Evaluation of Return and its determinants in Rotating Saving Credit Associations (ROSCAs)

Indu Choudhary

Assistant Professor, Department of Economics, Kalindi College, University of Delhi

Abstract

In this paper, we examine a particular form of informal credit institution known as Rotating Saving Credit Association, popularly called 'ROSCA'. A rosca is a revolving financial scheme where a group of individuals comes together to borrow and invest funds. Rosca serves as an important informal institution for people who either do not have access to the formal sector or are beleaguered by its insurmountable formalities, or find roscas more attractive options from an investment point of view. We examine the issues relating to returns from rosca and its determinants. Constructing a simple model of bidding in rosca auctions and using data on discount bidding roscas operating in two villages of Delhi, we find that shorter duration and lower denomination roscas yield higher returns for the savers, while longer duration and higher denomination roscas provide funds at lower rates of interest to the borrowers in rosca. We also compare returns from rosca with other formal and informal financial instruments and try to find a justification for the existence and persistence of this informal institution.

Keywords: rotating saving credit association, informal credit markets, bidding rosca, returns

1. Introduction

Credit markets universally are characterized by the presence of informational asymmetry. Lenders face problems of screening, incentive and enforcement (Stiglitz,1990) . These problems bother both informal lenders and formal institutional lenders but with varying degree of magnitude. In this paper, we analyze a particular form of credit market institution called the Rotating Saving Credit Association, more generally known as Rosca. Rosca is a unique financial instrument combining the features of both an investment instrument as well as a credit instrument. Roscas serve the role of financial intermediation for those who need money for exigencies and for those who are in search of a financial vehicle to park their savings and earn returns.

There is ample evidence to show that governments and reserve banks in developing countries struggle to mobilize savings of the household sector. The proponents of Gunnar Myrdal's vicious circle of poverty and the Lewis Model suggest that people in developing countries do not save enough. However, later research has disapproved this claim and as we shall show below people do save and save meaningfully in avenues that yield greater returns than the formal financial sector. The role of rosca as a financial intermediary assumes great importance in view of the limitations of the formal financial institutions in meeting saving and credit needs of a large fraction of the population, particularly comprising the poor in urban and rural areas. In fact, at times formal financial intermediation is not popular even among the better-off sections of society.

Different people join rosca with different motivations. While some join rosca to borrow, others join rosca to lend and earn interest on their savings. We provide an objective criterion to classify members as net borrowers and net savers in a rosca. With the methodology that we use, we were able to overcome the problem of generating multiple lending and borrowing rates that makes interpretation about returns from rosca difficult. Using this objective criterion, we classify members as net borrowers and net savers. We find a lot of variation in the interest rates across the two groups and also within the groups of net borrowers and net savers.

While there are volumes of work on moneylending[1], the empirical literature on roscas is relatively scant, especially that pertaining to the Indian context. Using data from roscas operating in two urbanized villages in Delhi, we examine returns in rosca and its determinants. The strategy for empirical estimation includes elicitation of risk and time preferences of rosca members from a field experiment using non-linear least squares, followed by reduced form regressions on individual returns using ordinary least squares.

2. Review of Literature

The interest of economists in roscas developed in the early 1990s with the work of Besley, Coate and Loury (1993). Using a theoretical model, Besley, Coate and Loury (1993) showed that individuals participate in rosca because rosca enables them to buy an indivisible durable good earlier than if they were to save on their own. This came to be known as the early-pot motive or the durable goods hypothesis.

Few years later, Calomiris and Rajaraman (1998) argued that not all people joined rosca for buying durable goods. They highlighted the existence of bidding roscas as evidence of this and suggested that a more important insurance role is provided by roscas, particularly amidst the poor in developing countries.

[1] See Basu (1984), Bell (1990), Ghate (1992), Banerjee (2001) for a review.

Aliber (2001) explored the possibility of people joining rosca to overcome their self-control problems. He argued that individuals are time-inconsistent and find it difficult to save alone. Rosca serves as an effective saving-commitment arrangement by way of which individuals can save and restrict themselves from unnecessary spending. This has been confirmed by several other studies like Gugerty (2007), Peterlechner (2009), Dagnelie and Boucher (2012). In fact, theoretical work by Ambec and Treich (2007) and Basu (2011) also shows that roscas are pareto-efficient saving-commitment devices.

The other interesting motive for joining rosca, particularly among females, is the intra-household conflict motive propounded by Anderson and Balland (2002). The authors examine rosca participation in a household decision framework. They show that in light of the minor bargaining power of a woman in a household but greater desire to save for household needs, rosca provides a safe avenue to the woman to park money and keep it beyond the reach of her husband who has a greater desire for immediate consumption. They conclude that participation in rosca improves the well-being of the household by increasing the overall household savings.

Anderson and Balland (2002) confirm the presence of this motivation among women participating in random roscas in slums of Nairobi. However, most studies do not find favor for this as the primary motive for joining roscas. Examples are Gugerty (2007) and Peterlechner (2009). In fact, using data from a field study in Benin, Dagnelie and Boucher (2012) dismiss this motivation by claiming that rosca participation is part of an individual wealth maximization mechanism rather than a household saving enhancing strategy.

We find that much of the empirical literature on roscas deals with the question of participation in roscas and the type of roscas: random, fixed and bidding. Some important studies in this regard are Besley and Levenson (1996), Anderson, Balland and Moene (2009), Dagnelie and Boucher (2005) and Tanaka and Nguyen (2009).

Besides, there is a strand in rosca literature that looks into the question of survival and sustainability of roscas, specifically random and fixed roscas. Major theoretical work on this is by Basu (2011) and Anderson, Balland and Moene (2003). Empirical studies on these are few: Handa and Kirton (1999), Anderson, Balland and Moene (2003) and Dagnelie (2007). The first one relates to banker roscas in Jamaica, the second one studies this in the context of random and fixed roscas while the last dwells on banker versus committee-run roscas.

Most other studies are descriptive studies explaining functioning of roscas in specific context and regions. Examples of these are Adams and de Sohonero (1989) on Bolivian roscas ‘Pasanakus’, Kirton (1996) on

Jamaican 'Partners', Aliber (2001) on South African 'Stockvels', Ghazali (2003) on Malaysian 'Kut' and Rogers (2006) on Nepalese 'Dhikuti'. Early anthropological works of Geertz (1962) and Ardener (1964) throw light on different variants of roscas existing in different parts of the world. Apart from this, roscas have held interest with sociologist and ethnologists like Anderson (1966), Kurtz (1978), Janelli and Yim (1988) and Smets (2000).

There are only a countable number of studies that examine bidding behavior in roscas like Besley, Coate and Loury (1993), Kovsted and Lyk-Jensen (1999) and Klonner (2003). Klonner (2008) studies the impact of interdependent preferences, that is, altruism on over-bidding in roscas. To our knowledge, it is the only empirical study on bidding behavior in roscas.

To summarize, we find that the literature on rocas has not kept pace with the growth in literature on other subjects. There is certain lop-sidedness in the number of empirical studies on roscas vis-à-vis theoretical ones. Moreover, studies dealing with issues related to bidding roscas are few both on theoretical side as well as empirical. The focus of this paper is to fill certain gaps in the rosca literature. Specifically, the objective of our study is to empirically investigate determinants of returns in roscas. Our study contributes to the literature on econometric estimation of rosca auctions that began with Klonner (2001). Our study is also related to the literature on discounting and risk attitudes, particularly, Benhabib, Bisin and Schotter (2010). Other related studies in this field are Holt and Laury (2002), Harrison et al (2002), Andersen et al (2008), Tanaka et al (2010), etc.

3. Estimating returns from roscas to savers, borrowers and organizers

3.1 Theoretical Model

We build a simple model of bidding in rosca keeping in mind the characteristic features demonstrated by the discount-bidding roscas that exist in Delhi. Since a discount-bidding rosca is a form of an auction, return that a participant earns from rosca depends on the bids submitted by the group. We therefore begin by outlining our bidding model. The set-up is as follows: n individuals join a discount bidding rosca to raise a lumpsum amount for investment in a project. All individuals contribute S per period to the rosca. Rosca contribution S is assumed to be exogenous. The rosca auction follows a symmetric independent private value auction framework. There are no enforcement issues. Members pay their contributions in time.[2] Social sanctions are strong and effective.

[2] We assume that the individual in all periods has money just sufficient enough to pay his net contribution for that period and no more to accommodate the assumption related to outside borrowing and to eschew any issue related to default.

The model is motivated by the fact that in practice individuals operate in an uncertain environment. Generally, at the time of joining a rosca, the individuals may be unsure of the project that they may want to undertake upon winning the rosca pot.[3] Besides, environmental conditions and individual circumstances are unlikely to remain static over the long course over which roscas operate.[4] Therefore, we relax the more prevalent assumption of individual project returns being generated once at the beginning of the rosca.[5] Instead, we assume that individual returns are independently and identically distributed both across individuals and across rosca rounds.

Specifically, we assume that in period t individual i can earn gross return $\mathrm{r}_\mathrm{i}^\mathrm{t}$ on his investment. As before, individual returns are private information. However, it is common knowledge that ex ante $\mathrm{r}_\mathrm{i}^\mathrm{t}$ is independently and identically distributed across different periods on the interval $[\underline{\mathrm{r}}, \overline{\mathrm{r}}]$ with $\underline{\mathrm{r}} > 1$. $\mathrm{r}_\mathrm{i}^\mathrm{t}$ has a continuous distribution F with density f, which is known to all agents.

In period t, upon learning about his r_i^t, an active member i submits a bid B_i^t in an oral ascending auction. The bid B_i^t is defined as the maximum discount individual i is prepared to offer to the rosca group in round t. The individual offering the highest discount wins the auction. Suppose member i wins round t. Being the winner, he makes a cumulative payment to the group which is equal to the bid submitted by him. Since winning bid in round t is denoted by $\tilde{B}_i^t$, each person in the rosca receives dividend equal to $\frac{\tilde{B}_i^t}{n}$.

Member i gets the rosca pot net of the total dividend paid. He receives $\left(S - \frac{\tilde{B}_i^t}{n}\right)$ from each of the n members. Therefore, in any round t where the winning bid equals $\tilde{B}_i^t$, the pool (including the winner's contribution) is equal to $n\left(S - \frac{\tilde{B}_i^t}{n}\right) = nS - \tilde{B}_i^t$.

The member who receives the pot gets excluded from the bidding process in subsequent rounds. However, he continues to get his share of dividend in subsequent rounds. This is the discount offered by the winners in those rounds. He, therefore, pays $(S - \frac{\tilde{B}_{-i}^j}{n})$ in round j where $\tilde{B}_{-i}^j$ is the winning bid in that round.

