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Essays on Rotating Savings and Credit Associations

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Three Essays on Rotating Savings and Credit Associations *to my parents*

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0 INTRODUCTION AND OVERVIEW

The rotating savings and credit association (Rosca) is a financial institution which is observed around the world, mainly in developing countries. Bouman (1995) lists about 80 countries in which Roscas are known to operate. Roscas 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.

The timing of the order of allotment follows one of the following two rules. First, the order is determined before or at the first meeting or, second, allotment occurs concurrently at each meeting. Depending on the timing of the order of allotment, several allotment mechanisms have been observed in practice. In the case of a predetermined order, seniority of the participants, negotiation, or a lottery before or at the first meeting (Gugerty, 2000) determine the order. When the order is not predetermined, pots are allotted through concurrent negotiations or a lottery at each meeting (Gugerty, 2000), the decision of the organiser (Handa and Kirton, 1999), or through an auction among those participants who have not yet received a pot. In this latter case, the highest bid wins the pot and the price the winner pays is distributed among the Rosca members or added to future pots. In accordance with the existing literature, Roscas with a lottery and an auction allotment mechanism will be called 'random Roscas' and 'bidding Roscas', respectively. The present dissertation is primarily concerned with bidding Roscas.

Since the methodological approaches which are taken in this dissertation do not have much in common with the large and growing body of anthropological literature describing Roscas in many parts of the developing world, we do not review this literature here but refer the interested reader to the surveys of Ardener and Burman (1995) and Adams and Fitchett (1992). Instead, we will highlight some particular aspects of this literature, which set the stage for the chapters to follow.

Unfortunately, there is no detailed historic account on the evolution of Roscas anywhere in the world because, traditionally, the Rosca has been an informal institution. It is believed that Roscas started as a very simple financial technology (Geertz, 1962). Today, everywhere in the developing world, Roscas come in different forms and levels of sophistication. Simple Rosca rules are still frequently observed in contemporary studies (see the references above). At the other end of the scale of sophistication are certain bidding Roscas in Cameroon, where there is not only an auction for the pot, but also a secondary market in which the price a winner has to pay for a pot is lent to another member of the Rosca group who offers to pay the highest interest on it (Tchuindjo, 1998). Other case studies from this country report Rosca arrangements which have become so flexible that neither the number of participants nor the contribution in each round is fixed in advance (Tankou and Adams, 1995).

In India, Roscas seem to have emerged in the southern part of the subcontinent. Today they are known throughout the country as ‘chit funds’, or ‘chits’ in short. ‘Chitty’ is a Tamil word meaning written piece of paper or palm leaf. In fact, traditionally, there is one written piece of paper for each participant, which serves as a lot to determine the order of receipt. Radhakrishnan et al. (1975) cite evidence that chit funds had been in existence in the form of grain chits well before the introduction of money. Such Roscas in kind still exist, even in comparatively well-developed villages as the one studied in Chapter 2. On the other hand, India probably also has the most professionally organised formal Roscas in the world. In major cities, large chit fund companies run as many as 10,000 auction Roscas simultaneously. These are regulated, just as banks are regulated in the western world. The Chit Fund Act obliges every organiser of a Rosca to register with a government authority, to deposit some reserves to compensate participants in the case of bankruptcy, and to end auctions prematurely at specified bid ceilings (Radhakrishnan, 1977). In consequence, Roscas which are not registered with the government are illegal. In rural settings like the village studied in Chapter 2, however, Roscas are almost never registered. Perhaps this explains why informal Roscas in India have received so little attention from researchers compared to informal Roscas in African countries. A notable recent exception, however, is Calomiris and Rajaraman (1998).

For less developed countries, little is known about general participation rates in Roscas because, first, Roscas are mostly operated on an informal basis and, in this case, do not appear in any financial statistics, and, second, in such countries, large-scale sample surveys are typically rare. Even in India, where there is the exemplary National Sample Survey Organisation (NSSO) and Roscas play an important role, the NSSO does not canvas participation in Roscas. For some African countries, somewhat rough estimates of Rosca participation are reported by anthropological authors and range between 45 and 95% of households. Gugerty (2000) provides a good, up-to-date survey of this literature. The only developed country for which substantial Rosca participation is documented is Taiwan. Levenson and Besley (1996) report that, in 1991, about 80% of the households participated in at least one Rosca. This does not mean, however, that Roscas are completely unheard of in western countries. With the international migration of labour, Roscas seem to have spread to any place where people from areas where Roscas traditionally play an important role have settled. Ardener and Burman (1995) report Roscas among employees of the International

Monetary Fund headquarters in Washington D. C. as well as among Asian immigrants in London.

Little theoretical work has been done on Roscas. This is astounding given the world-wide prevalence of this institution and the enormous attention devoted to other contractual arrangements encountered in the developing world, like sharecropping contracts and interlinked transactions. To my knowledge, there are only four papers which use advanced analytical tools (Besley et al. 1993, 1994; Kovsted and Lyk-Jensen, 1999; Kuo, 1993), and three recent applied papers, which involve simple models (Aliber, 2000; Anderson and Balland, 1999; Gugerty, 2000). None of these three latter-mentioned papers involves bidding Roscas, which are the subject of this dissertation. Instead, the emphasis is on the analysis of primary data on Rosca participation which these authors have collected. In contrast, the papers by Besley et al. and Kovsted and Lyk-Jensen deal with both random and bidding Roscas. It will now be argued that the settings in which these authors analyse bidding Roscas are found rarely, if at all, in the real world.

Besley, Coate and Loury (1993) consider individuals who have an identical, deterministic income stream and no access to outside credit. Individual utility is concave in current consumption and the funds from a Rosca are used to purchase an indivisible durable good which facilitates extra utility in each period after its purchase. The costs of the durable require saving for more than one period. Individuals may differ in the utility they derive from the durable, but information on this is public. The authors find that identical individuals prefer a lottery allotment mechanism, while the bidding allotment mechanism is preferred if the valuation for the durable differs sufficiently among the participants. In their framework, the auctions in the course of a bidding Rosca serve to identify the bidder with the highest valuation for the durable. Since all information is public, the auction does not involve any strategic element. The particular auction protocol which Besley et al. design requires that, in a

n-person bidding Rosca, all n - 1 auctions take place at the beginning of the Rosca and ensures that all participants obtain the same level of utility from joining the Rosca. Its singular drawback, as Calomiris and Rajaraman (1998) point out, is that it is not reported at all in the empirical literature. In my view, the major contribution of Besley et al.'s 1993 paper is to the economics of indivisible goods, which had not received much attention in neoclassical economics before, and only secondly to the economics of Roscas, as the title of their paper would suggest.

