factor μ_t, say, enters a bidder's utility. Then

$$U_{t,i}^A(\rho \mid r) \equiv U_{t,i}(\rho \mid r) + \frac{\mu_t}{\nu_t} \sum_{j \neq i} E[\tilde{U}_{t,j}(\rho)]/(1+\mu_t). \tag{12}$$

We choose to normalize μ_t such that observed bidding behavior satisfies two conditions: (i) in the absence of altruism, that is for $\phi = 0$, bidders bid according to the non-altruistic Nash Equilibrium; (ii) for $\phi = 1$, bidders bid truthfully. This defines $\mu_t = \nu_t\phi / (\nu_t(c\text{-}1)+\phi)$ and we obtain

$$b_t^A(r_t) \equiv \frac{\nu_t}{1+c\nu_t}\left(nmr_t - EU_t^l\right) + (1-\phi)\frac{\nu_t(nm-z)\theta}{(1+\nu_t c)^2}. \tag{13}$$

In all of the sample Roscas, there is no auction in the second round, where the organizer receives the pot without a discount. In turn, he is not a bidder in any of the n-2 auctions that occur during the live of the Rosca. Further, in 9 of the 23 Roscas in the sample the organizer receives a fixed commission only in the last round and, in each auction, shares the winning bid equally with the auction's losers. We shall refer to this form of commission as 'variable commission'. Consequently, in the Roscas where the organizer keeps a fixed commission

$$\nu_t = \begin{cases} n-t, t>2 \\ n-2, t=1 \end{cases}, \tag{14}$$

while with a variable commission

(15) $$\nu_t = \begin{cases} n-t+1, t \geq 3 \\ n-1, t=1 \end{cases}.$$

The expected utility of a losing bidder from remaining active in the following auctions, EU_t^l, is obtained through the following recursion:

$$EU_{t-1}^l = \begin{cases} \delta(nm-z)(\lambda+\theta),\ t=n \\ \delta\left(\frac{1}{K}\left((nm-z)E[R_{K:K}]-cE[b_t^A(R_{K-1:K})]\right)+\frac{K-1}{K}\left(E\left[\frac{b_t^A(R_{K-1:K})}{\nu}\right]+EU_t^l\right)\right),\ t=3,4,\ldots,n-1 \\ \delta EU_t^l,\ t=2, \end{cases}$$

where, as above, $R_{j:l}$ denotes the j'th lowest order statistic in a sample of l iid draws from F and K the number of bidders in round t,

$$K \equiv \begin{cases} n-1,\ t=1 \\ n-t+1,\ t=3,4,\ldots,n-1 \end{cases}.$$

For the estimation, we will assume that all individuals have identical preferences, namely the same discount factor δ, that all individuals are confronted with the same cost for external funds c and the same lower bound of the revenue distribution λ, and that, in a given Rosca, bidders have the same extent of altruism and bid symmetrically. We will abstract from any problem that potential simultaneous participation in several Roscas and other forms of unobserved heterogeneity among the participants may cause. Such heterogeneity could be due to permanent individual characteristics such as different access to credit as well as considerations of Rosca group formation where, for example, an individual without a daughter who is due to marry soon would choose to join a group without any fathers of such daughters. These hypotheses, however, cannot be tested with our dataset, which does not contain information on bidders' identities.

In contrast, the objective of the econometric exercise is to detect differences in bidding across auctions in the dataset with a model of symmetric bidding as the benchmark. In this connection, n, m, z, K and ν can be viewed as exogenous control variables, while δ, c and λ are nuisance parameters. The key parameters in our analysis are θ and ϕ. Making these two parameters functions of Rosca- and auction-specific characteristics will allow us to identify the causes of differences in bidding across auctions. In particular recall that, for each Rosca in our dataset, we have information on the history of each Rosca group and the experience of the organizer. For each auction, moreover, we know the season, fall or winter, in which the auction took place, the purpose the winner used the funds from the pot for, and whether the information on the said purpose was private or public before the auction. To incorporate such effects into our hypothesized bidding function, we need to distinguish between permanent and transitory effects: we will call those characteristics permanent which affect the bidding function in each auction of a Rosca and which participants include into their expectations about future auctions in that Rosca. On the other hand, effects which affect only the bidding in one auction and which participants do not include into their expectations about future auctions in the Rosca will be called transitory.