---

[3] Handa and Kirton (1999) find that 14 percent of their sample rosca households spent rosca funds on unplanned expenditures. This indicates the presence of a precautionary motive to save in roscas.
[4] In our field study, we witness discount bidding roscas with duration ranging from 10 to 25 months.
[5] The theoretical set-up in our paper closely follows Kovsted and Lyk-Jensen (1999).

Individuals instantly use the rosca pot (fund) for investment in a project.[6] This means that the period in which the individual invests in the project is the same as the period in which he receives the rosca pot. The project requires investment of P which is equal to the full amount of rosca fund, i.e. $P = nS$.

The pool obtained from the rosca is insufficient to meet the full amount of investment required in the project. The amount of funds required for investment is nS while the amount of funds that the individual has subsequent to winning the pot is equal to $\left\{(n-1)\left(S - \frac{\tilde{B}_i^t}{n}\right) + S\right\}$.[7] This produces a shortfall of $(n-1)\frac{\tilde{B}_i^t}{n}$ for period t winner. Individuals who do not raise sufficient resources for investment from the rosca raise the balance from elsewhere at cost $c \geq 1$, which is same for all agents and proportional to the amount borrowed.

The gross pay-off of individual i in round t is given by $\pi_i^t(r_i^t)$

$$= \begin{cases} (n-1)\left(S - \dfrac{B_i^t}{n}\right) + S - P + r_i^t P + (1-c)\left((n-1)\dfrac{B_i^t}{n}\right) & if\ \ B_i^t > max\, B_{-i}^t \\ -\left(S - \dfrac{max\, B_{-i}^t}{n}\right) & if\ B_i^t < max\, B_{-i}^t \end{cases} \tag{1}$$

Here, the upper term is the pay-off of individual i from winning the rosca pot in round t. This happens when the bid submitted by individual i in round t given by B_i^t is higher than the highest of bids submitted by his opponents in that round. The first term $(n-1)\left(S - \frac{B_i^t}{n}\right)$ is the amount of rosca fund that member i receives from other rosca members upon winning, the second term S is the per-period contribution which stays with him upon winning in this round, the third term P is the investment made in the project, the fourth term $r_i^t P$ is the gross return from investment, the last term is the shortfall in investment which is financed externally at cost c.

The lower term gives the share of dividend that member i receives upon losing the auction in round t and per period contribution S that has to be paid irrespective of winning or losing. Individual i loses the auction in a given round t whenever $B_i^t < max\, B_{-i}^t$ where the latter is the maximum of all bids submitted by potential bidders in round t, other than individual i.

[6] The model can account for the situation where rosca pot is used for consumption purposes.
[7] The first term is the amount he receives from other rosca members and the second is his contribution that remains with him in the period he wins.

In any round t, let all active bidders (other than i) bid according to the same monotonic strictly increasing bid function $\beta^t : [\underline{r}, \overline{r}] \rightarrow \mathcal{R}^+$ for all t and $\beta^t(\underline{r}) = 0$. Following Kovsted and Lyk-Jensen (1999), in equilibrium, it is optimal for member i also to bid according to β^t.

Since individual project returns are i.i.d. across rounds and individual bids are a function of project returns, the individual cares only about how his project return is placed relative to the project returns of other individuals that are bidding in that round. The earlier rounds and their realizations do not matter. This implies that in the oral ascending rosca framework assumed here, learning about the bids and therefore returns of bidders in previous rounds serves no useful purpose towards deciding on the bids in the current round.

The probability of member i winning round t by submitting a bid $B_i^t = \beta^t(z_i^t)$ is given by

$$\Pr\{B_i^t \geq \max B_{-i}^t\} = \Pr\{\beta^t(z_i^t) \geq \beta_t(Y_1^t)\}$$

$$= \Pr\{z_i^t \geq Y_1^t\}$$

$$= F_{Y_1^t}(z_i^t)$$

where $F_{Y_1^t}(.) = (F(y))^{n-t} = (F(y))^{k-1}$ denote the distribution of Y_1^t, the highest of the returns of individual i's competitors in round t. The probability of member i losing the auction in round t is $(1 - F_{Y_1^t}(z_i^t))$.

The expected pay-offs of member i with true return r_i^t from bidding B_i^t can be written as

$$E\pi_i^t(r_i^t) = F_{Y_1^t}(z_i^t) . \left\{ nSr_i^t - c\left((n-1)\frac{B_i^t}{n} \right) \right\}$$

$$+ (1 - F_{Y_1^t}(z_i^t)) . \left\{ \left(\frac{max\, B_{-i}^t}{n} \right) - S \right\} \tag{2}$$

$$= F_{Y_1^t}\left(\beta^{t^{-1}}(B_i^t)\right) . \left\{ nSr_i^t - c\left((n-1)\frac{B_i^t}{n} \right) \right\}$$

$$+ (1 - F_{Y_1^t}(\beta^{t^{-1}}(B_i^t))) . \left\{ \left(\frac{max\, B_{-i}^t}{n} \right) - S \right\}$$

Maximizing member i's expected payoffs $E\pi_i^t(r_i^t)$ with respect to B_i^t yields an equilibrium bid function as under:

$$B_i^{t^*}(r_i^t) = \frac{n(n-t)}{(n-1)c}\left[nS\int_{\underline{r}}^{r_i^t}\frac{Z\, f(Z)\, dZ}{F(r_i^t)} - \frac{max\, B_{-i}^t}{n} + S\right] \tag{2'}$$

When we introduce risk-aversion in the above model and suppose that a representative rosca member has a von-Neumann Morgenstern utility function $u(.)$ which is strictly increasing and strictly concave i.e. $u'(.) > 0$ and $u''(.) < 0$, we can show that differences in risk attitudes of participants in a rosca group result in submission of higher bids by individuals having higher degree of risk aversion.

Besides, introduction of a minimum bid or reserve price alters the equilibrium bidding strategy of member i such that he stays out of bidding whenever his true return falls below that discerned from the reserve price. In all other cases, the reserve price is not binding and the bidding strategy remains unchanged. Now that we have outlined our bidding model, we proceed to discuss the evaluation of returns in a rosca and provide the criteria for classification of rosca members as net borrowers and net investors.

In general, the cash flow of a rosca member who wins the rosca pot in round t of an n-period rosca are:

Round 1: $-\left(\mathrm{S} - \frac{\mathrm{B}_1}{\mathrm{n}}\right)$

Round 2: $-\left(\mathrm{S} - \frac{\mathrm{B}_2}{\mathrm{n}}\right)$

Round t: $-\left(\mathrm{S} - \frac{\mathrm{B}_t}{\mathrm{n}}\right) + \mathrm{n}\left(\mathrm{S} - \frac{\mathrm{B}_t}{\mathrm{n}}\right) = (\mathrm{n}-1)\left(\mathrm{S} - \frac{\mathrm{B}_t}{\mathrm{n}}\right)$

Round n: $-\left(\mathrm{S} - \frac{\mathrm{B}_n}{\mathrm{n}}\right)$

where, as stated earlier, n denotes duration of rosca, S is monthly contribution, B_t refers to the winning bid in any round t, and $\frac{B_t}{n}$ gives the share of dividend in round t, where round $t = 1,2, \dots, n$.

The *internal rate of return* (IRR) for rosca as a project is defined as that rate of interest or discount that makes value of the present worth equal to zero, i.e., $\hat{\imath}$ that solves $\mathrm{PW}(\hat{\imath}) = 0$. The cost of borrowing for the borrowers and rates of return for the savers and organizers in roscas therefore is obtained as solutions of $\hat{\imath}^*$ in the present worth equation $\mathrm{PW}(\hat{\imath}^*) = 0$ over the feasible range of $\hat{\imath}$, where

$$\mathrm{PW(i)} = -\left(\mathrm{S} - \frac{\mathrm{B}_1}{\mathrm{n}}\right) - \frac{\left(\mathrm{S} - \frac{\mathrm{B}_2}{\mathrm{n}}\right)}{(1+\hat{\imath})^1} - \frac{\left(\mathrm{S} - \frac{\mathrm{B}_3}{\mathrm{n}}\right)}{(1+\hat{\imath})^2} - \cdots + \frac{(n-1)\left(S - \frac{B_t}{n}\right)}{(1+\hat{\imath})^{t-1}} - \cdots - \frac{\left(S - \frac{B_n}{n}\right)}{(1+\hat{\imath})^{n-1}}$$

Rosca is an example of a non-cooperative zero sum game. This means that there will be some gainers and some losers. However, in the net, total gains will equal total losses. The gainers are the individuals who are investors and the losers are those who borrow in a rosca. It can be shown that, for the net borrowers, $PW(0) < 0$ and $\frac{dPW(\hat{\imath})}{d\hat{\imath}} > 0$ which implies a positive cost of procuring capital from the rosca. This is the price the net borrower pays for procuring an early pot. For the latter half who are termed as net investors, $PW(0) > 0$ and $\frac{dPW(\hat{\imath})}{d\hat{\imath}} < 0$, which yields a positive return from the rosca.

Conjecture 1: In an n -member rosca, if n is odd, members 1 to $\frac{n-1}{2}$ are 'net borrowers' over domain $(0,100)$. That is, for these members $\frac{dPW(\hat{\imath})}{d\hat{\imath}} > 0$ hold and $\mathrm{PW(i)} = 0$ has a unique solution. Members $\frac{n+1}{2}$ to n are 'net investors' i.e., for these members $\frac{dPW(\hat{\imath})}{d\hat{\imath}} < 0$ hold and $\mathrm{PW(i)} = 0$ has a unique solution over domain $(0,100)$. If n is even, members 1 to $\frac{n}{2} - 1$ are 'net borrowers' and members $\frac{n}{2} + 1$ to n are 'net investors' i.e., over domain $(0,100)$.[8]

The organizer represents a special case with $PW(0) > 0$ and $\frac{dPW(\hat{\imath})}{d\hat{\imath}} > 0$. The internal rate of return, $\hat{\imath}^*$, defined at $PW(\hat{\imath}^*) = 0$ for the organizer is unique and negative over the interval $(-1, \infty)$. Thus, we can term the organizer as a non-conventional investor in a rosca. the organizer's receipts from the rosca exceed the amount of payments made by him. So, the present value of the receipts does not equal the present value of payments even at an interest rate of zero. Moreover, since the organizer receives the pot in the beginning, a positive discount rate would

[8] This interval (0,100) is wide enough to accommodate the existing formal and informal credit market rates of interest in the real world.

further decrease the present value of sum of payments made by him during the rosca cycle, further increasing the present worth of his revenue stream. Thus, there cannot exist positive rate of interest that can make the present worth equation go to zero for the organizer. The only possible solution to $PW(i) = 0$ equation is a negative one. In other words, if the organizer throws away a part of the money received from rosca, he will still not incur any loss!