In a companion paper, Besley et al. (1994) use the same indivisible-good framework and compare allocations which result from participation in random and bidding Roscas with allocations which are feasible when individuals borrow and lend each other money. In this paper, they restrict themselves to identical individuals who thus have identical valuations of the indivisible good. The authors show that allocations with borrowing and lending are always superior to allocations with a bidding Rosca, but that the element of chance inherent in a random Rosca may yield allocations which are superior to a credit market. The result on the efficiency of bidding Roscas is scarcly surprising since, first, the payoffs of a bidding Rosca are less flexible than those of direct borrowing and lending and, second, there is neither heterogeneity nor private information on the individuals' valuation of the durable good.

An approach which is related to Besley et al. (1993) is taken by Kovsted and Lyk-Jensen (1999), who also assume that all participants have an identical, deterministic income stream. Instead of desiring to purchase a durable consumption good, however, their participants have prospective investment projects which, once purchased, yield a certain revenue but whose fixed costs exceed an individual’s period income. Costly credit from outside the Rosca is available and all participants’ preferences are identical. Before the beginning of the Rosca, each participant privately observes the revenue of the investment project to which he has access. Assuming that nature draws this revenue from the same distribution for all participants, the authors apply the symmetric, independent private value (SIPV) approach to analyse the auctions of a bidding Rosca in such an environment. In contrast to Besley et al., the strategic analysis of Rosca auctions under Kovsted and Lyk-Jensen's assumptions is not trivial because the investment project's revenue is each bidder's private information. The goal of their paper is to identify criteria which determine whether allocations with a random or a bidding Rosca are preferred ex ante, that is, before each participant observes his revenue. On the one hand, a random Rosca has the advantage of allocating the full pot to each winner, while an auction's winner in a bidding Rosca has to incur costly debt to finance the price he has to pay for the pot. On the other hand, in a bidding Rosca, each auction identifies the bidder with the highest revenue, while, with a random Rosca, less profitable investment projects may be implemented first. In this connection, the authors find that, when outside credit is not too costly, or when the distribution of revenues is sufficiently widely dispersed, a bidding Rosca is preferred to a random Rosca.

It should be remarked that, to solve for the bidding equilibrium of a Rosca, Kovsted and Lyk-Jensen consider only first-price sealed bid auctions in which only the winner's bid is revealed. To my knowledge, however, such auctions are not reported in any of the empirical literature. Consider, therefore, the frequently-practised oral ascending bid auction. In this case, Kovsted and Lyk-Jensen's sequential bidding equilibrium breaks down, because, after each auction, the losing bidders, who remain for the next auction, have learned something about the revenue of their competitors. For Kovsted and Lyk-Jensen's equilibrium analysis it is essential, however, that, from each bidder's perspective, all other bidders be identical.

The approaches to bidding Roscas taken by Besley et al. and Kovsted and Lyk-Jensen are deterministic in the sense that all payoffs which occur during the course of the Rosca can be calculated before the beginning of the first auction because each participant's income stream as well as his preferences (Besley et al.) and his revenue of the investment project

(Kovsted and Lyk-Jensen) remain constant from the beginning till the end of the Rosca. As a consequence, all auctions can be staged at the beginning of the Rosca and need not take place concurrently with allotment, as reported by almost all empirical studies.

In a stochastic Rosca model, in contrast, random variables which are not yet realised at the beginning of the Rosca determine the outcome of each auction. The first stochastic Rosca model is due to Kuo (1993), who analyses bidding Roscas when individuals are risk neutral and use Rosca funds for consumption. He assumes that individual future consumption is discounted with a random discount rate, whereby each individual is assigned a new discount rate before each auction. Assuming that the bidders' discount rates are independently drawn from a common distribution before each auction and privately observed, the author applies the SIPV framework to derive bidding equilibria. In his model, the advantage of joining a Rosca arises from the possibility to consume more in a period in which one has a comparatively high marginal utility of current consumption. In this context, the auction is a mechanism to overcome information asymmetries. To my knowledge, however, there is no empirical study which reports that, in an environment without risk aversion and income uncertainty, Rosca funds are used for current consumption. Instead, it appears from the empirical evidence that Rosca funds are invariably used for either some lumpy expenditure, be it a consumer durable, an investment project or a marriage festival, or for consumption in order to smooth an income shock (Calomiris and Rajaraman, 1998).

Based on the discussion in the preceding paragraphs, we claim that the theory papers by Besley et al. (1993, 1994), Kovsted and Lyk-Jensen (1999) and Kuo (1993) are irrelevant as "applied" theory because they contain essential elements that do not even closely correspond to the real world. The aim of this dissertation is to develop models of bidding Roscas with more realistic assumptions. There is much empirical evidence in favour of the choice of stochastic Rosca models as the basis for analysis. First, as Calomiris and Rajaraman

(1998) note, all empirical studies on bidding Roscas except one report auctions which take place concurrently with allotment rather than at the beginning of the Rosca. Second, deterministic models are not compatible with fluctuating winning bids, which are observed in practice. That is to say, a higher winning bid is observed in the t-th than in the $(t - 1)$-th auction. The model of Kovsted and Lyk-Jensen, however, yields the result that, during the course of the Rosca, the winning bid decreases from auction to auction.