Formally we write the bidding function and the expected utility of an auction's loser as functions of possibly different sets of model-parameters so that (11) becomes

$$b_t^A(r_t;\delta,c,\lambda,\theta_1,\phi_1,\theta_2,\phi_2) \equiv \frac{\nu}{1+c\nu}\left((nm-z)r_t - \widehat{EU_t^l}\right) + (1-\phi_1)\frac{\nu(nm-z)\theta_1}{(1+\nu c)^2},$$

(16)

$$\text{where } \widehat{EU_t^l} \equiv EU_t^l(\delta,c,\lambda,\theta_2,\phi_2).$$

Permanent characteristics are reflected by θ_1, ϕ_1, θ_2 and ϕ_2, while transitory characteristics only affect one auction and are thus reflected by θ_1 and ϕ_1 only.

Recall that, while θ is a parameter determined by nature, ϕ reflects the degree of altruism and captures deviations from the non-altruistic, private information Nash equilibrium. It thus characterizes bidders' strategic behavior. For the econometric model, we will therefore make θ a function of those effects that are exogenous to the bidders. These effects can be divided into two subgroups, namely (i) those that we will call strictly exogenous, such as seasonal fluctuations peculiar to the agricultural cycle in E with its two harvests per year, and (ii) those that we will call exogenous heterogeneity. This latter subgroup comprises characteristics that vary between the Roscas in our sample. As to (i), it has been mentioned in Section 1.1 that, for farmers in E, the autumn harvest yields about 50% more profit than the one in winter. Given a certain degree of impatience, the net present value in utility terms from the future revenues of a field plot should thus be higher after the winter than after the autumn harvest. Also, after an exceptionally bad harvest as it occurred in the fall of 1997, farmers cannot finance the inputs for the following growing season from the failed harvest's revenues. Given the marginal product of seedlings and fertilizers, however, one would expect a higher average return on Rosca funds after such a harvest if they are the only way to finance these inputs. As to (ii), we will use information on the experience of the organizer to control for exogenous heterogeneity between different Roscas. We therefore allow for the possibility that experienced organizers may select participants with different average revenues than less experienced ones. We will also use the contribution m as a proxy for the wealth of each Rosca's members, the idea being that a farmer's wealth may be correlated with the rate of return he can expect of an investment, e.g. because of higher managerial skills. Formally, we define

$$(17) \quad \theta_1 \equiv \theta_0 + \theta_m\,(m/1000\text{-}1) + \theta_{org}\,OE + \theta_{seas} + \theta_{972},$$

(18) $\theta_2 \equiv \theta_0 + \theta_m\,(m/1000\text{-}1) + \theta_{org}\,OE + \theta_{seas}$,

where OE is the number of Roscas an organizer claims to have completed before the one in the sample, θ_{seas} equals zero when the observation stems from an auction after an autumn harvest, and θ_{972} is a dummy on θ_1 for the failed harvest in the autumn of 1997.

Turning to the altruism parameter, we make ϕ a function of several permanent and transitory characteristics: of the permanent characteristics, we include the contribution and the organizer's experience to see whether the extent of overbidding is correlated with any of these variables. We also include the number of Roscas that the organizer has had with the group in the sample before, RB, to see whether there is anything like a learning curve from repeated interaction between the same participants. To allow for a more flexible shape of such a curve, we also include RB^2. To see whether a different commission regime, namely a share of the winning bid instead of a fixed commission for the organizer, affects bidders' behavior further than implied by the difference between (14) and (15), we include the dummy $\phi_{varcomm}$ for those nine Roscas that operate with a variable instead of a fixed commission regime. Transitory characteristics affecting ϕ are given by the information structure before each auction. In particular, we include a dummy for those auctions where the purpose of the auction's winner was known to the other bidders before the auction. The crucial point concerning all the variables that may affect ϕ is that, due to Proposition 3, a higher value of ϕ ceteris paribus increases the welfare of participating in a Rosca. Formally, we define

(19) $\phi_1 \equiv \phi_0 + \phi_m(m/1000\text{-}1) + \phi_{org}OE + \phi_{Rb}\,RB + \phi_{Rbsq}\,RB^2 + \phi_{varcomm} + \phi_{publ,marr} + \phi_{publ,nomarr}$,

(20) $\phi_2 \equiv \phi_0 + \phi_m(m/1000\text{-}1) + \phi_{org}OE + \phi_{Rb}\,RB + \phi_{Rbsq}\,RB^2 + \phi_{varcomm}$.

We have divided the public information cases in two subcategories, marriage (22 occurrences) and other than marriage purposes (14 occurrences), to test whether the common village wisdom holds that bidding is more moderate in the case of a publicly known 'emergency', which usually takes the form of a marriage, but less so if the winner needs the funds for a productive purpose. Thus, $\phi_{publ,marr}$ is a dummy which is different from zero only when the winner's purpose was publicly known before the auction and he used the money for a marriage or puberty function, while $\phi_{publ,nomarr}$ is a dummy which is different from zero only when the winner's purpose was publicly known before the auction and he used the money for some other purpose.