3.2 Empirical Model

The basic model that we estimate takes the following form:

$$\mathrm{Y_{irt}} = \beta_1 + \beta_2 \mathrm{X_{2i}} + \beta_3 \mathrm{X_{3r}} + \mathrm{u_i} \qquad (3)$$

where $\mathrm{Y_{irt}}$ is the dependent variable denoting the outcome of interest. The explanatory variables include $\mathrm{X_{2i}}$, a vector of individual characteristics, and $\mathrm{X_{3r}}$, a vector of rosca characteristics; $\mathrm{u_i}$ is the random error term.

The individual-specific explanatory variables included in X_{2i} are *Returns from project, Number of sources of outside credit, Individual risk aversion* and *Individual impatience.* The explanatory variables in X_{3r} are *Rosca Contribution, Duration, Reserve price, Bid increment, Opponent group risk aversion* and *Group impatience.* In addition, we have a set of individual-level covariates to act as controls: *Male, Age and Education.*

a. Expected direction of the effect of factors determining cost of borrowing for borrowers

- *Returns from project:* we expect a positive sign on the coefficient of this variable since individuals with investment projects will be willing to bid higher than those using the rosca pot for consumption purposes. Since the former group offers higher discount, therefore, their cost of borrowing the pot from rosca would be higher.
- *Number of sources of outside credit:* greater availability of outside credit has the effect of lowering the winning bid, thereby resulting in lower cost of borrowing from rosca. We expect the associated coefficient to have a negative sign.
- *Individual risk aversion* and *Individual impatience* are expected to have positive signs. Since risk aversion and individual impatience cause winning bid of the borrower to be higher, the cost of borrowing from rosca for him will increase with increases in individual risk aversion and individual impatience.

- Our conjecture is that an increase in group risk aversion and an increase in group impatience should increase the winning bid of the borrower and therefore his cost of borrowing from rosca. Likewise, bid increment and reserve price would lead to increases in the cost of borrowing. We therefore expect the coefficients of *Opponent group risk aversion, Group impatience, Reserve price* and *Bid increment* to be positive.
- We are not making any conjectures about the expected signs of *Rosca Contribution* and *Duration* since these variables enter into both the receipts and the payments of the present worth function of a net borrower.

b. Expected direction of the effect of factors determining returns to savers or investors from roscas

The dependent variable Y_{irt} in equation (3) now denotes the rate of return for saver i who wins the pot in round t of Rosca r (in annual percentage terms). It is the annual value of i^* which solves the equation $PW(i^*) = 0$ for the saver.

- *Returns from project;* a member who can earn higher returns from investment projects outside of rosca will be willing to forgo his returns from rosca. Since increasing project returns lead to higher winning bid, we expect individuals with investment projects to bid higher and have lower returns from rosca as compared to those who use the rosca pot for consumption and bid less aggressively. We therefore expect *Savers' return* to vary inversely with *Returns from project* and the associated coefficient to have a negative sign.
- *Number of sources of outside credit:* Greater availability of outside credit has the effect of lowering the winning bid, thereby increasing the returns to the savers. Therefore, we expect the sign of the coefficient of this variable to be positive.
- *Individual risk aversion* and *Individual impatience* will lead to higher winning bid for the saver, they are therefore expected to decrease returns to savers. The sign of the coefficients of these variables will be negative.
- Our conjecture is that group characteristics that cause higher cost of borrowing for net borrowers will lead to higher gains for net savers. We therefore expect *Reserve price, Bid increment, Group risk aversion* (an average of the risk aversion of the rosca group) and *Group impatience* to increase returns for the savers. Positive sign is expected to be associated with these variables.
- As before, since *Rosca Contribution* and *Duration* enter both the receipts and the payment side of the present worth function, we do not know a priori the likely impact of these variables. However, we can be sure that the effect of these variables for increasing borrowing costs for net borrowers

and increasing returns for net savers will move in the same direction in view of the reasons outlined above.

c. Factors determining returns to rosca organizer

The dependent variable in equation (3) in this case is the 'negative' internal rates of returns of the organizer (in annual % terms) of rosca r. As discussed above in Section 3.1, the internal rate of return for the organizer is negative. A more negative value of $\hat{\imath}^*$ in the present worth equation $PW(\hat{\imath}^*) = 0$ of the organizer is considered to be better.

Since organizer gets his pot without bidding, individual factors influencing his bid do not matter. His pay-off from rosca depends on the winning bids of other members. Other members' winning bids decide the amount of dividend he gets from rosca. Therefore, rosca-level variables assume importance. Moreover, group characteristics that cause higher cost of borrowing for net borrowers lead to higher gains for the organizer.

The explanatory variables included in the organizers' regression are:

- *Group returns:* it is the average of the kind of projects that members in a group undertake. Its value can range from 0 to 1. A value close to zero implies that the rosca money was mostly used for consumption by group members. A value close to 1 implies that it was used mainly for investment. If a higher percentage of group members use rosca funds for investment, their winning bids will be higher. This will translate into higher dividend for the organizer and thereby higher returns from rosca. Since the dependent variable is negative internal rate of return, we expect a negative sign on the coefficient of group returns.
- *Group risk aversion* will cause the winning bids of other members in the group to increase and will yield higher returns for the organizer. The sign of the associated coefficient of this variable is expected to be negative.[9]

[9] We are considering total group risk aversion instead of the opponents group risk aversion used in the bidding and cost of borrowing regressions because for the last winner, there are no opponents who bid.

- *Group impatience*: An increased level of impatience leads to higher winning bids in the group; this will increase organizers' returns from rosca. The associated coefficient will be negative.
- *Reserve price percent* (in %); it indicates the minimum dividend as a percentage of rosca pot that is assured to all rosca members. Also, an increase in reserve price percentage puts an upward pressure on the winning bids; it is expected to generate higher dividends for the organizer. So, we expect the coefficient of *Reserve price percent* to be negative.
- The other rosca-specific covariate is *Organizer's pot*; a dummy variable which takes the value 1 if the organizer picks up the pot in the second round and 0 if he takes the first pot. We expect a negative sign on this coefficient since bidding is likely to be more aggressive in the first round which means the dividend will be larger in the first round than the second. If the organizer takes the second pot, his dividends from rosca are expected to be larger and so are his returns.
- With respect to the variables *Contribution* and *Duration*, it is difficult to infer the likely signs of their coefficients as they affect both the receipts and the payments of the organizer. Unfortunately, theory does not provide a concrete answer to this question.
- *Bid increment* increases the winning bids in rosca. Therefore, organizers returns are increasing in bid increment. We expected the coefficient associated with this variable to be negative.

Lastly, we include some individual level variable as controls in the organizers' regression like *Male, Age, Education and Experience.*

4. Data and Methodology

The data for this study is based on a field survey in two villages in the Union Territory of Delhi. These two villages were selected through purposive sampling, based on availability of informants and willingness to participate in the survey. Informal roscas, popularly known as 'kameti' in Delhi, are required to be registered under Section 4 of the Chit Funds Act 1982. The Act specifically prohibits the conduct of chits that do not have prior sanction and are not registered under the Act with the Registrar of Chit Funds. In practice, however, most kametis operate informally and are not registered, despite the penalty they may attract for contravening the provision of mandatory registration under the Chit Funds Act 1982.

The two villages chosen for survey in this study were identified from a list of villages where people were relatively more willing to share information on the functioning of the roscas that they either operated or participated in. One of the sample villages is a rural village located in North Delhi, while the other is an urban village located in South Delhi. Delhi has 369 villages which are categorized either as urban or rural. According to the Delhi government records, 135 of these 369 villages are urbanized.

A complete enumeration of all rosca organizers in the two villages was done. While all 12 rosca organizers from village 1 willingly participated in the survey, 4 out of 28 organizers dropped out from the survey in village 2. Informed consent of both organizers as well as members was obtained for the survey and the experiment. Interview method was used for sourcing data from rosca organizers and participants. The data have been collated from three sources: the informally maintained records of rosca organizers, a structured interview of rosca members and a field experiment on risk attitudes and time preferences of rosca participants.

Our sample consists of 36 concluded roscas. These 36 roscas comprise 572 rounds covering 456 individuals. Data were collected at two levels: rosca level and participant level. The rosca level data contains information on denomination, duration, contribution, reserve price, bid increment, winning bid in each round, amount of dividend and the (unwritten) rules relating to functioning of roscas. The individual level data contains information on the demographic details of the members like gender, age, education, occupation and wealth level. In addition, information was sought on current rosca participation status, the use of rosca funds, the timing of picking up the pot and the credit needs of members. Table 1 presents summary statistics of the data using all observations (a few outliers are dropped in the estimation).

Individual risk aversion and time preference parameters are expected to play a key role in determination of winning bids and consequently, returns to participants. These parameters had to be estimated for each individual in our sample. In order to elicit these preferences, we conducted an experiment, following the technique employed in Benhabib, Bisin and Schotter (2010) as their technique allows us to measure both discount rates and risk attitudes through a single experiment. The experiment design of our study falls under the stated preference approach to discounting.

To estimate the risk aversion and time preference each rosca participant replied to a set of 30 questions. The questions were asked in the following form:

"What amount of money y will make you indifferent between an amount x paid to you today and an amount y paid t days from now?"

The amount x used in the questions was derived from the type of monetary choices over which rosca members usually decide. The x amounts are equal to either monthly rosca contributions or total rosca denomination. The amount of x varied from Rs. 1000 to Rs. 10 lacs and the duration of delay spanned over 3 days to 20 months. We intentionally included 20 months since that was the longest duration of roscas in our sample. These questions were asked hypothetically. Given the amounts involved, it was not possible to provide real incentives. Offering small sums or asking questions over small x amounts would have diluted the purpose.

For each individual i, we have a series of 30 observations in the form of pairs (y,t), $(x,0)$ which leave the individual indifferent. This means

$$x = y(x,t).D^i(y(x,t),t)$$

$D^i(y,t)$ represents exponential discounting if $D^i(y,t) = \exp\{-rt\}$ and it represents quasi-hyperbolic discounting if $D^i(y,t) = \alpha\exp\{-rt\}$ where $r > 0$ is the discount rate of individual i. In quasi-hyperbolic discounting, α represents present-bias. An individual is considered to be present-biased if $\alpha < 1$. Exponential discounting is a time-consistent discounting model which assumes that the rate at which individuals discount future pay-offs remains constant overtime. In contrast, quasi-hyperbolic discounting assumes that individuals are time-inconsistent. Since many studies in rosca literature like Gugerty (2007), Tanaka et al (2009) suggest the presence of time-inconsistency among rosca participants; we estimate a quasi-hyperbolic specification of discounting.