The first chapter elaborates on the idea advocated by Calomiris and Rajaraman that bidding Roscas can serve as insurance when the participants face income shocks which are not perfectly correlated over individuals. In the first chapter, we analyse a bidding Rosca with risk averse participants who face identically and independently distributed, privately observed incomes which are drawn anew by nature before each meeting. In the context of the existing literature, this approach has most in common with Kuo's. As in his paper, Rosca funds are used for consumption and the SIPV framework is applied to analyse Rosca auctions. Our approach differs substantially from his, however, in that we consider income shocks instead of taste shocks and in that our participants are risk averse whereas his are risk neutral. Moreover, while he restricts attention to first-price sealed bid Rosca auctions, we focus on oral ascending bid Rosca auctions, which are empirically more relevant and have some particular properties which make them substantially different from standard SIPV oral ascending bid auctions.

In the light of the first chapter, it would have been most desirable to collect Rosca data in a setting where participation in bidding Roscas is motivated by the intention to insure against income shocks. Calomiris and Rajaraman (1998) describe such a Rosca among casual labourers in an Indian city. Since the time frame for the field study was limited, however, and since I had access to excellent data of a longitudinal study of a south-Indian village (van Dillen, forthcoming) including a survey on Rosca activity, I decided to investigate bidding Roscas in the said village – although it was quite clear that, within this setting, the insurance aspect of Roscas plays only a minor role. Thanks to the contacts, trust and infrastructure established by van Dillen, I managed to collect an extensive dataset on Rosca auctions. Comparing the auction outcomes of informal Roscas is particularly difficult, however, because, typically, each Rosca is different from any other, be it with respect to the number of participants, the amount of the contribution, or the way in which the Rosca organiser is remunerated. Therefore, some structure is needed to make the auction outcomes in the dataset comparable. To this end, in Chapter 2, we develop a stochastic Rosca model which reflects the salient features of Rosca auctions in the study village and estimate the resulting structural model by maximum likelihood. To my knowledge, this is the first empirical analysis of Rosca auctions.

To summarise, the central idea underlying both chapters is the one of a stochastic approach to bidding Roscas in a private information environment. In accordance with much of the empirical literature, this is motivated by the persuasion that, so far, economists have unfairly neglected the potential which the auction allocation mechanism offers to overcome information asymmetries and to respond to shocks or opportunities which cannot be observed when a Rosca begins.

1 ROSCAS WHEN PARTICIPANTS ARE RISK AVERSE

Abstract

Recent theoretical research on rotating savings and credit associations (Roscas) suggests that identical individuals prefer a random to a bidding Rosca when participants save for a lumpy durable or an investment good. Here, in contrast, under the assumption that Rosca funds are used for consumption, that participants are risk averse, and that their incomes are stochastic, independent and privately observed, it is shown that a random Rosca is not advantageous, while a bidding Rosca is so if temporal risk aversion is less pronounced than static risk aversion. The payoff scheme of a bidding Rosca helps to mitigate the problem of information asymmetries. In bidding Roscas, the intertemporal pattern of observed bids depends on impatience and risk aversion in a non-trivial way.

1.1 Introduction

It is widely recognised that in low-income countries risk plays a crucial role in everyday life. In the agricultural sector, there is uncertainty about rainfall and crop damage, in the cities, casual labourers face employment uncertainty. In both sectors, the prevalence of infectious diseases makes labourers' ability to generate income uncertain. At the same time, poor public infrastructure, illiteracy and an inefficient legal system impose limits on the functioning of formal market institutions that may insure such risks (see Besley, 1995). While some governments try to mitigate aggregate shocks, e.g. by accumulating and releasing food stocks, the absence of formal health and unemployment insurance often leaves individuals alone when they are affected by idiosyncratic shocks. Because of this lack of formal insurance markets, however, numerous nonmarket risk-sharing institutions are observed. The basic idea underlying all these institutions is that, if shocks are not perfectly correlated across individuals, transfers contingent on each individual's shock improve each individual's situation, at least from an ex ante perspective.

The analysis of such institutions has a long history in development economics dating back to Cheung's (1968) contribution on risk sharing in sharecropping contracts. More recently, economists' interest in this field has grown rapidly. In an empirical investigation, Udry (1990) finds that informal credit in rural Nigeria serves as insurance against idiosyncratic risks. In a theoretical paper, Coate and Ravallion (1993) characterise optimal risk sharing between two households when contractual claims cannot be enforced. In both studies, each household head observes not only his own but also his contract partner's income. This assumption may be reasonable in the context of rural villages, where information flows freely. In urban settings, where income is generated mostly outside the residential neighbourhood (or slum), individuals may only observe their own incomes.

Eswaran and Kotwal (1989) allow private information on incomes but exclude any enforcement problems. They find that, in a two-period world, a market for consumption credit facilitates higher investment than autarky because individuals can smooth their consumption streams by lending and borrowing instead of putting money aside unproductively.

In a multi-period world, the analysis of risk sharing with private information becomes rather complicated. Green (1987), Phelan and Townsend (1990), and Atkeson and Lucas (1992) consider a principal and one or many risk averse agents and characterise incentive-compatible allocations. 'Incentive-compatible' in this context means that, for each agent, reporting the realisation of his income truthfully, constitutes a Nash equilibrium. In all of these papers, there is neither individual borrowing nor saving and aggregate consumption does not need to equal aggregate income. In Wang (1995), in contrast, there is no principal and an aggregate budget-balancing constraint is imposed. He analyses the constrained efficient, incentive-compatible insurance contract among two infinitely lived, ex-ante identical agents when incomes are privately observed and enforcement problems are absent.

There are very few papers addressing the performance of existing nonmarket institutions in developing countries when incomes are privately observed. The reason for this is likely that the mainstream of micro-development economics has focused on the theory of contracts and institutions in the agricultural sector and, as argued above, within a village, information on individual states is often public knowledge. An exception is Udry (1994), who also considers idiosyncratic income shocks which are privately observed.

In the empirical literature on Roscas, it has been argued for a long time that, when participants are exposed to risk, Roscas can serve as a risk-sharing mechanism. In the context of Roscas without a bidding allocation mechanism, this has first been suggested by Ardener (1964), who observed that, in Roscas with a predetermined order of receipt of the pot, the order may be changed in favour of a participant who suffers some unforeseen liquidity crisis in the course of the Rosca. Of course, this mechanism only works when the said liquidity crisis is observed by all participants or at least by the organiser. Platteau (1997) interprets bidding Roscas as an intertemporal redistribution mechanism, where “the group member who accepts the biggest deduction and who is presumably the most hard-pressed by emergency needs, receives what remains of the common fund after the agreed deduction is effected” (p. 785).