3.2 Econometric Issues

Since this paper is the first attempt to analyze Rosca auctions econometrically, we need to discuss some methodological issues concerning the estimation of standard auctions and relate them to the problems which the estimation of OA-Rosca auctions as modeled in this paper poses. In the existing literature on the parametric estimation of standard auctions, it is invariably assumed that each bidder's type υ is drawn from a hypothesized parametric distribution, H say. The major concern is whether the auction protocol is such that bidders tell the truth or not, since, if bidders tell the truth, the parameters characterising H can be estimated without further complication. If, like in standard first-price sealed bid or Dutch auctions, the bidding equilibrium does not involve truth-telling, however, observed winning bids in general depend on covariates and additional parameters, which enter into a bidder's hypothesized bidding function (see Hendricks and Paarsch, 1995). Since truth-telling is not an equilibrium of OA-Rosca auctions, the present estimation faces the same econometric problem as the estimation of standard first-price sealed bid and Dutch auctions.

Two parametric methods for the structural estimation of standard first-price sealed bid and Dutch auctions have been in use in the literature so far. First, generalized non-linear least squares, advocated by Laffont et al. (1995), and, second, the method of maximum likelihood, whose non-standard asymptotic properties have been derived by Donald and Paarsch (1996) and generalized by Hong (1999). We adopt the method of maximum likelihood (ML) because, first, it is much more efficient than the least squares approach, as Monte Carlo evidence by Paarsch (1994) indicates, and, second, the likelihood function for the (rather complicated) present structural econometric model behaves numerically better than the least squares objective function. ML estimation of the present model, however, suffers from a problem similar to the one analyzed by Donald and Paarsch (1996) and Hong (1999), namely, that parameters which determine the boundary of the distribution have to be estimated. This violates an assumption used to prove the standard asymptotic properties of maximum likelihood estimators (see Scholz, 1985). Donald and Paarsch (1996) consider first-price sealed bid and Dutch auctions with a finite upper bound of the support of the distribution from which the bidders' values are drawn. The difficulty arises from estimating this upper bound, α say, which, in the more interesting cases, is a function of covariates and a vector of further parameters, β say. As a remedy, they suggest to maximize the observed bids' log-likelihood subject to a set of inequality restrictions, which ensure that the estimator $\hat{\beta}$ is chosen such that none of the observed bids exceeds $\alpha(\hat{\beta})$. The asymptotics of $\hat{\beta}$ are not standard and involve extreme value theory. A key assumption of their analysis is that, evaluated at α, the density function corresponding to the values' distribution is bigger than zero.

In the present case, each observed bid in the dataset, b_j^w say, $j = 1,..., J$, where J is the total number of observations in the dataset, is a linear function of a random variable which is the second highest order statistic from a sample of K_j exponential random variables, $K_j \geq 2$. We write

$R_{K_j-1:K_j} \sim G_{K_j-1:K_j}(\cdot;\lambda,\theta_{1j})$, where θ_{1j} is defined as in (17) and $G_{k:K}(\cdot;\zeta,\gamma)$ is the distribution function of the *k*-th smallest order statistic from a sample of *K* random variables drawn from an exponential distribution with shift parameter ζ and scale parameter γ. By virtue of (11), B_j^w is distributed according to $G_{K_j-1:K_j}(\cdot;\eta_j,\omega_j)$, where

$$\eta_j = \frac{\nu_j}{1+c\nu_j}\left((n_j m_j - z_j)\left(\lambda + \frac{\rho_{1j}\theta_{1j}}{1+c\nu_j}\right) - \widehat{EU}_{t_j}^{l}\right) \text{ and } \omega_j = \frac{\nu_j(n_j m_j - z_j)}{1+c\nu_j}\theta_{1j},$$

where ρ_{1j} is defined as in (19) and $\widehat{EU}_{t_j}^{l}$ is a function of θ_{2j} and ρ_{2j}, which in turn are defined as in (18) and (20). Note that every variable which depends on the specific characteristics of the Rosca auction from which B_j^w had been sampled has been indexed with *j*. Defining $G \equiv G_{1:1}$ and *g* as the density function corresponding to *G*, the density of B_j^w can be written as

$$f_{B_j^w}(b) \equiv K_j(K_j-1)\big(G(b;\eta_j,\omega_j)\big)^{K_j-2}\big(1-G(b;\eta_j,\omega_j)\big)g(b;\eta_j,\omega_j)$$