For econometric estimation, the above equation was suitably modified as follows to account for risk aversion (CRRA)[10]:

$$x^{\beta} = y^{\beta}(x,t).D^{i}(y(x,t),t) \quad (2)$$

where β is the coefficient of risk aversion. $\beta < 1$ implies risk aversion, $\beta = 1$ implies risk neutrality and $\beta > 1$ implies risk seeking.

We estimated the above equation under quasi-hyperbolic specification of discounting for each individual i. Since this equation (2) is intrinsically non-linear, it was estimated using non-linear least squares.

The estimates generated from the regression were daily rates. We converted these into effective annual rates for use in the final regression on returns. The formula used for this purpose was $R = ((1 + r)^{365} - 1) \times 100$. For obtaining discount rates for a rosca group, we took the average of the discount rates of individuals belonging to that particular group. Likewise, for getting the estimate for group risk aversion, we obtained the average of individual risk estimates of all rosca members in a particular group.

5. Results

The minimum duration in our sample of 36 roscas was 10 months; using the classification criteria outlined in Section 3.1 above, we find that borrowers are the top four ranks in the 10-month roscas. We therefore restricted the borrowers' sample to only the first four rounds in each rosca. This gave us a sample of 144 borrowers. Since the organizers enter rosca with a different motivation, the rounds in which the organizers take their pots are not included in the cost of borrowing regressions. This left us with a total of 108 observations. So, effectively the information relates to first three net borrowers from among the first four rounds in each rosca. In order to keep conformity with the borrowers' sample, we therefore use data on internal rate of return of 108 savers for investigating factors affecting returns to savers from rosca. The organizers' returns regression pertains to 36 roscas. Descriptive statistics relating to the borrowers, savers and organizers regression have been provided in Table 2, 3 and 4 of the appendix respectively.

---

[10] The utility function assumed here is $u(x) = x^{\beta}$, where $u' > 0$. It belongs to the class of CRRA utility functions.

a. Results on factors determining cost of borrowing for the borrowers

Results for the borrowers' regression are specified in Table 5. The rosca specific variables seem to be the most important determinants of cost of borrowing for net borrowers. Our empirical findings suggest that cost of borrowing is higher in roscas with smaller monthly contribution and shorter duration. *Cetris paribus,* an increase in monthly rosca contribution by Rs. 10000 is expected to reduce the cost of borrowing by about 4.4 percentage point per annum. On the other hand, an increase in the duration of rosca by a month results in a fall in the average cost of borrowing by 3 percentage point per annum. These are quite large effects given the mean cost of borrowing in a rosca of around 39 percent per annum. In fact, just the way bigger and long tenure loans from formal sector have lower lending rates; rosca which is an informal financial institution seems to offer a similar kind of deal to its member borrowers.

Moreover, we find higher reserve price and larger bid increments increase the cost of borrowing for net borrowers. This is evident from the positive and significant signs of the coefficients associated with these variables. These results point to the impact that presence of higher reserve price and higher bid increment has on the amount of bid submitted by players. While reserve price is generally not a binding factor in initial rounds, comparing across roscas of similar duration and similar contribution, roscas with higher reserve price for the same round is likely to attract a higher winning bid. The same is true for roscas with higher bid increments although bid increments do bind the level of bid that the next player can submit.

Statistically individual project returns and availability of credit from outside source have no bearing on the cost at which borrowers borrow from rosca. A joint F-test of individual characteristics such as gender, age and education indicates that these are also statistically insignificant. On the other hand, group characteristic of risk aversion reportedly has a significant positive effect on the borrowing costs in rosca. This implies that more risk averse the rosca group, higher would be the bids submitted by the players, higher therefore will be the winning bids and consequently the cost of borrowing from the rosca.

b. Results on factors determining returns for the savers in roscas

In a rosca, there is internal transfer of funds from savers to borrowers. Returns to savers are governed not only by the amount of discount at which they pick the pot, they crucially depends on the winning bids of the other members. Specifically, returns to savers depend on what borrowers pay as dividend to them. So, we expect that factors that affected the cost of borrowing for net borrowers would impact the savers' returns from rosca. It is not surprising therefore that savers' returns are higher in roscas that have smaller monthly contribution and are shorter in duration (See Table 6). *Cetris paribus,* a rosca with a 10000 rupees lower monthly contribution provides on an average, a 2 percentage point rise in returns to the savers; while roscas completing their cycle one month earlier result in a gain of 1.5 percentage points in the average returns to its saver members.

In addition, we find that higher bid increment leads to higher return for the savers. Bid increment is not a round-specific variable. It is same for all rounds in a rosca. But it is more constraining in certain rounds than in others. Since a higher level of bid increment increases the winning bids in different rounds, the dividend obtained by savers rises.

The impact of bid increment in raising the saver's own winning bid in last few rounds is not that large. Towards the end of the rosca cycle most pots are allocated at the reserve price. There is no effective bidding. Therefore, the amount of winning bid in these last rounds as a proportion of the rosca pot is much lower than the winning bid in the initial rounds. Hence, the effect of bid increment in raising dividends from other rounds is much stronger than its effect on raising the amount of discount that the saver pays on his rosca pot, thereby leading to a rise in the savers' returns.

Comparing the results of the borrowers' and the savers' regressions, we can infer that the group risk aversion that was leading to rise in cost of borrowing for borrowers is getting its effect from its influence on own winning bid of the rosca member. As pot allocation in the last few rounds of rosca occurs at the reserve price, the effect of the group risk aversion on winning bid and therefore on savers' return is seen to be absent. This explains the reason why group risk aversion and reserve price while significant in the borrowers' regression are not so in the case of savers' regression.

c. Results on factors determining returns to rosca organizers

We had stated above that the solution to the present worth function of the rosca organizer yields a negative value of internal rate of return. As discussed above in Section 3.1, this negative internal rate for the organizer is not a bad thing. The more negative the internal rate of return for the organizer, the better it is. A rosca organizer can never make a loss from his rosca operations unless of course some member defaults on his payments. Rather, he is the one who gains the most so much so that if he were to throw a part of this surplus, he would still not incur a loss.

Our dependent variable for the organizers regression in Table 7 is the negative internal rate of return earned by the organizer. We consider two specifications for analyzing organizers' returns. In the first specification, we have group –related variables like group project returns, group risk aversion and group impatience along with other rosca-specific characteristics like contribution, duration, reserve price etc. In the second specification, we control for individual characteristics of rosca organizers. The variables used are gender, age, education and experience.

Since the organizer gets his pot without bidding his project returns, his own risk aversion and impatience do not play a role in deciding his returns from rosca. It is the factors that influence bids in the group that matter; for the dividend that he gets is dependent on the winning bids of other rosca members.

We find group project returns, monthly contribution and duration to be significant in the first specification. The negative coefficient associated with project returns implies that a rosca group that uses rosca funds for investment purposes yields a higher return for its organizer. Roscas that have a larger number of members with investment projects have correspondingly higher winning bids, thereby generating greater dividends for the organizer and thus higher returns.

The variable group returns is positively correlated with the male dummy. Once we control for gender, we find group returns to be no longer statistically significant. In fact, the coefficient associated with male dummy is negative and significant suggesting that male organizers earn higher returns in rosca. Since rosca is one of the primary sources of income for most male organizers, they probably put more thought into successful operation of their rosca businesses.

88% of the roscas in the sample are same gender roscas. This means that roscas where the organizer is a male are more likely to have male members who as seen in the bidding regression tend to submit higher bids on an average, thereby yielding greater returns for the organizer. Additionally, males are more likely to use rosca funds for investment.

We also find that more aged rosca organizer earn higher returns from rosca. Controlling for experience of rosca organizers, this result suggests that aged rosca organizer might be putting their higher social capital into use for forming rosca groups with an optimal combination of borrowers and savers such that their returns from rosca are maximized.

Returns for the organizer are decreasing in the level of monthly contribution and duration. This result is expected because as seen from the borrowers' regression, cost of borrowing for borrowers is higher in smaller contribution and shorter roscas. Since the payments made by borrowers on their loans is enjoyed as dividend by all other members including the organizer, therefore, organizer returns are bound to be high in roscas that have small monthly contribution and shorter length. We find the effect of these two variables to be robust across the two specifications.

In the full model i.e. the second specification, we find the coefficient associated with reserve price percent to be negative and significant. The reserve price percent denotes the minimum percentage of dividend that can be earned by members in a rosca since the winning bid cannot be less than the reserve price in any given round of rosca. This implies that a higher reserve price percent ensures higher dividends for the members including the organizer. These higher dividends in turn contribute to higher returns for the rosca organizer.

We had expected that group risk aversion and group impatience would increase the returns for the organizer by increasing bids of other rosca members. However, statistically there seems to be no effect of these variables in determining returns for the rosca organizer.

To sum up, organizers of smaller contribution and shorter duration roscas earn much higher returns than other rosca organizers. Moreover, rosca organizers gain by fixing a higher reserve price in their roscas. Further, male and more aged rosca organizers reap higher returns from rosca.

6. Discussion and Conclusion

We find that the average rate of interest for borrowers in roscas is 38.72% per annum. This is much higher compared to the interest on bank loans which is about 12% per annum but is lower than the average interest rate charged by professional moneylender which is about 52% per annum.[11] Interest rate on rosca loans is comparable and in most cases less than the rate of interest on microfinance loans that are available at rates of interest ranging from 30-70% per annum.[12]

Individuals who participate in roscas usually fail to meet the eligibility criteria for a bank loan. So, in effect, the rate of interest on a loan from bank is close to infinity for these individuals. In such a scenario, rosca appears to provide loan to borrowers at cheaper rates. Besides, banks refrain from giving consumption loans in absence of any physical collateral. We find that nearly 43% of the rosca members in our sample utilized rosca money for consumption purposes.

Also, small ticket size loans are difficult to service for banks. In our sample, 20% of the members participate in roscas of denomination less than Rs. 1 lac which is suggestive of the small-sized loan requirements of these members. Small loans are hard to service by banks since the cost of loan administration is higher for small-sized loans.

Chit Funds offer an alternative option. The imposition of 30 percent cap on bidding considerably brought down the rates of interest for the chit fund borrowers.[13] However, participation in regulated roscas requires fulfillment of certain criteria like furnishing personal sureties of at least two salaried persons working with a state/ central government/ public limited company/ bank and other reputed companies, or deposits of title deeds of urban property etc. which often are difficult to comply with by the kind of people who participate in informal roscas.