Calomiris and Rajaraman (1998) find evidence that the timing and the extent of such emergency needs are not known to the participants when they join a Rosca and interpret this as evidence against the deterministic Rosca models of Besley et al. (1993, 1994). Calomiris and Rajaraman argue that, except for one case[1], all of the empirical literature reports Rosca arrangements where bidding is concurrent with the allocation of pots. In the approaches taken by Besley et al. (1993) and Kovsted and Lyk-Jensen (1999), however, the auctions for all future pots can be staged at the beginning of the Rosca. Another striking difference lies in the course of the winning bid from period to period. For an actual Rosca in an Indian city, Calomiris and Rajaraman (1998) find that winning bids do not decrease steadily from auction to auction, which contradicts the predictions of the models of Besley et al. (1993) and Kovsted and Lyk-Jensen (1999). Calomiris and Rajaraman conclude that, at least for their particular Rosca, deterministic models do not capture the essential features. Instead, they stress the role of Roscas as an insurance mechanism by allocating each period’s pot to the bidder who has suffered the most severe shock.

Of course, Roscas cannot effectively insure against aggregate shocks when participants belong to an economically and socially homogenous group like small farmers in a village whose harvests depend on the weather to a large extent. But even here, as Townsend’s

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[1] This is Campbell and Ahn (1962) for Korea.

(1994) results suggest, a variety of mechanisms appear to be at work in providing substantial insurance against idiosyncratic risks like illness or the death of farm animals. We do not claim that Roscas never play a role for the accumulation of funds to finance lumpy goods. There is, however, a startling imbalance between the number of empirical studies which stress the risk-sharing aspect of Roscas and the focus of theoretical papers on Roscas, which have completely neglected this aspect so far. It is this imbalance which motivates this essay.

In this essay, we analyse how a bidding Rosca functions under the following assumptions, which are set out and discussed in detail in section 1.2. First, participants are risk averse and use funds from the Rosca entirely for consumption, each participant's income being stochastic. Second, participants cannot observe other participants' incomes, but all share the same beliefs about the distribution from which the incomes are drawn. By assuming such a private information environment, the analysis focuses on urban Roscas among homogenous participants who do not observe each other's incomes, e. g. hawkers and shoeshine boys (see Nayar, 1983, and Calomiris and Rajaraman, 1998, for examples from India). Third, we employ the invariable assumption in the literature on risk sharing (see, among many others, Coate and Ravallion, 1993, and Wang, 1995) that transfers of income across periods are possible neither through storage nor through borrowing and lending. Fourth, the analysis of this chapter is restricted to the case of participation in one single bidding Rosca. Section 1.3 investigates what restrictions on preferences are required to induce participation in either a random or a bidding Rosca. Section 1.4 looks at the intertemporal pattern of observed winning bids. Section 1.5 summarises the findings and offers conclusions.

1.2 Risk Sharing and the Functioning of Bidding Roscas under Private Information

It is well known that in the absence of borrowing and savings opportunities, the optimal risk-sharing contract among n ex ante identical individuals involves pooling all individual incomes and allocating one n'th thereof to each individual in each period. Such an arrangement, however, requires that, in any period, each individual's income is public knowledge. While this is a reasonable assumption for residents of a small rural village who generate their incomes within that village, it is less persuasive in an urban setting, where the income of a casual labourer may be exclusively his private knowledge. In such cases, the arrangement just outlined collapses, because there is an incentive to underreport one's income and thus contribute less to the income pool. Thus a risk-sharing mechanism under such informational constraints must give individuals an incentive to report their incomes truthfully. Specifically, in a two-individual-two-period context, such an incentive can be generated by intertemporal trade, compensating the individual who is a net payer in the first period with a positive net transfer in the second. If the world ends after two periods, then, in the second period, no further intertemporal trade can take place.

Exactly these features can be found in a two-participant-two-period bidding Rosca: before the first period, the two participants A and B make an arrangement whereby each pays a stipulated amount m into a pot in each period. In the first period, the participants bid for pot one. Assuming that half the price paid for this pot, b say, is allocated to each participant, one would expect the participant with the higher current need for funds, A say, to win this auction. In this context, 'higher need' is equivalent to 'lower first-period income'. Consequently, in the first period, A receives a net transfer of $m – b/2$ from B. According to the rules of the Rosca, however, B receives the pot and thus a net transfer of m from A in the second period.

This latter transfer can be viewed as the 'price' A has to pay for the transfer she received from B in the first period.

To set out the analytical framework, assume that each of the two participants[2] evaluates consumption levels in periods one and two c_{i1} and c_{i2}, respectively, with a bivariate von-Neuman-Morgenstern utility function, $u(c_{i1}, c_{i2})$, which is strictly increasing and concave in each argument, and that, in period t, her income y_{it}[3] is drawn from a distribution characterised by the smooth distribution function F on the domain $I = [y_l, y_u]$. All Y_{it}, i, $t = 1, 2$ are assumed to be independently and identically distributed according to F. Support for this assumption comes from the fact that Rosca participants typically belong to the same social and professional group (see, e. g., Bouman, 1979). It is further assumed that participants have access to neither credit nor savings opportunities outside the Rosca. Although the absence of savings opportunities in particular appears to be a very restrictive assumption, it is a fact that in many urban settings where Roscas are observed it may be dangerous or even impossible to store money. Also, as Anderson and Balland (1999) argue, a Rosca may offer a wife the opportunity to withdraw money from her husband's sphere, who may have different, likely more short-sighted, ideas about how to use the money. In this section it is further assumed that each individual participates in only one Rosca and that the contribution to the Rosca each member makes in each period, m say, has been agreed upon beforehand and can be considered fixed.

To avoid technical complications, we assume that participants can always pay their

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[2] For ease of exposition, I restrict attention to two-period Roscas.