(21)

$$= \begin{cases} 0, b < \eta_j \\ K_j(K_j-1)\omega_j^{-1}\left(1-\exp\left(-\frac{b-\eta_j}{\omega_j}\right)\right)^{K_j-2}\exp\left(-2\frac{b-\eta_j}{\omega_j}\right), b \geq \eta_j. \end{cases}$$

To highlight the methodological issues involved, consider the non-regression case of a sample of identically distributed winning bids and parameters η and ω that do not depend on covariates and further parameters. The log-likelihood for this estimation problem is

$$(22)\ \ell_K(\eta,\omega) \equiv \begin{cases} -\infty, b_{1:J} < \eta \\ J\log\big(K(K-1)\big) - J\log(\omega) + \sum_{j=1}^{J}\left((K-2)\log\left(1-\exp\left(-\frac{b_j-\eta}{\omega}\right)\right) - 2\frac{b_j-\eta}{\omega}\right), b_{1:J} \geq \eta. \end{cases}$$

Note that, for all $K \geq 2$, ML estimation is nonregular because the domain of B^w depends on η.

For $K = 2$, $\ell_K(\eta,\omega)$ is strictly increasing in η as long as $\eta < b_{1:J}$, which means that $\ell_K(\eta,\omega)$ does not have an interior maximum w.r.t. η.[5] Consequently, the ML estimator of η in this case is $b_{1:J}$. If, moreover, η is a function of covariates and further parameters, ML estimation poses the same econometric problem as the one considered by Donald and Paarsch (1996) and Hong (1999) and involves extreme value theory. For $K > 2$, on the other hand, it is readily verified that $\ell_K(\eta,\omega)$ has an interior maximum.

To put the present estimation problem into the context of the existing literature on nonregular ML estimation, we adopt Smith's (1985) notation. He considers probability densities of the form

$$(23) \quad f(b;\eta,\phi) = (b-\eta)^{K-2} h(b-\eta;\phi),\ \eta \leq b,\ K \geq 2,$$

where η and ϕ, the latter a vector, are unknown parameters and the function h tends to the constant $(K\text{-}1)\chi$ as $b \searrow \eta$. We then obtain

<u>Lemma 1:</u> *Let $g_{K-1:K}(b;\eta,\omega)$ denote the density function of the second highest order statistic from a sample of K random variables drawn from an exponential distribution with shift parameter η and scale parameter ω. Define $h_K(b - \eta;\ \omega) \equiv g_{K-1:K}(b;\eta,\omega)\ (b-\eta)^{2-K}$ and $\chi_K \equiv \lim_{b\downarrow\eta} h_K(b-\eta;\omega)/(K\text{-}1)$. Then, for all $K \geq 2$, $\chi_K = K\omega^{1-K}$.*

<u>Proof:</u> see the Appendix.

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[5] In fact, for $K = 2$, B^w has an exponential distribution with shift parameter η and scale parameter $\omega/2$.

Lemma 1 establishes that the non-regression variety of the present estimation problem is a special case of the nonregular class considered by Smith (1985), who shows that,

(i) if $K > 3$, the likelihood function has an interior maximum and the nonregular ML estimators $\hat{\eta}$ and $\hat{\omega}$ have the same asymptotic properties as in regular cases, i.e. both $\hat{\eta}$ and $\hat{\omega}$ converge at an order of $O(J^{0.5})$ to a bivariate normal distribution whose covariance matrix may be estimated consistently with the inverse of the observed information matrix. Moreover, Greene (1980) has generalized this result to the regression case.

(ii) if $K = 3$, the likelihood function has an interior maximum and the nonregular ML estimators $\hat{\eta}$ and $\hat{\omega}$ are consistent and asymptotically normal. While, for $\hat{\omega}$, the order of convergence is the usual $O(J^{0.5})$, $\hat{\eta}$ converges faster to the true value of η, namely at an order of $O\left(\left(J\log(J)\right)^{0.5}\right)$. Although the expected information matrix does not exist, the inverse of the observed information matrix is a consistent estimator of the asymptotic covariance matrix of $\hat{\eta}$ and $\hat{\omega}$.

(iii) if $K = 2$, the likelihood function does not have an interior maximum w.r.t. η. Instead, $\hat{\eta} = b_{1:J}$, whose asymptotic distribution can be derived using results from extreme value theory. For the regression case, Hong (1999) shows that the asymptotic distribution of ML estimators is not normal and quite complicated.