We must highlight that the natives of our sampled villages do not have documents that can prove their legal entitlement over their houses. The reason is that the houses in which the village people reside fall in the so-called 'lal dora'.[14] As a result, they cannot use their immovable properties as collateral.[15]

[11] Summary Report on Informal Credit Markets in India (Dasgupta, 1989).
[12] Asian Development Bank Report (Fernando, 2006).
[13] Eeckhout and Munshi (2010).
[14] The term 'lal dora' was first used in 1908 by the land revenue department who used a red thread or lal dora for marking a boundary between the village agricultural land and the village 'abadi' or inhabitation. As per Delhi Municipal Corporation Act 1957, lal dora is exempt from building bye-laws and strict construction norms and regulations.
[15] Properties built on lal dora land are not recognized by MCD and DDA. Since there is no registry available for such properties, banks do not provide home loans to owners of such properties. Furthermore, individuals residing in these properties cannot use them as collateral for any other loan too.

For the net savers, we find that the rate of interest earned in a rosca is much higher around 23.56% per annum. It is much higher than the interest rates on deposits offered by formal financial institutions. The best rate of interest in the formal sector if offered on recurring deposits which is about 9% per annum. Parking money in equities and mutual funds is an option but equity and debt markets are more sophisticated financial institutions usually beyond comprehension of the kind of people who normally participate in roscas. In our sample, 86% of the rosca participants have education no more than class 12.

Another virtue of rosca as a saving instrument is that it offers flexible saving scheme to people with different saving abilities. We observed that savings in roscas varied from Rs. 1000 to Rs. 1 lac per month.

Also, rosca instills a sense of saving discipline since individuals have to make contribution on a regular basis. This in part is facilitated by the fear of social sanctions and threat of future exclusion which holds credence in the setting that we study.

Though there is risk for lower ranks in roscas since the (technical) possibility of earlier winners exhibiting moral hazard exists, it is partly mitigated by a careful choice of members in the group.

A rosca organizer bears the maximum risk in a rosca. Almost all roscas hold the organizer responsible for making timely pot payment to all rosca members irrespective of the fact that there might be late payments of contribution from some members. This is true even when a member defaults after procuring the pot.[16] It is to compensate for this huge risk that rosca organizers are awarded the full amount of pot in the beginning only.

We find that maximum gains accrue to the organizer in a rosca. Supposing that the rosca organizer parks his lump sum in a fixed deposit in a bank earning around 8% per annum, the average returns of organizers from rosca are as high as 43.64% per annum. This is just a lower bound on the organizers' returns. They usually earn much more since most of them lend their rosca pots further at informal rates of 12.68-26.82% per annum.[17]

[16] There are marginal chances of full default in a rosca. This is primarily because roscas typically exist among relatively homogenous individuals who are linked either socially or economically. Therefore, social sanctions and threat of future exclusion play an important role in ensuring compliance.

[17] These are equal to 1-2% monthly rates which are again the lowest lending rates prevailing in the informal sector.

Thus, rosca as a financial instrument scores reasonably well in terms of meeting the diverse needs of individuals in a homogenous group. It is probably for this reason that rosca holds relevance in the presence of other alternative market and non-market financial institutions.

In the course of examining returns from rosca, the paper developed a theoretical framework of bidding behavior in rosca. The theoretical model outlined captured most of the features of the type of roscas that were found operating in our survey area.

Conjectures relating to cost of borrowing, returns for savers and organizers were found to be empirically valid, except for individual risk aversion and individual impatience. We find that cost of borrowing from rosca is lower in roscas of larger monthly contribution and longer duration. Although winning bid varies positively with contribution and duration, the impact of these variables on cost of borrowing is more complex. Reason is that overall cost of borrowing from rosca depends not just on the winning bid of a particular borrower but also on the winning bids of other rosca members.

Reserve price and bid increment were found to exert an upward pressure on the cost of borrowing for net borrowers. Also, higher group risk aversion caused the borrowing costs to be higher for net borrowers in these groups.

Since savers' returns come from lending funds to the borrowers, factors that cause costs to be higher for net borrowers favorably affect the returns to savers. We find that savers' returns are higher in shorter duration roscas. Further, savers earn relatively more in roscas with smaller monthly contribution. Higher bid increments also yield a positive impact in raising returns of savers.

The empirical findings suggest that rosca-level variables are the most important factors affecting returns for different members. While shorter duration and smaller contribution roscas reap greater gains for the savers, participating in longer duration and larger contribution roscas seems to be more beneficial for the borrowers as it brings down their costs of borrowing.

To conclude, the paper presented a theoretical framework in which bidding behavior and returns from rosca can be analyzed. It also gave several new insights about the functioning of bidding roscas by providing an empirical analysis of the factors that determine borrowing and lending rates in roscas.

In the course of our study, we discovered various additional aspects that need to be studied. Theoretical and empirical literature on bidding roscas is scant. It would be interesting to analyze how bidding behavior changes if individual project returns are correlated. A structural estimation of rosca auction is a possible course of study by overcoming the present deficiencies in data as we had information only on the winning bids in each round and not all the bids in a given round. Further, we feel empirical investigation of factors influencing choice of particular financial institutions and the degree of involvement in these institutions also deserves attention. Apart from this, future research is also warranted on issues relating to peer monitoring and enforcement in bidding roscas.

With this empirical investigation of roscas, we have generated a better understanding of bidding behavior of rosca members and returns generation in roscas. We find that people participating in roscas come from different economic background, with different motives of saving and borrowing. Thus, Rotating Saving Credit Association (rosca) is an umbrella institution that caters to the needs of all in the kind of rural economy we considered while also pointing to the presence of duality in the financial market.

References

Adams, D. W., and de Sahonero, M. L. Canavesi (1989). "Rotating Savings and Credit Associations in Bolivia," *Savings and Development*, 13, 219-235.

Aliber, M. (2001) `Rotating savings and credit associations and the pursuit of self-discipline.' *African Review of Money Finance and Banking* (2001), 51-72.

Ambec, S., & Treich, N. (2007). Roscas as financial agreements to cope with self-control problems. Journal of Development Economics, 82(1), 120-137.

Andersen, S., Harrison, G. W., Lau, M. I., & Rutström, E. E. (2008). Eliciting risk and time preferences. Econometrica, 76(3), 583-618.

Anderson, R. T. (1966). Rotating credit associations in India. *Economic Development and Cultural Change*, 334-339.

Anderson, Siwan & Baland, Jean-Marie, (2002). The Economics of Roscas and Intrahousehold Resource Allocation. *The Quarterly Journal of Economics*, MIT Press, 117(3), 963-995.

Anderson, S., Baland, J. M., & Moene, K. O. (2003). Sustainability and organizational design in informal groups, with some evidence from Kenyan Roscas (No. 2003, 17). Memorandum, Department of Economics, University of Oslo.

Anderson, Siwan & Baland, Jean-Marie & Moene, Karl Ove, (2009). Enforcement in informal saving groups. *Journal of Development Economics*, Elsevier, 90(1), 14-23.

Ardener, S. (1964). The comparative study of rotating credit associations.*Journal of the Anthropological Institute of Great Britain and Ireland*, 201-229.

Banerjee, A. V. (2001). Contracting constraints, credit markets and economic development. Working Paper 02-17, MIT.

Basu, K. (1984). Implicit interest rates, usury and isolation in backward agriculture. *Cambridge Journal of Economics*, *8*(2), 145-159.

Basu, K. (2011). Hyperbolic discounting and the sustainability of rotational savings arrangements. *American Economic Journal: Microeconomics*, *3*(4), 143-171.

Bell, C. (1990). Interactions between institutional and informal credit agencies in rural India. *The World Bank Economic Review*, *4*(3), 297-327.

Benhabib, J., Bisin, A., & Schotter, A. (2010). Present-bias, quasi-hyperbolic discounting, and fixed costs. *Games and Economic Behavior*, *69*(2), 205-223.

Besley, T., Coate, S. and Loury, G. (1993). The Economics of Rotating Savings and Credit Associations. *American Economic Review*, 83, 792-810.

Besley, T., & Levenson, A. R. (1996). The role of informal finance in household capital accumulation: evidence from Taiwan. *The Economic Journal*, 39-59.

Calomiris, C. W., & Rajaraman, I. (1998). The role of ROSCAs: lumpy durables or event insurance?. *Journal of Development Economics*, *56*(1), 207-216.

Dagnelie, O. (2007). Life and Death of Roscas: If Power Corrupts, Does Powerlessness Make One Blameless?.

Dagnelie, O., & Lemay-Boucher, P. (2012). Rosca Participation in Benin: A Commitment Issue*. *Oxford Bulletin of Economics and Statistics*, *74*(2), 235-252.

Dasgupta, 1989

Eeckhout, J., & Munshi, K. (2010). Matching in informal financial institutions. *Journal of the European Economic Association*, *8*(5), 947-988.

Fernando, N. A. (2006). Understanding and dealing with high interest rates on microcredit. *Asian Development Bank*.

Geertz, C. (1962). The rotating credit association: A" middle rung" in development. *Economic Development and Cultural Change*, *10*(3), 241-263.

Ghate, P. (1992). Informal finance: some findings from Asia. Oxford University Press.

Ghazali, S. (2003). Kut (informal rotating credit) in the livelihood strategies of urban households in Penang, Malaysia. *Area*, *35*(2), 183-194.

Gugerty, M. K. (2007). You can't save alone: Commitment in rotating savings and credit associations in Kenya. *Economic Development and Cultural Change*, *55*(2), 251-282.

Handa, S., & Kirton, C. (1999). The economics of rotating savings and credit associations: evidence from the JamaicanPartner'. *Journal of Development Economics*, *60*(1), 173-194.

Harrison, G. W., Lau, M. I., & Williams, M. B. (2002). Estimating individual discount rates in Denmark: A field experiment. *American Economic Review*, 1606-1617.

Holt, C. A., & Laury, S. K. (2002). Risk aversion and incentive effects. *American Economic Review*, *92*(5), 1644-1655.

Janelli, R. L., & Yim, D. (1988). Interest rates and rationality: Rotating credit associations among Seoul women. *The Journal of Korean Studies*, 165-191.

Kirton, C. (1996). Rotating savings and credit associations in Jamaica: some empirical findings on partner. *Social and Economic Studies*, 195-224.

Klonner, S. (2003). Rotating Savings and Credit Associations When Participants are Risk Averse*. *International Economic Review*, *44*(3), 979-1005.

Klonner, S. (2008). Private Information and Altruism in Bidding Roscas*. *The Economic Journal*, *118*(528), 775-800.

Kovsted, J., & Lyk-Jensen, P. (1999). Rotating savings and credit associations: the choice between random and bidding allocation of funds. *Journal of Development Economics*, *60*(1), 143-172.

Kurtz, D. V., & Showman, M. (1978). The tanda: a rotating credit association in Mexico. *Ethnology*, 65-74.

Peterlechner, L. (2009). Roscas In Uganda-Beyond Economic Rationality?-. *African Review of Money Finance and Banking*, 109-140.