[3] Throughout this dissertation, random variables are denoted by capital letters, while lower case letters denote realisations.

contribution m, even if they are hit by the most severe income shock possible. Formally, define $c_{\min} \equiv y_l - m$. We require that $c_{\min} \geq 0$ and that $u(x_1, x_2)$ be strictly bounded from below on the domain $D_u \equiv \{(x_1, x_2): x_1 \geq c_{\min}, x_2 \geq c_{\min}\}$.

Any problems of enforceability of contributions to the Rosca by members who have received a pot earlier, and are thus left with only obligations, are neglected. This can be justified by the fact that defaulting on contributions results in exclusion from future Roscas and by assuming that the disutility therefrom is prohibitively high.[4] Another important empirical feature, the remuneration of the Rosca organiser, is also excluded from this analysis.

In the literature, a variety of arrangements have been observed when it comes to the auctioning of the pot. There are various rules determining how the price for a period's pot is used. The most important issue is whether the said price is added to future pots (as in Calomiris and Rajaraman, 1998), or distributed at once, and if the latter, either among all or only among the active participants (as in Radakrishnan et al., 1975).[5] Throughout this dissertation, we will focus on the latter system, where the price is distributed instantaneously. In this chapter we will, moreover, assume that the winning bid is distributed among all Rosca participants.

We will confine our analysis to oral ascending bid (OA) auctions, which are the predominantly encountered auction type in actual bidding Roscas. In an OA-Rosca auction,

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[4] There is sufficient empirical evidence in support of this assumption. See, among others, Calomiris and Rajaraman (1998).

[5] In accordance with the literature, those participants who have not yet received a pot are referred to as 'active'.

the active participants meet and submit successive oral bids until only one bidder, the winner, remains. As in the analysis of standard auctions with symmetric, independent private value (SIPV) bidders,[6] one may model such an OA-Rosca auction as a button Rosca auction where each of the two bidders presses a button in front of her as the standing bid continuously increases. The auction is over once one of the two bidders, *i* say, releases her button. In this case, the other bidder, *j* say, receives the pot at a price equal to the standing bid at the moment *i* dropped out. For the derivation of bidding equilibria in a button Rosca auction, it is useful to consider a second-price sealed bid (SPS) Rosca auction. In this auction, both bidders submit their bids in sealed envelopes. The highest bid wins and the winner pays a price equal to the second highest bid submitted. Although this type of auction is not reported in any of the Rosca literature, in the present case, its equilibrium is also an equilibrium in the button Rosca auction. In the button Rosca auction, each bidder's problem is to decide when to release her button. Suppose that each bidder releases her button at a standing bid equal to her bid in the SPS-Rosca auction. If both bidders follow this rule, the payoffs to both of them are equal in the SPS and the button Rosca auction. Moreover, in a button Rosca auction with two bidders, the information set of each bidder during the auction is the same as the information set of a bidder in a SPS-Rosca auction because, during the course of the button auction, each bidder

[6] In a standard SIPV bidder 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.

only observes whether the auction is still going on or not.[7] In the language of game theory, 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.[8]

With this in hand, we can now embark on the strategic analysis of OA-Rosca auctions. As a first step, it is useful to introduce the concept of the maximum willingness to pay for period one's pot. After a participant, *i* say, has observed her first-period income, *y* say, and if she receives pot one at price *b*, her consumption in the first period is given by $y - m + (2m - b + b/2) = y + m - b/2$, where $y - m$ is her first-period income minus her contribution to the Rosca and $(2m - b + b/2)$ is the pot she receives minus the price *b*, plus the half of this price that is redistributed to her according to the rules of the Rosca. In this case, *i*'s second-period consumption is $y_2 - m$, where y_2 denotes the realisation of her second-period income. Accordingly, her expected utility after observing *y* is $u^{win}(b, y) \equiv \tilde{u}(y+m-b/2, Y-m)$, where *Y* denotes the random variable corresponding to y_2 and $\tilde{u}(\cdot, X) \equiv E_X[u(\cdot, X)] = \int_{y_l}^{y_u} u(\cdot, x)dF(x)$. If, on the other hand, the other participant receives pot one at price *b*, *i*'s expected utility is given by $u^{lose}(b, y) \equiv \tilde{u}(y-m+b/2, Y+m)$.

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[7] A discussion of button Rosca auctions with more than two bidders can be found in section 2.3.

[8] This reasoning is similar to the argument which establishes strategic equivalence of first-price sealed bid and Dutch auctions for standard SIPV bidder auctions. See, e.g., Matthews, 1990.

Now consider an OA-Rosca auction where the standing bid b is raised subsequently. At low levels of b, a bidder with first-period income y prefers winning pot one to losing it, formally $u^{\text{win}}(b, y) > u^{\text{lose}}(b, y)$ for sufficiently small b. Given the definition of $u(\cdot,\cdot)$, however, the said bidder's preference over winning or losing pot one is reversed at sufficiently high levels of the standing bid, formally $u^{\text{win}}(b, y) < u^{\text{lose}}(b, y)$ for sufficiently large b. We define the maximum willingness to pay for pot one, b^0 say, as that level of the standing bid at which a bidder is indifferent between winning and losing pot one. Formally, $b^0(y)$ is the value of b that satisfies

$$(1) \qquad \tilde{u}(y-m+b/2, Y+m) = \tilde{u}(y+m-b/2, Y-m).$$

It is now argued that b^0 corresponds to a bidder's value in a standard (not a Rosca) auction with SIPV bidders. In such auctions, by definition, a bidder is indifferent between winning and not winning the item auctioned when she has to pay a price equal to her true value. This definition applies to $b^0(y)$ in the present case; for by (1), a bidder with first-period income y is indifferent between receiving pot one and not receiving it at a level of the standing bid equal to $b^0(y)$.