Our dataset includes observations with K ranging between 2 and 16. The bulk of observations, however, belongs to the first and second of the three just-mentioned categories (131 and 10 of 149, respectively). Since, for a sample where all $K_j \geq 3$, the likelihood function always has an interior maximum, we choose to drop those eight observations where $K_j = 2$ to ensure that the likelihood function has an interior maximum and that standard methods of asymptotic inference can be applied. Although, for the regression case, results on the asymptotic distribution of the ML estimators are not available when $K = 3$, we choose to also use the 10 observations in the second category for the estimation because, first, the applicability of standard methods of inference has been demonstrated by Smith (1985) for the non-regression case and, second, Monte Carlo experiments which I conducted with artificial data indicate that this result carries over to the regression case, at least for the present model.

3.3 Results

As explained in the previous subsection, for the estimation, we use all 141 observations in the dataset that stem from auctions with more than two bidders. Table 2 shows the distribution of these winning bids with respect to the date of the auction and the contribution. The seemingly irregular pattern of recorded winning bids over time is due to the fact that, in the second round of each Rosca, there is no auction and thus no winning bid recorded.

The estimation results are set out in Table 3. Our structural model performs well in that convergence of the numerical likelihood maximization occurs at reasonable values of the parameters without further calibration of the model.[6] Before discussing the results, we briefly turn to some diagnostics. First, and most importantly, residuals are not trending with respect to Rosca rounds, which means that the sequential structure of our model is capable of explaining the intertemporal pattern of observed bids successfully.

Another issue that needs to be addressed at this point is the assumption we have made in setting up the theoretical model, namely that an auction's winner always prefers to invest the

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[6] In contrast, in a static model with log-normally distributed private values, Laffont et al. (1995) encounter convergence problems in their attempt to structurally estimate Dutch auctions for eggplants among wholesalers in Marmande, France, which they only manage to overcome by fixing the value of the shape parameter of the log-normal distribution at some calibrated value, which they obtain by rules of thumb methods.

funds he obtains from the Rosca over consuming them (see eq. (1)). It is easily shown that, conditional on the revenue an auction's winner observes, $R_{K_j:K_j}$, this is the case whenever the winning bid realized in that auction does not exceed a certain threshold, $\tilde{b}_j(R_{K_j:K_j})$ say, where the subscript j in $\tilde{b}_j(\cdot)$ indicates that, for each observation in the dataset, $\tilde{b}$ depends on the realized values of the covariates. Note that $\tilde{b}_j(R_{K_j:K_j})$ may be smaller than $b^A_{t_j}(R_{K_j:K_j})$ for all $R_{K_j:K_j} > \lambda$, in which case our assumption on the use of Rosca funds would be supported by observation j without qualifications. With the point estimates reported in Table 3, the total probability that a winner wins the pot at a price higher than $\tilde{b}(R_{K_j:K_j})$, that is $P\left(b^A_{t_j}(R_{K_j-1:K_j}) > \tilde{b}_j(R_{K_j:K_j})\right)$, is zero for each observation in the dataset. Thus our assumption on the use of Rosca funds is consistent with the data.

Turning to the results, the estimates of both δ and c have a reasonable order of magnitude. If we take into account a rate of inflation of 4.6% from harvest to harvest (see Section 2.1), which enters δ in addition to pure individual impatience, then, after any harvest, individuals value the revenues in real terms from the following harvest about 5% less. To provide some intuition for the estimated value of c, suppose the winner of a pot had to finance the amount of the winning bid by a loan, which is repaid two harvests later and bears an interest rate of i per harvest. Since c measures the present value of all contemporaneous and future costs in utility terms, we obtain $c = 1 + i(\delta + \delta^2)$. Using this equation, we find a value of i of about 0.30. This is well in accordance with prevailing moneylender interest rates in E, which range between 3 and 5% per month. The point estimate of λ supports the working hypothesis made in Section 2.1 that the payoff for each Rupee invested be bigger than one, although, taking into account the estimated standard error, the hypothesis that λ is equal to or smaller than unity fails to be rejected at common significance levels.

Turning to the parameters of interest, note that λ-1+θ_0 measures the average profitability of an investment project after the autumn harvest for bidders in a Rosca with a contribution of Rs. 1000. The point estimates of λ, θ_0 and c imply that the utility cost of external funds are about 25% higher than the average profit of an investment project. The point estimates of the two parameters that measure strictly exogenous effects on θ, θ_{seas} and θ_{972}, both have the expected positive sign but are not significant at conventional levels. At the 5% level, the only significant source of exogenous heterogeneity is the amount of the contribution, which, as has been argued, serves as a proxy for participants' wealth. Taking together the point estimates of λ, θ_0 and θ_m, we find that participants in Roscas with a contribution of Rs. 5000 have access to investment projects whose average rate of return is about 24% higher than in Roscas with a contribution of Rs. 1000.