Report of the Expert Committee on Lal Dora and Extended Lal Dora in Delhi (2007).

Rogers, C. (2006). Financing Rural Enterprise: The Use of Rotating Credit by a Village Community in Nepal. *Savings and Development*, 109-130.

Smets, P. (2000). ROSCAs as a source of housing finance for the urban poor: an analysis of self-help practices from Hyderabad, India. *Community Development Journal*, *35*(1), 16-30.

Stiglitz, J. E. (1990). Peer monitoring and credit markets. *The World Bank Economic Review*, *4*(3), 351-366.

Tanaka, T., & Nguyen, Q. (2009). Committing the uncommitted: ROSCA as a saving commitment device for sophisticated hyperbolic discounters: Field experiment from Vietnam. George Mason University Interdisciplinary Center for Economic Sciences working paper.

Tanaka, T., Camerer, C. F., & Nguyen, Q. (2010). Risk and time preferences: linking experimental and household survey data from Vietnam. *The American Economic Review*, *100*(1), 557-571.

APPENDIX

Table 1: Descriptive statistics of Rosca participants and Roscas

I. Descriptive statistics of all Rosca participants

Variable	Mean	s.d.	min	max
Returns from project (%)	0.57	0.50	0	1
No. of sources of outside credit	1.79	0.71	0	3
% reporting availability of credit from friends	0.73	0.44	0	1
Interest rate charge by friend (%)	9.85	11.92	0	60
Individual risk preference	1.01	0.05	0.59	1.16
Individual impatience (%)	23.50	10.07	0.75	89.31
Male (%)	0.70	0.46	0	1
Age (in years)	42.44	10.38	19	80
Education (in years)	10.43	3.57	0	18
Monthly expenditure (Rs. per month)	16304	10457	3000	100000
Rental value of house (Rs.)	11057	15246	1000	150000
N=456				

II. Descriptive statistics of Rosca

Variable	Mean	s.d.	min	max
Denomination (Rs.)	220921	248993	16000	1200000
Contribution (Rs.)	14700	19768	1000	100000
Duration (in months)	16.14	2.79	10	20
Reserve price (Rs.)	15780	24460	0	190000
Round (number)	8.63	4.84	1	20
Bid increment (Rs.)	224.67	219.84	0	1000
Organizer's pot (%)	0.64	0.49	0	1

N=36

Table 2: Descriptive statistics of Borrowers

Variable	Mean	s.d.	min	max
Cost of borrowing (%p.a.)	38.72	14.11	9.91	78.62
Project returns	0.56	0.49	0	1
No. of sources of outside credit	1.38	0.56	1	3
Individual risk preference	1.003	.071	0.58	1.16
Individual impatience (%)	24.04	11.69	1.03	89.31
Opponent group risk preference	1.008	.013	.9772	1.039
Group impatience (%)	23.59	4.94	9.48	33.24
Monthly contribution (Rs.)	14699	19582.27	1000	100000
Monthly contribution (Rs.'00)	146.99	195.82	10	1000
Reserve price (Rs.)	29760	33980	0	190000
Reserve price (Rs.'00)	297.60	339.80	0	1900
Duration (months)	15.89	2.83	10	20
Bid increment (Rs.)	233.33	224.33	0	1000
Male (%)	0.69	0.46	0	1
Age (in years)	41.44	10.62	19	70
Education (in years)	11.27	3.02	5	18
N= 108				

Table 3: Descriptive statistics of Savers

Variable	Mean	s.d.	min	max
Savers returns (%p.a.)	23.56	7.66	13.73	61.38
Project returns (%)	0.58	0.49	0	1
No. of sources of outside credit	1.34	0.53	0	3
Individual risk preference	1.009	0.05	0.66	1.15
Individual impatience (%)	22.98	10.29	0.87	53.68
Rosca group risk preference	1.007	.014	.98	1.04
Rosca group impatience (%)	23.37	4.80	11.19	30.93
Monthly contribution (Rs.)	14699	19582.27	1000	100000
Monthly contribution (Rs.'00)	146.99	195.82	10	1000
Reserve price (Rs.)	2560	3998	0	24000
Reserve price (Rs.'00)	25.60	39.98	0	240
Duration (months)	15.88	2.83	10	20
Bid increment (Rs.)	233.33	224.33	0	1000
Male (%)	0.69	0.47	0	1
Age (in years)	43.36	10.50	19	66
Education (in years)	10.07	3.33	0	15
N=108				

Table 4: Descriptive statistics of Rosca Organizers

Variable	Mean	s.d.	min	max
Organizers' IRR	-19.11	4.72	-37.30	-11.48
Group returns	0.58	0.21	.067	1
Organizer's pot	0.64	0.49	0	1
Reserve price (%)	1.30	0.65	0	3
Male (%)	0.69	0.47	0	1
Age (in years)	44.31	7.09	30	60
Education (in years)	11.19	2.98	0	15
Experience (in years)	9.94	7.69	2	30
N=36				

Table 5: OLS Regression of cost of borrowing in ROSCA

VARIABLES	Cost of borrowing
Returns from project	-0.160
	(3.211)
No. of sources of outside credit	-2.934
	(2.110)
Individual risk aversion	7.479
	(16.46)
Individual impatience	-0.107
	(0.129)
Rosca Contribution (in Rs.'00)	**-0.0442*** **
	(0.0123)
Duration	**-3.077*** **
	(0.590)
Reserve price (in Rs.'00)	**0.0102** **
	(0.00451)
Bid increment	**0.0200** **
	(0.00807)
Male	2.765
	(2.736)
Age	-0.0214
	(0.129)
Education	0.528
	(0.467)
Opponent-group risk aversion	**194.3* **
	(110.0)
Group impatience	-0.0379
	(0.347)
Constant	290.4**
	(114.8)
Observations	107
R-squared	0.284

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: OLS Regression of savers' returns from ROSCA

VARIABLES	**Saver's return**
Returns from project	0.567
	(1.291)
No. of sources of outside credit	-1.260
	(1.170)
Individual risk aversion	1.550
	(20.09)
Individual impatience	0.0492
	(0.0827)
Rosca Contribution (in Rs.'00)	**-0.0214*** **
	(0.00670)
Duration	**-1.500*** **
	(0.341)
Reserve price (in Rs.'00)	0.0267
	(0.0165)
Bid increment	**0.00855***
	(0.00488)
Male	-1.262
	(1.554)
Age	0.0990
	(0.0640)
Education	-0.0608
	(0.189)
Group risk aversion	7.573
	(44.72)
Group impatience	0.0183
	(0.149)
Constant	54.05
	(48.41)
Observations	108
R-squared	0.381

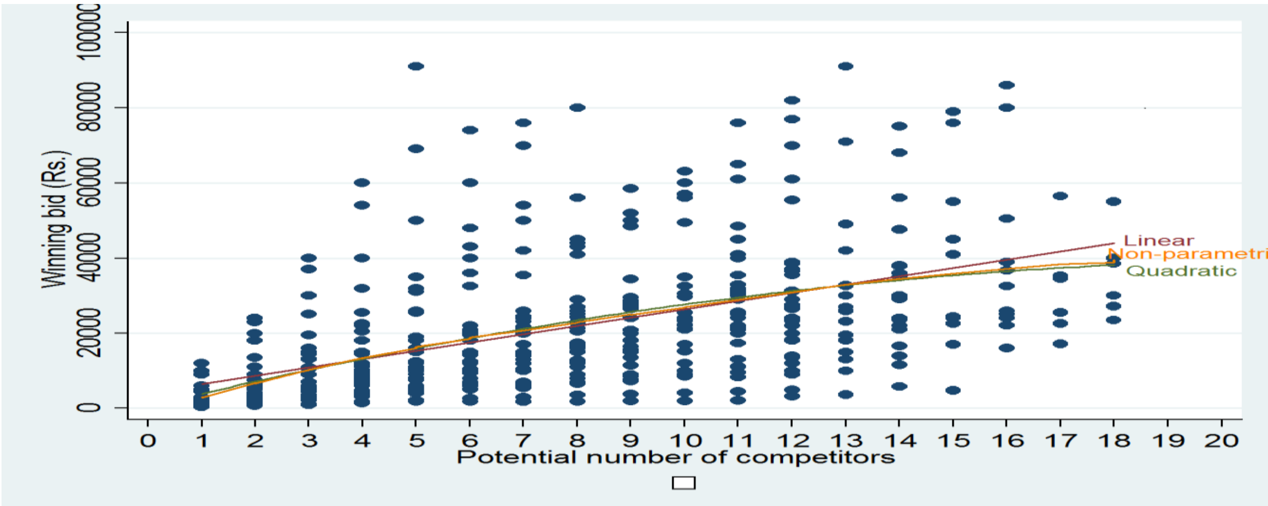
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: OLS Regression of Organizers' returns from ROSCA

	(1)	(2)
VARIABLES	**Organizers' returns**	**Organizers' returns**
Group returns	**-6.742***	-5.156
	(3.510)	(3.366)
Group risk aversion	1.905	-10.86
	(40.66)	(39.14)
Group impatience	-0.0377	0.0362
	(0.157)	(0.129)
Rosca Contribution ('00)	**0.0120*****	**0.0139****
	(3.66e-05)	(4.97e-05)
Duration	**1.024*****	**1.241*****
	(0.252)	(0.301)
Reserve price (%)	-1.858	**-2.098***
	(1.256)	(1.126)
Bid increment	-0.00261	-0.00380
	(0.00392)	(0.00418)
Organizer's pot	-1.669	-0.419
	(1.006)	(1.486)
Male		**-3.051***
		(1.671)
Age		**-0.256***
		(0.140)
Education		-0.0254
		(0.217)
Experience		0.0942
		(0.0967)
Constant	-26.38	-33.02
	(41.96)	(42.16)
Observations	36	36
R-squared	0.683	0.754