In what follows, it will be assumed that the participant with the more severe income shock in period one has a higher maximum willingness to pay for pot one:

<u>Assumption 1:</u> b^0 *is strictly decreasing in period-one income, formally*

$$(2) \qquad \frac{db^0(y)}{dy} = 2\,\frac{\tilde{u}_1(y+m-b^0(y)/2, Y-m) - \tilde{u}_1(y-m+b^0(y)/2, Y+m)}{\tilde{u}_1(y+m-b^0(y)/2, Y-m) + \tilde{u}_1(y-m+b^0(y)/2, Y+m)} < 0 \text{ for all } y.$$

We now derive a symmetric Bayes-Nash bidding equilibrium of a SPS-Rosca auction, which is also a symmetric equilibrium of an OA-Rosca auction, as has been argued above. Towards this end, assume that i conjectures that j determines her bid b_j according to a smooth, strictly decreasing function $b(y_j)$, where y_j denotes j's first-period income. Because of the private information assumption, for i, j's first-period income is a random variable distributed according to F. Therefore, from i's perspective, the probability of losing the auction conditional on bidding b_i is $P(b_i < b(Y_j)) = P(b^{-1}(b_i) > Y_j) = F(b^{-1}(b_i))$, where the events $b_i < b(Y_j)$ and $b^{-1}(b_i) > Y_j$ are identical by virtue of the assumption that $b(\cdot)$ is a strictly decreasing function. The probability that i loses is, by definition, $1 - P(b_i < b(Y_j)) = 1 - F(b^{-1}(b_i))$.

If i loses the auction, her expected utility conditional on her first-period income y_i and her bid b_i is $\tilde{u}(y_i - m + b_i/2, Y + m)$. If, on the other hand, i wins the auction, her expected utility conditional on y_i and b_i is $E[\tilde{u}(y_i + m - b(Y_j)/2, Y - m) | Y_j > b^{-1}(b_i)]$. Consequently, i's interim expected utility[9] as a function of her bid b_i is given by

$$
\begin{aligned}
E[U(b_i)|\, y_i] \equiv{} & \tilde{u}(y_i - m + b_i/2, Y + m)\, F(b^{-1}(b_i)) \\
& + E[\tilde{u}(y_i + m - b(Y_j)/2, Y - m) | Y_j > b^{-1}(b_i)]\,(1 - F(b^{-1}(b_i))),
\end{aligned}
\tag{3}
$$

and i's task is to maximise $E[U(b_i)|\, y_i]$ by choice of b_i. The corresponding first-order condition reads

$$
\begin{aligned}
\frac{\partial E[U(b_i)|y_i]}{\partial b_i} ={} & \frac{1}{2}\tilde{u}_1\big(y_i - m + b_i/2, Y + m\big)F(b^{-1}(b_i)) \\
& + \big(\tilde{u}\big(y_i - m + b_i/2, Y + m\big) - \tilde{u}\big(y_i + m - b_i/2, Y - m\big)\big)\frac{f(b^{-1}(b_i))}{b'(b^{-1}(b_i))} = 0.
\end{aligned}
\tag{4}
$$

---

[9] In accordance with the literature on SIPV auctions, at the interim stage, a bidder has observed her type (in the present case determined by y_i) but not yet submitted her bid.

The Bayes-Nash equilibrium bidding strategy, $b_s(\cdot)$ say, is obtained by substituting $b(y_i)$ for b_i in the RHS of (4), where the subscript s indicates that $b_s(\cdot)$ characterises an equilibrium of a SPS- and thus of an OA-Rosca auction.

Proposition 1: Consider a two-participant-two-period bidding Rosca with an oral ascending bid auction, in which assumption 1 holds. Then

(i) in a symmetric Bayes-Nash equilibrium, each bidder quits the auction at a standing bid equal to $b_s(y)$, where y is a bidder's privately observed first-period income and

(5) $$b_s'(y) = 2\frac{f(y)}{F(y)}\left[\frac{\tilde{u}(y+m-b_s(y)/2, Y-m)-\tilde{u}(y-m+b_s(y)/2, Y+m)}{\tilde{u}_1(y-m+b_s(y)/2, Y+m)}\right],$$

(6) $$b_s(y_l) = b^0(y_l);$$

(ii) in such an equilibrium, bidders overbid relative to their maximum willingness to pay, i.e. $b_s(y) > b^0(y)$ for all $y > y_l$;

(iii) bids are strictly decreasing in income, i.e. $b_s'(y) < 0$ for all y.

Proof:

(i) Necessity follows from (4).

(ii) By applying L'Hôpital's rule to the RHS of (5) in view of the fact that y_l constitutes a singularity for the differential equation (5), we obtain

(7) $$b_s'(y_l) = 2\frac{\tilde{u}_1(y_l+m-b^0(y_l)/2, Y-m)-\tilde{u}(y_l-m+b^0(y_l)/2, Y+m)}{\tilde{u}_1(y_l+m-b^0(y_l)/2, Y-m)+2\tilde{u}_1(y_l-m+b^0(y_l)/2, Y+m)},$$

where, according to (6), $b^0(y_l)$ has been substituted for $b_s(y_l)$. Comparing (2) with (7), it follows that

(8) $0 > b_s'(y_l) > b^{0\prime}(y_l)$.

Combining (8) with (6), we obtain

Lemma 1: There exists an $\varepsilon > 0$ such that $b_s(y) > b^0(y)$ for all $y_l < y \leq y_l + \varepsilon$.

Now assume that

(9) $b_s(y_0) = b^0(y_0)$ for some $y_0 > y_l$.

By (1) and (5), (9) implies that

(10) $b_s'(y_0) = 0$.

By assumption 1, however,

(11) $b^{0\prime}(y_0) < 0$.

Hence, for any $y_0 > y_l$, b_s intersects b^0 from below, which contradicts Lemma 1. Thus,

(12) b_s and b^0 cannot intersect for any $y > y_l$.

Moreover, by combining (10) and (11), we find that (9) implies that $b_s'(y_0) > b^{0\prime}(y_0)$ and hence

(13) b_s cannot touch b^0 for any $y > y_l$.

Combining (12) and (13) with Lemma 1 gives the desired result.

(iii) Since, by virtue of (ii), $b_s(y) > b^0(y)$ for all $y > y_l$, it follows from (1) and the fact that u is strictly increasing in its first argument that the RHS of (5) is negative. Together with the first inequality in (8), this gives the desired result.