We now discuss the results pertaining to ϕ, which, as has been argued, matters for the welfare from Rosca participation. At first glance, the point estimate of ϕ_0 seems to suggest that, in the sample, there is in fact negative altruism, the T-statistic for the hypothesis $\phi_0 = 0$ being -2.79. Notice, however, that ϕ_0 is the value of ϕ for private-information auctions in Roscas where the organizer is completely inexperienced, receives a fixed instead of a variable commission, and the group has not completed any Rosca cycle before. Taking into account the average experience of Rosca organizers in the sample and the lower degree of overbidding in groups where the organizer earns a variable commission, we arrive at a value of ϕ of -0.42 for an auction with private information, which is different from zero by less than one standard deviation.

Turning to the Rosca-specific characteristics affecting ϕ in more detail, we included a dummy for those 9 groups that compensate the organizer through a share in the winning bid rather than a fixed commission. Note that, within the benchmark model, the presence of another member who shares the winning bid in each auction implies less overbidding than when there is a fixed commission. The point estimate of $\phi_{varcomm}$ points into the direction that this effect might be even stronger than implied by the theory.

The amount of the contribution, which serves as a proxy for participants' wealth, does not appear to affect the extent of altruism. On the other hand, we find a significant positive relationship between the experience of a Rosca organizer and the extent of altruism. Thus experienced organizers generate a higher welfare for their participants than newcomers. Not surprisingly, all organizers whom I interviewed pointed out that high bidding is bad for an organizer's reputation (see also observation 9 in Section 1.3). It was also pointed out that a high winning bid decreases a winner's motivation to follow up his obligations to pay future Rosca contributions and thus potentially causes the organizer trouble. Experienced organizers explained that they are in general very careful in the selection of new participants and that, when a Rosca ends, they would not invite those participants to new Roscas who regularly drive up the bid more than usual. On the other hand, some newcomer organizers in the village had the reputation of admitting more or less everybody to their Roscas. This selection process may also be the reason for the empirical observation that many individuals join a Rosca with a less experienced organizer although the welfare implications are likely to be known to them.

An interesting finding is the inverted U-shape of the relationship between the number of completed Roscas a group had run through before and the extent of overbidding. The estimates of ϕ_{Rb} and ϕ_{Rbsq} imply that, for a group which had three Roscas before, ϕ is about 4.76 bigger than for a group which had run through exactly one Rosca cycle before. Following the estimates, altruism is less strong in groups which had completed one Rosca cycle previously than in newly formed groups. After two Rosca cycles have been completed, however, the extent of altruism increases sharply with every further cycle completed.[7] This finding suggests that long lasting repeated relationships facilitate social gains, however, with the adjustment to such a favorable outcome taking a non-monotonic path.

The dummy for auction outcomes where the winner needs money for a publicly known marriage or puberty function has the expected positive sign and is significant at conventional levels. Averaging over commission regimes and organizer's experience, the point estimates imply a value of ϕ of about 0.5 for such auctions, and thus, compared to the private information equilibrium, a degree of altruism which corresponds to bids even below the maximum willingness to pay. Lower winning bids in such cases indicate that Rosca participants show a co-operative behavior, which is likely based on reciprocity and social enforcement. It is well known that when information on an individual's situation is publicly observable, self-enforcing reciprocal relationships can be implemented in a straightforward fashion (see Coate and Ravallion, 1993, for a theoretical analysis of bilateral consumption insurance). Organizers pointed out that it is considered improper behavior to raise the bid as usual when some other bidder has an 'emergency'.[8]

On the other hand, the significant positive dummy for the 16 observations with a publicly known purpose other than a marriage or puberty function at first sight contradicts the common wisdom in the village that a productive purpose should be always kept secret since otherwise other bidders would take advantage of one's desire to obtain the pot. It is, therefore, worthwhile to look at these observations in more detail. Only in two cases was the pot used for the purchase of a field, which is the most common use in the private information category. Other purposes

[7] If only a linear term is included, an insignificant estimate of 0.1 obtains.

mentioned are the purchase of a motor bike, starting a non-agricultural business, buying jewels and domestic use (one occurrence each). The bulk of winners in this non-marriage-public-information category, in contrast, needed money to repair their houses (6 occurrences) or settle debt (3 occurrences). It is likely that the need to repair one's house (which, in E, is mostly not a cosmetic, but a vital operation) and, in certain instances, also to repay debt is evident to other bidders and that therefore the auction outcomes in these cases reflect the same element of co-operative behavior based on reciprocity as those in the marriage-public-information category.[9]