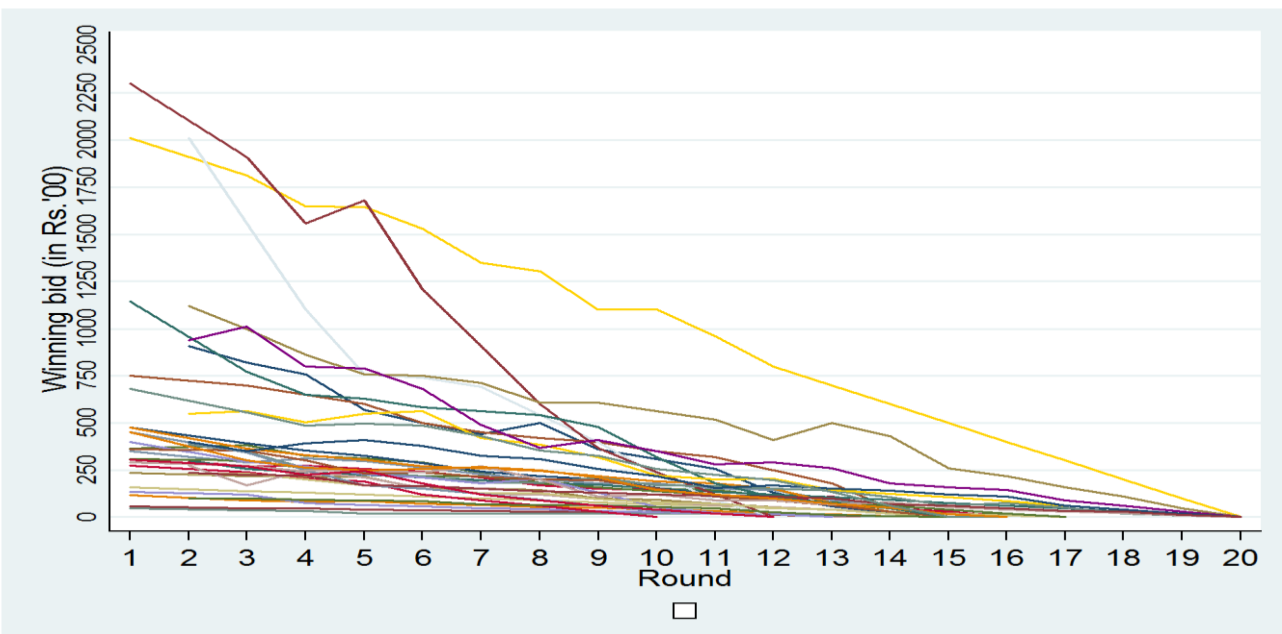
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Graph 1: Winning bids and potential competition in a rosca



Winning bids increase as potential competition in a rosca increases (n=500)[18]

Graph 2: Fluctuating winning bids in rosca



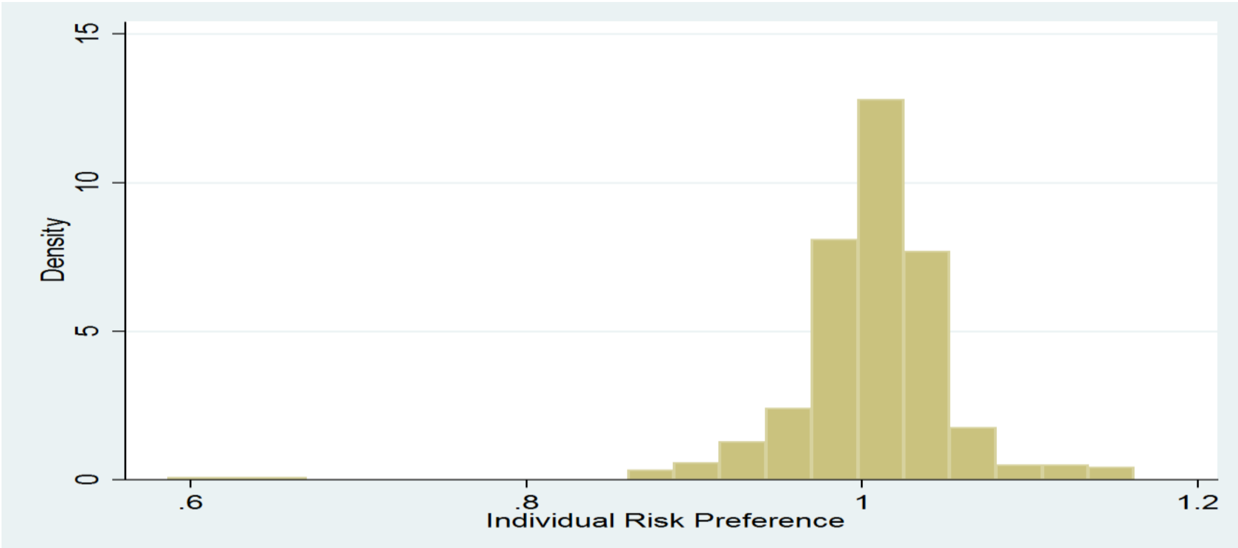
Winning bids in a rosca fluctuates as the rosca cycle progresses (n=536)[19]

---

[18] Data from rounds in which no bidding takes place have been omitted. These correspond to the organizer's round and the last round in each rosca.

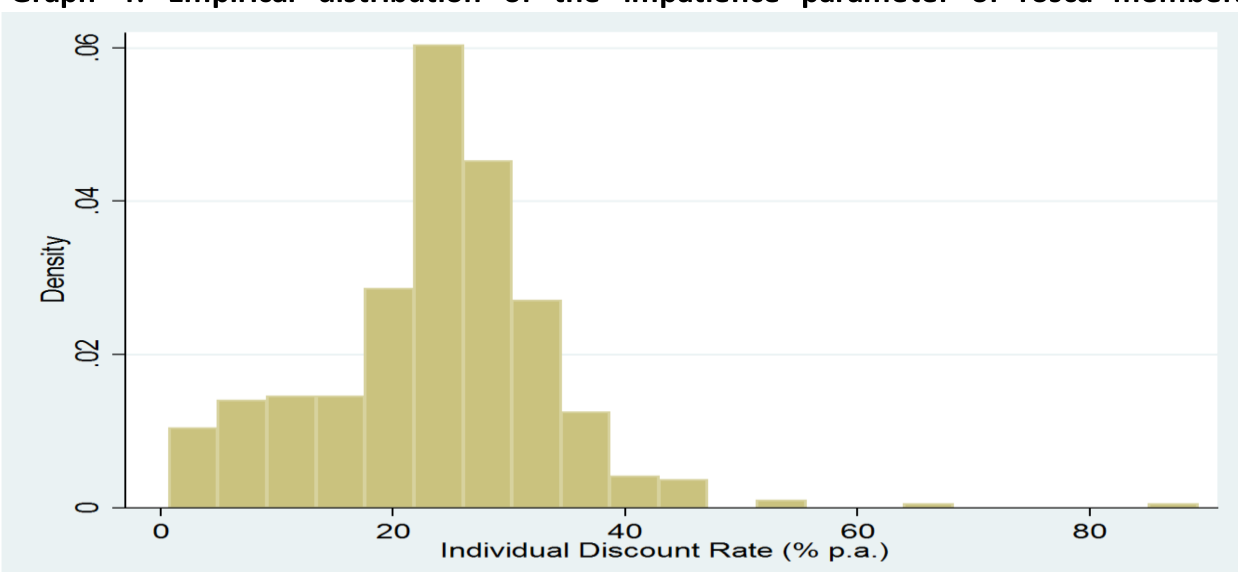
[19] Data for rounds in which the organizers collect the rosca pot have not been included. Recall that there is no bidding in the round in which the organizer collects the pot.

Graph 3: Empirical distribution of the risk preference parameter of rosca members



The graph shows the empirical distribution of the risk preference parameter of rosca members obtained through field experiment. A parameter value of less than 1 implies risk aversion, equal to 1 implies risk neutrality and greater than 1 implies risk seeking behavior. (n=456)

Graph 4: Empirical distribution of the impatience parameter of rosca members



The graph shows the empirical distribution of the impatience parameter of rosca members obtained through field experiment. Lower discount rates imply more patience among rosca members and vice-versa. (n=456)

1. Derivation of the equilibrium bid when rosca participants are risk neutral:

Maximizing member i's expected payoffs $E\pi_i^t(r_i^t)$ with respect to B_i^t yields the following first-order condition:

$$\frac{f_{Y_1^t}(\beta^{t^{-1}}(B_i^t)}{\beta^{t'}(\beta^{t^{-1}}(B_i^t)}\left\{nSr_i^t - c\left((n-1)\frac{B_i^t}{n}\right)\right\} - \frac{c(n-1)}{n}F_{Y_1^t}(\beta^{t^{-1}}(B_i^t) - \frac{f_{Y_1^t}(\beta^{t^{-1}}(B_i^t)}{\beta^{t'}(\beta^{t^{-1}}(B_i^t)}\left\{\left(\frac{max\ B_{-i}^t}{n}\right) - S\right\} = 0$$

Following Kovsted and Lyk-Jensen (1999), at the symmetric equilibrium, $z_i^t = r_i^t$ and $B_i^t = \beta^t(z_i^t) = \beta^t(r_i^t)$. This gives us the following differential equation:

$$F_{Y_1^t}(r_i^t)\ \ \beta^{t'}(r_i^t) + f_{Y_1^t}(r_i^t)\,\beta^t(r_i^t) = \frac{n}{(n-1)c}f_{Y_1^t}(r_i^t)\left\{nSr_i^t - \left(\frac{max\ B_{-i}^t}{n}\right) + S\right\}$$

$$\frac{d}{dr_i^t}\left(F_{Y_1^t}(r_i^t)\right)\beta^t(r_i^t)) = \frac{n}{(n-1)c}f_{Y_1^t}(r_i^t)\left\{nSr_i^t - \left(\frac{max\ B_{-i}^t}{n}\right) + S\right\}$$

We have assumed $\beta^t(\underline{r}) = 0$. On integrating, we have

$$B_i^t(r_i^t) = \frac{1}{F_{Y_1^t}(r_i^t)}\frac{n}{(n-1)c}\int_{\underline{r}}^{r_i^t}\left\{nSZ - \left(\frac{max\ B_{-i}^t}{n}\right) + S\right\}.f_{Y_1^t}(Z)\,dZ$$

$$= \frac{1}{F_{Y_1^t}(r_i^t)}\frac{n}{(n-1)c}\left[\int_{\underline{r}}^{r_i^t} nSZ\,f_{Y_1^t}(Z)\,dZ - \int_{\underline{r}}^{r_i^t}\frac{max\ B_{-i}^t}{n}f_{Y_1^t}(Z)\,dZ + \int_{\underline{r}}^{r_i^t} S\ f_{Y_1^t}(Z)\,dZ\right]$$

$$= \frac{n}{(n-1)c}\left[\frac{nS\int_{\underline{r}}^{r_i^t} Z\,f_{Y_1^t}(Z)\,dZ}{F_{Y_1^t}(r_i^t)} - \frac{max\ B_{-i}^t}{n}\frac{\int_{\underline{r}}^{r_i^t} f_{Y_1^t}(Z)\,dZ}{F_{Y_1^t}(r_i^t)} + \frac{S\int_{\underline{r}}^{r_i^t} f_{Y_1^t}(Z)\,dZ}{F_{Y_1^t}(r_i^t)}\right]$$

Using the following result: $F_{Y_1^t}(x) = (F(x))^{n-t}$ and $f_{Y_1^t}(x) = (n-t)(F(x))^{n-t-1}f(x)$, and assuming $F(\underline{r}) = 0$, we can simplify and write the above expression as

$$= \frac{n}{(n-1)c}\left[n(n-t)S\int_{\underline{r}}^{r_i^t}\frac{Z\,f(Z)\,dZ}{F(r_i^t)} - \frac{max\ B_{-i}^t}{n}(n-t) + S(n-t)\right]$$

$$B_i^{t^*}(r_i^t) = \frac{n(n-t)}{(n-1)c}\left[nS\int_{\underline{r}}^{r_i^t}\frac{Z\,f(Z)\,dZ}{F(r_i^t)} - \frac{max\ B_{-i}^t}{n} + S\right]$$

2. Effect of Reserve Price on the equilibrium bid:

In the roscas that we study in this paper, at the start of the auction, a reserve price is announced.[20] Reserve price in round t is calculated as follows: $\tilde{R}^t = (x\ \%\ \text{of}\ nS) * (n - t + 1)$

The reserve price is defined as the minimum dividend that will have to be paid to the entire group by the winner. In other words, it is the minimum discount at which a member can obtain the pot. It also defines the level at which bidding begins in a particular round. This implies that a winning bid can never be below the reserve price for that particular round. Suppose that all active bidders submit bids that are less than the reserve price. Then, the pot is allocated randomly to one of the active members at the reserve price.