QED

Sufficient conditions for the existence of the Bayes-Nash equilibrium characterised in Proposition 1 are given in section 1.6.1 of the Appendix to this chapter.

The result that, in an OA-Rosca auction, bidders overbid relative to their maximum willingness to pay is in marked contrast to equilibrium behaviour in a standard SIPV oral English auction, where bidding one's true value is a dominant strategy. As argued above, the analogue to a bidder's value in a standard SIPV auction is $b^0(y)$ in a Rosca auction. Suppose participant i originally intends to quit the auction at a standing bid equal to $b^0(y_i)$ and the other participant, j say, is also still in the auction at $b^0(y_i)$. By staying in the auction up to $b^0(y_i) + \varepsilon$ instead of $b^0(y_i)$, i takes the chance of winning the pot at a price at which she prefers not to win the pot, because, by definition, $u^{lose}(b^0(y_i) + \varepsilon, y_i) > u^{win}(b^0(y_i) + \varepsilon, y_i)$. This happens whenever j quits the bidding process before $b^0(y_i) + \varepsilon$. On the other hand, staying in the auction up to $b^0(y_i) + \varepsilon$ instead of $b^0(y_i)$ improves i's situation whenever j does not quit the bidding process at a standing bid lower than $b^0(y_i) + \varepsilon$ because now i receives $(b^0(y_i) + \varepsilon)/2$ instead of $b^0(y_i)/2$ as her share of the price j pays for the pot. In a standard SIPV auction, only the former of these two effects is present and therefore, in such auctions, there is no gain from overbidding. Proposition 1, however, shows that, in the equilibrium of a Rosca auction, the gains from overbidding exceed the losses except for a bidder with income y_l, who wins the pot with probability one. Thus $b_s(y_l) = b^0(y_l)$.

The lesson from this is that, contrary to standard SIPV bidder oral English auctions, bidding in a Rosca auction is always strategic and equilibria in dominant strategies fail to exist. The reason for this arises from the fact that, in the terminology of Kovsted and Lyk-Jensen (1999), in a Rosca auction, the seller is internalised in the group of bidders. As a consequence, the loser of a Rosca auction is not left in the same economic situation as before the beginning of the auction, but rather receives a gain from the share of the winning bid that is allocated to him.[10]

1.3 Preferences for Risk Bearing and Preferences for Random and Bidding Roscas

With the results of the previous section in hand, we can now ask: how do preferences for risk bearing influence the decision to participate in a random or a bidding Rosca? We shall make use of the concept of temporal risk aversion, which was first defined by Richard (1975) as follows: a decision maker is said to be multivariate risk averse if, for any pair (x, y), $u_{12}(x, y) < 0$ and multivariate risk seeking if $u_{12}(x, y) > 0$. The case of $u_{12}(x, y) = 0$ is defined as multivariate risk neutrality. If u's arguments refer to consumption at two points in time, 'multivariate' may be replaced by 'temporal' (see Ingersoll, 1987). This concept can be illustrated as follows: Consider two lotteries L_1 and L_2 which are both resolved in period zero. L_1 involves a consumption level of x in both the first and the second period with probability 0.5 and a consumption level of y in both periods with probability 0.5. L_2 involves a consumption level of x in the first and y in the second period with probability 0.5, and y in the first and x in the second period with probability 0.5. A temporal risk averse decision maker prefers L_2 to L_1, while a temporal risk seeking decision maker prefers L_1 to L_2 for any pair (x, y). Thus, loosely speaking, a temporal risk seeking agent has a preference for lotteries

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[10] Roscas share this feature with so called fair division games, which are auctions where the price the winner pays is distributed to the other bidders. Such games with risk averse bidders, however, have not yet been studied. See Güth et al. (1999a) for an experimental application and Güth and van Damme (1986) for a theoretical analysis.

whose payoffs are positively correlated over time while a temporal risk averse agent prefers negatively correlated payoffs.[11]

We begin with a random Rosca. While uncorrelated without such a Rosca, the consumption levels of participants in a random Rosca are negatively correlated. We write the interim expected utility of a participant with first-period income y as

$$(14) \quad E[U^R | y] \equiv \left(\tilde{u}(y+m, Y-m) + \tilde{u}(y-m, Y+m)\right)/2 .$$

For the sake of analytical tractability, we concentrate on Roscas with an infinitesimally small contribution m. Evaluating the derivative of (14) w.r.t. m at $m = 0$ yields zero, while the second derivative is

$$(15) \quad \frac{d^2 E[U^R | y]}{dm^2}_{|m=0} = 2\left(\tilde{u}_{11}(y,Y) + \tilde{u}_{22}(y,Y) - 2\tilde{u}_{12}(y,Y)\right).$$

It is seen that, if $u_{12} \geq 0$, the said derivative is strictly negative. Thus, not participating in a random Rosca is the optimal decision for temporal risk seeking and temporal risk neutral agents. A simple continuity argument, moreover, establishes at once the result that agents who are sufficiently mildly temporal risk averse will not participate either. In general, however, if $u_{12} < 0$, the case is ambiguous. The question then is whether the effect of temporal risk aversion arising from the negative cross derivative outweighs the effect of static risk aversion arising from the concavity of u in each argument. Formally, similar to Ronn (1988), define the coefficients of static and temporal risk aversion as

---

[11] Ronn (1988) argues that for a temporal risk averse agent, consumption levels in any two periods are ‘substitutes through time’, whereas they are complements for a temporal risk seeker.

$$RA_t(x_1,X_2) \equiv -\frac{\tilde{u}_{tt}(x_1,X_2)}{\tilde{u}_t(x_1,X_2)} \text{ and } TRA_{kt}(x_1,X_2) \equiv -\frac{\tilde{u}_{kt}(x_1,X_2)}{\tilde{u}_t(x_1,X_2)},$$

respectively, and rewrite (15) as

$$\frac{d^2E[U^R|y]}{dm^2}_{|m=0} = 2\left(\tilde{u}_1(y,Y)(TRA_{21}(y,Y)-RA_1(y,Y))+\tilde{u}_2(y,Y)(TRA_{12}(y,Y)-RA_2(y,Y))\right).$$

Defining autarky as not participating in a Rosca, we have

<u>Proposition 2:</u> If

(16) $TRA_{21}(y, Y) \leq RA_1(y, Y)$ and $TRA_{12}(y, Y) \leq RA_2(y, Y)$ for all y,

then autarky is preferred to participation in a random Rosca with a small contribution m.