4 Concluding Remarks

In this paper, the symmetric, independent private value bidder framework for the analysis of auctions has been applied to develop a novel stochastic model which reflects the basic features of bidding Roscas in a typical agricultural village of south India. We find that the non-altruistic equilibrium of this model involves a notion of overbidding because losing bidders benefit from a high price through a price-proportional side payment. Moreover, based on the empirical evidence that funds from the Rosca are used to overcome indivisibilities and that outside credit is costly for Rosca members, bidding creates a social cost of strategic behavior. Since village Roscas operate in an environment where repeated interaction between bidders occurs both within and outside the Rosca and where the information structure may change from auction to auction, we introduce altruism, whereby each bidder's utility is not only a function of the payoffs that occur to himself

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[8] On the other hand, Bouman (1979) reports such 'crafty' bidding practices when information on a bidder's need of funds is public.

[9] Inclusion of a dummy for the purposes renovating house and settling debt in private information auctions gives no significant result indicating that, in general, the revenue of the said purposes in utility terms appears to be similar to the more frequently-mentioned purposes under private information such as buying a field plot or livestock.

but also of the payoffs to all other bidders. We find that the extent of altruism positively affects the welfare derived from joining a Rosca.

We estimate a structural econometric model and find evidence that, on average, groups of experienced Rosca organizers act more altruistically than groups of newcomer-organizers, indicating that effective leadership positively affects the welfare of Rosca members. Moreover, in groups which have completed more than one Rosca cycle before, altruism is stronger than in Rosca groups with only a short history, which points to social gains from enduring relationships in an environment of private information.

Our data show that, in most of the auctions, information is private, especially when the funds from the Rosca are used for productive investment. On the other hand, when a bidder has a pecuniary emergency like the marriage of a daughter and this information is public within the village, auction outcomes display a stronger altruistic element than when information is private, which provides evidence for reciprocal risk sharing in an environment of public information.

This study shows that actual bidding Roscas succeed in accommodating several different financial needs that involve an amount of money which an individual could most likely not obtain from other sources such as the formal financial sector. It, moreover, illustrates how bidding Roscas allocate funds in an environment in which both private and public information are present and how repeated interaction among economic actors helps to reduce strategic costs. However, bidding Roscas as studied in this paper involve two major drawbacks: first, the auction protocol of oral ascending bids generates an incentive for bidders to overbid relative to their valuation, which in turn decreases the welfare from Rosca participation. Second, Roscas provide financial intermediation on a very small scale, in our dataset among ten to seventeen individuals at a time, which results in highly volatile auction outcomes. Our results suggest, however, that the auction protocol is crucial for the flexibility of a Rosca to respond to changing informational environments. Oral ascending bids enable participants to make exceptions from competitive bidding when a bidder has to meet an unforeseen expenditure and this information is public. The limited size of the group allows experienced organizers to limit the extent of bidding and facilitates gains from an enduring relationship when the same participants join the same Rosca group repeatedly.

In previous theoretical research on bidding Roscas among ex-ante identical individuals, it was assumed that participants observe all relevant signals before the beginning of a Rosca, that information is either completely private (Kovsted and Lyk-Jensen, 1999) or completely public (Besley et al. 1993, 1994), and that a Rosca is a one-shot game. Not surprisingly, these authors have found that the strategic costs which the auction allocation mechanism entails make a lottery allocation of funds superior and that, due to a more flexible payoff pattern, a credit market creates a higher welfare than a bidding Rosca. Our analysis shows that that these authors have missed the central features of a typical environment in which bidding Roscas operate, namely that participants receive new signals before each auction, that the information structure may change from auction to auction, and that repeated interaction plays an important role. While this paper does not compare Roscas with other financial institutions, it should serve as a point of departure for a more realistic comparison of the performance of different rural financial institutions and help to design optimal institutions under more realistic assumptions.

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Appendix

Proof of Lemma 1:

First note that $g_{K-1:K}(\cdot;\eta,\omega)$ is equal to $f_{B_j^w}(\cdot)$ as given in (21) with the subscript j dropped throughout. It is easily verified that the derivative of $g_{K-1:K}(\cdot;\eta,\omega)$ has the following property:

(24) $$\frac{\partial g_{K-1:K}(b;\eta,\omega)}{\partial b} = \omega^{-1}\left(K g_{K-2:K-1}(b;\eta,\omega) - 2 g_{K-1:K}(b;\eta,\omega)\right),\ K \geq 3.$$

Equation (24) may be used to prove the following representation of the L-th derivative of $g_{K-1:K}(\cdot;\eta,\omega)$ by induction.