Random allocation occurs also when there is a tie at or above the reserve price. However, in case, there is only one individual with return more than the reserve price and the highest bid among his opponents equal to the reserve price, he could obtain the pot by bidding a little higher, that is, up to the next bid increment.

Let r^{0t} be a return in the interval $[\underline{r}, \overline{r}]$ such that $r^{0t} = {\beta^t}^{-1}(\tilde{R}^t)$. The reserve price $\tilde{R}^t$ is the minimum permissible bid in round t. Therefore, active members with returns below r^{0t} do not submit bids in that round.

Notice that in round t, it is not optimal for member i with true return r_i^t to bid an amount $B_i^t < \beta^t(r^{0t})$. In fact, the rules of the game are such that bids below $\beta^t(r^{0t})$ are not allowed. Also, it is not optimal for member i to bid an amount $B_i^t > \beta^t(\overline{r})$ which would ensure that he wins the pot but he would end up unnecessarily paying a very high discount such that his payoff would be lower. Therefore, member $i's$ problem is to submit a bid B_i^t such that $\beta^t(r^{0t}) \leq B_i^t \leq \beta^t(\overline{r})$.

The probability of member i winning round t by submitting a bid $B_i^t = \beta^t(z_i^t)$ conditional on $B_{it} \geqslant \tilde{R}^t$ is given by

$$\Pr\{B_i^t > \max B_{-i}^t \mid B_i^t \geqslant \tilde{R}^t\}$$

$$= \Pr\{\beta^t(z_i^t) \geq \beta^t(Y_1^t) \mid \beta^t(z_i^t) \geqslant \beta^t(r^{0t})\}$$

$$= \Pr\{z_i^t \geq Y_1^t \mid z_i^t \geqslant r^{0t}\}$$

$$= F_{Y_1^t}(z_i^t \mid z_i^t \geqslant r^{0t})$$

The probability of member i losing the auction in round t is $(1 - F_{Y_1^t}(z_i^t \mid z_i^t \geqslant r^{0t}))$. As before, member i's optimization problem is to maximize his expected payoffs with respect to bid B_i^t. Under plausible conditions, this gives the following equilibrium bid function:

$$B_i^{t^{**}}(r_i^t) = \frac{n(n-t)}{(n-1)c}\left[\{nS \,.\, E(Z \mid Z \leq r_i^t \cap r^{0t} \leq r_i^t)\} - \left\{\left(\frac{\max B_{-i}^t}{n}\right) - S\right\}\right]$$

[20] In local language (vernacular), reserve price is called 'sarkari ghaata'

Notice that the equilibrium bidding strategy above looks similar to the one derived in equation (2') whenever $r_i^t \geqslant r^{0t}$. This is so because whenever $r_i^t \geqslant r^{0t}$, the reserve price $\tilde{R}^t$ is not binding. What matters most to member i then is how his return could be placed relative to the highest bid among his competitor.

However, the presence of reserve price does put a weak upward pressure on the sequence of winning bids obtained in a rosca. This arises due to the fact that whenever $r_i^t < r^{0t}$, member i submits a bid of zero. In rounds where all submit a zero bid, the rosca pot is allocated randomly at the reserve price in that round.

Since reserve price falls as rosca proceeds, the sequence of winning bid is still decreasing with fluctuations but it lies (weakly) at or above that obtained in the earlier case when there was no reserve price.

3. Equilibrium Bidding Strategy under Risk Aversion

We now relax the assumption of risk neutrality and introduce risk aversion. We examine the effect of varying attitudes towards risk of members in a particular rosca. The following proposition is derived under the assumption that difference in risk attitudes does not lead to differences in the equilibrium bid functions. In some context, this assumption might not hold. However, since the focus of this study is on empirical analysis of rosca, we have made this assumption.

Suppose a representative rosca member has a von-Neumann Morgenstern utility function $u(.)$ which is strictly increasing and strictly concave i.e. $u'(.) > 0$ and $u''(.) < 0$. In the presence of risk aversion, rosca members will now maximize expected utility instead of expected payoffs. Maximizing member i's expected payoff $E\pi_i^t(r_i^t)$ w.r.t B_i^t we got

$$f_{Y_1^t}(r_i^t).\{\theta_1\} - \beta^{t'}(r_i^t).\ F_{Y_1^t}(r_i^t)\, c\,\frac{(n-1)}{n} - f_{Y_1^t}(r_i^t).\{\theta_2\} = 0$$

where $\theta_1 = \left\{ nSr_i^t - c\left((n-1)\frac{B_i^t}{n}\right)\right\}$, $\quad \theta_2 = \left\{\left(\frac{max\, B_{-i}^t}{n}\right) - S\right\}$, $\theta_3 = c\frac{(n-1)}{n}$

$$\beta_t'(r_{it}) = \frac{1}{\theta_3}\frac{f_{Y_1^t}(r_i^t)}{F_{Y_1^t}(r_i^t)}\{\theta_1 - \theta_2\}$$

Similarly, maximizing i's expected utility w.r.t B_i^t under risk aversion, we get

$$\frac{dEu(\pi_i^{tR}(r_i^t))}{dB_i^t} = \frac{f_{Y_1^t}(\beta^{tR^{-1}}(B_i^t))}{\beta^{tR'}(B_i^t)}.\{u(\theta_1)\} - F_{Y_1^t}u'(\theta_1).\, c\,\frac{(n-1)}{n} - \frac{f_{Y_1^t}(\beta^{tR^{-1}}(B_i^t))}{\beta^{tR'}(B_i^t)}.\{u(\theta_2)\}$$

Replacing $B_i^t = \beta^{tR}(r_i^t)$ and equating $\frac{dEu(\pi_i^{tR}(r_i^t))}{dB_i^t} = 0$, we have

$$\beta^{tR'}(r_i^t) = \frac{1}{\theta_3}\frac{f_{Y_1^t}(r_i^t)}{F_{Y_1^t}(r_i^t)}\frac{\{u(\theta_1) - u(\theta_2)\}}{u'(\theta_1)} \tag{4}$$

For another member j,

$$\beta^{tR'}\left(r_j^t\right) = \frac{1}{\theta_3}\frac{f_{Y_1^t}\left(r_j^t\right)}{F_{Y_1^t}\left(r_j^t\right)}\frac{\{u_j(\theta_1) - u_j(\theta_2)\}}{u_j{}'(\theta_1)} \tag{5}$$

Assume that

$$r_i^t = r_j^t = r$$

$$u_i(\theta_1) = -e^{-\mu_i(x)}$$

$$u_j(\theta_1) = -e^{-\mu_j(x)}$$

We continue to assume that $\theta_1 > \theta_2$ holds.

We further assume that individual i is more risk averse than individual j.

To prove the proposition, we have to show

$$\beta^{tR'}(r_i^t) > \beta^{tR'}\left(r_j^t\right)$$

From (4) and (5)

$$\frac{\{u_i(\theta_1) - u_i(\theta_2)\}}{u_i{}'(\theta_1)} > \frac{\{u_j(\theta_1) - u_j(\theta_2)\}}{u_j{}'(\theta_1)}$$

$$\Rightarrow \frac{-e^{-\mu_i(\theta_1)} + e^{-\mu_i(\theta_2)}}{\mu_i e^{-\mu_i(\theta_1)}} > \frac{-e^{-\mu_j(\theta_1)} + e^{-\mu_j(\theta_2)}}{\mu_j e^{-\mu_j(\theta_1)}}$$

$$\Rightarrow -\frac{1}{\mu_i} + \frac{1}{\mu_i}e^{\mu_i(\theta_1-\theta_2)} > -\frac{1}{\mu_j} + \frac{1}{\mu_j}e^{\mu_j(\theta_1-\theta_2)}$$

$$\Rightarrow \frac{1}{\mu_i}\left[e^{\mu_i(d)} - 1\right] > \frac{1}{\mu_j}\left[e^{\mu_j(d)} - 1\right]$$

where $d = \theta_1 - \theta_2$

This can be written as

$$\Rightarrow \frac{e^{\mu_i(d)} - 1}{\mu_i} > \frac{e^{\mu_j(d)} - 1}{\mu_j} \tag{6}$$

So if we can prove that $\frac{e^{xd}-1}{x}$ is increasing in x, then, given $\mu_i > \mu_j$, (6) will hold true.

Proof of $\frac{e^{xd}-1}{x}$ is increasing in x is as follows:

The first order derivative of $\frac{e^{xd}-1}{x}$ is given by

$$\frac{(de^{dx})x - (e^{xd} - 1)}{x^2}$$

$$= \frac{dxe^{dx} - e^{xd} + 1}{x^2}$$

For the first order derivative to be greater than 0, it is sufficient to show that numerator is greater than 0, as x^2 is always greater than 0 holds. (At $x = 0$, there is no risk aversion.)

$$dxe^{dx} - e^{dx} + 1 = he^h - e^h + 1,$$

where $h > 0$ since $d > 0$, $x > 0$.

At $h = 0$, the above function is equal to 0.

At $h > 0$, its derivative $he^h > 0$ as $h > 0$ and $e^h > 0$. Hence, $he^h - e^h + 1 > 0 \ \forall \ h > 0$

So, $\frac{e^{xd}-1}{x}$ is increasing in x. Given $\mu_i > \mu_j$,

$$\frac{e^{\mu_i(d)} - 1}{\mu_i} > \frac{e^{\mu_j(d)} - 1}{\mu_j}$$

$$\beta^{tR'}(r_i^t) > \beta^{tR'}(r_j^t)$$