(25) $$\frac{\partial^L g_{K-1:K}(b;\eta,\omega)}{\partial b^L} = \omega^{-L}\sum_{l=0}^{L}(-2)^{L-l}\binom{L}{l}\frac{K!}{(K-l)!}g_{K-l-1:K-l}(b;\eta,\omega),\ L \leq K-2.$$

Notice that $g_{K-1:K}(\eta;\eta,\omega) = 2/\omega$ if $K = 2$ and $g_{K-1:K}(\eta;\eta,\omega) = 0$ if $K > 2$. Together with (25), this implies that $\left.\frac{\partial^L g_{K-1:K}(b;\eta,\omega)}{\partial b^L}\right|_{b=\eta} = 0$, if $L < K-2$, and $\left.\frac{\partial^L g_{K-1:K}(b;\eta,\omega)}{\partial b^L}\right|_{b=\eta} = K!\omega^{1-K}$, if $L = K-2$. We can thus apply L'Hôpital's rule $(K-2)$ times to obtain $\lim_{b\downarrow\eta} h_K(b-\eta;\omega) = \lim_{b\downarrow\eta}\frac{g_{K-1:K}(b;\eta,\omega)}{(b-\eta)^{K-2}} = \frac{K!\omega^{1-K}}{(K-2)!}$. Recalling the definition of χ_K, the result stated in Lemma 1 follows immediately.

Table 1. The sample: some descriptive statistics.

	Minimum	Maximum	Mean	Std. Dev.
Rosca-specific characteristics				
Contribution (Rupees)	700	5000	2461.75	1544.37
Number of participants in the Rosca	10	17	11.80	2.43
Number of Roscas the group has run before the one from which the observation stems	0	3	0.90	1.03
Number of Roscas completed by the organizer before starting the one from which the observation stems	0	8	2.07	2.26
Auction-specific characteristics				
Round of the Rosca in which the auction took place	1	16	5.57	3.35
Private (= 0) vs. public (= 1) information before the auction	0	1	0.27	0.44
Season: Auction occurred after a winter (=1) or autumn (=2) harvest	1	2	1.52	0.50

Table 2. Frequency table of recorded auction outcomes used for the estimation.

date*→ m ↓	19922	19931	19932	19941	19942	19951	19952	19961	19962	19971	19972	19981	19982	19991	19992	20001	20002	Total
700	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	4
1000	1	1	1	2	2	2	2	3	3	3	5	4	5	5	4	2	1	46
2000	0	0	0	0	0	0	1	0	2	2	2	5	3	5	7	5	5	37
3000	0	0	0	0	0	0	0	1	0	1	2	1	3	3	3	4	4	22
5000	0	0	0	0	0	2	0	2	2	3	3	3	4	3	3	5	2	32
Total	1	1	1	2	2	4	3	6	7	9	12	13	16	16	18	17	13	141

* date=XXXXY, where XXXX = year, Y = 1 for winter harvest, Y = 2 for autumn harvest (e.g. 19952: autumn harvest of 1995)

Table 3. Estimation results.

Parameter		Estimate	STD #	T
δ	Individual discount factor	0.904	0.035	26.16*
c	Disutility per Rupee borrowed	1.519	0.575	2.64*
λ	Lower bound of the profitability distribution	1.264	0.576	2.20*
θ_0	Scale of the profitability distribution: intercept	0.163	0.057	2.85*
ϕ_0	Altruism parameter: intercept	-2.521	0.904	-2.79*
Rosca-specific characteristics				
θ_m	Change in θ as a function of the Rosca contribution	0.026	0.013	1.97*
ϕ_m	Change in ϕ as a function of the Rosca contribution	-0.174	0.179	-0.98
θ_{org}	Change in θ as a function of the organizer's experience	-0.009	0.005	-1.88
ϕ_{org}	Change in ϕ as a function of the organizer's experience	0.799	0.220	3.64*
ϕ_{Rb}	Change in ϕ as a linear function of the number of Roscas the group had before	-3.743	1.122	-3.34*
ϕ_{Rbsq}	Change in ϕ as a quadratic function of the number of Roscas the group had before	1.530	0.458	3.34*
$\phi_{varcomm}$	Dummy on ϕ for Roscas where the organizer shares the winning bid	1.174	0.664	1.77
Auction-specific characteristics				
$\phi_{pub,marr}$	Dummy on ϕ for public information, purpose = marriage	1.893	0.760	2.49*
$\phi_{pub,nomarr}$	Dummy on ϕ for public information, purpose other than marriage	2.704	1.073	2.52*
θ_{seas}	Dummy on θ for winter auctions	0.028	0.016	1.70
θ_{972}	Dummy on θ for the 1997 autumn auction	0.056	0.034	1.66

obtained from the empirical Hessian

* significant at the 5% level