A borderline case arises when $u(x_1, x_2) = v(x_1 + x_2)$ for some strictly increasing and concave function v.[12] Then $TRA_{tk} = RA_t = RA_k$ and such individuals are indifferent between participating in a random Rosca or not. Although a certain degree of temporal risk aversion seems plausible for individuals whose consumption is not well above the subsistence level, it is rather unlikely that any such individual would improve her situation by joining a random Rosca.[13]

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[12] If $v(x) = x$, this is the case of risk neutral agents who do not discount future consumption.

[13] Only few studies have addressed the relationship between static and temporal risk aversion empirically, none of them in the context of developing countries. In a data set of US consumers, however, Epstein and Zin (1991) find a statistically significant positive intertemporal elasticity of substitution, which, in their framework, implies that static risk aversion is more pronounced than temporal risk aversion.

Turning to bidding Roscas, interim expected utility in equilibrium $E[U|\, y]$ is obtained by substituting $b_s(\cdot)$ for $b(\cdot)$ and $b_s(y_i)$ for b_i in (3). Further, for notational convenience, we drop the subscript i.

(17) $E[U|\, y] \equiv \tilde{u}(y-m+b_s(y)/2, Y+m)\, F(y) + E[\tilde{u}(y+m-b_s(Y_j)/2, Y-m)|Y_j > y]\,(1\text{-}F(y))$.

The following proposition is based on the expression $\dfrac{dE[U|y]}{dm}$ evaluated at $m = 0$. We thus ask, as for random Roscas, how participation in a small bidding Rosca changes interim expected utility with autarky as the reference point.

Proposition 3:

At the interim stage, two individuals will choose to form a bidding Rosca that results in pot one going to the participant with lower first-period income if, and only if,

(18) $RA_1(y,Y) \geq TRA_{12}(y,Y)$ for all y and

(19) there exists an $\varepsilon > 0$ such that $RA_1(y,Y) > TRA_{12}(y,Y)$ for all $y_l < y < y_l + \varepsilon$.

Proof (Sketch):

A *Sufficiency*

Sufficiency requires two things:

(i) For an infinitesimally small bidding Rosca, there exists an equilibrium bidding function $b_s(y)$ which is strictly decreasing in first-period income y, because only a strictly decreasing $b_s(\cdot)$ ensures that pot one always goes to the participant with lower first-period income.

(ii) For all y, $E[U|\, y]$ is increasing in m at $m = 0$.

<u>Proof of (i):</u>

It is easily verified that $b_s(y)_{|m=0}$, and thus $b_s'(y)_{|m=0}$, is equal to zero for all *y*. It is, moreover, established in section 1.6.2.1 of the Appendix to this chapter that

$$(20)\quad \frac{\partial b_s'(y)}{\partial m}_{|m=0} = -4\frac{f(y)}{(F(y))^3}\int_{y_l}^{y}\frac{\tilde{u}_2(\rho,Y)}{\tilde{u}_1(\rho,Y)}\left(RA_1(\rho,Y)-TRA_{12}(\rho,Y)\right)\left(F(\rho)\right)^2 d\rho\,.$$

By L'Hôpital's rule, $\frac{\partial b_s'(y_l)}{\partial m}_{|m=0}$ is always zero, whereas, if (18) and (19) hold, the RHS of (20) is strictly negative for all $y > y_l$, which implies that, for small *m*, $b_s(y)$ is strictly decreasing for all *y*.

To verify that bidding according to $b_s(y)$ is a best response, section 1.6.2.2 of the Appendix to this chapter establishes that, for all *y*, (18) is sufficient for the pseudoconcavity of $\frac{\partial E[U_s(b)|y]}{\partial m}_{|m=0}$ in *b*, where $E[U_s(b)|\,y]$ is equal to $E[U(b)|\,y]$ as defined in (3) with $b_s(\cdot)$ substituted for $b(\cdot)$.

<u>Proof of (ii)</u>:

Given (i), it is established in section 1.6.2.3 of the Appendix to this chapter that

$$(21)\quad \frac{\partial E[U|y]}{\partial m}_{|m=0} = \tilde{u}_1(y,Y)$$

$$*\left(\int_{y}^{y_u}\frac{\tilde{u}_2(\rho,Y)}{\tilde{u}_1(\rho,Y)}\left(RA_1(\rho,Y)-TRA_{12}(\rho,Y)\right)\left(1-F(\rho)\right)^2 d\rho+\int_{y_l}^{y}\frac{\tilde{u}_2(\rho,Y)}{\tilde{u}_1(\rho,Y)}\left(RA_1(\rho,Y)-TRA_{12}(\rho,Y)\right)\left(F(\rho)\right)^2 d\rho\right),$$

which is clearly positive for all *y* if (18) and (19) hold.

B *Necessity*

(i) Necessity of (18): Assume that

$$(22)\quad RA_1(y',Y) < TRA_{12}(y',Y)\ \text{ for some } y'.$$

It is established in section 1.6.2.4 of the Appendix to this chapter that (22) implies that, evaluated at $b = b_s(y')$, $\frac{\partial E[U_s(b)|y']}{\partial m}_{|m=0}$ is strictly convex in b. Thus $b_s(y') \neq \arg\max_b E[U_s(b)|\, y']$ for small values of m and so the strictly decreasing function $b_s(\cdot)$ is not an equilibrium bidding function, which contradicts the statement 'two individuals will choose to form a bidding Rosca that results in pot one going to the participant with lower first-period income'.

(ii) Necessity of (19): Assume that there exists no $\varepsilon > 0$ such that $RA_1(y,Y) > TRA_{12}(y,Y)$ for all $y_l < y < y_l + \varepsilon$. Then it follows from (20) that in some neighbourhood of y_l, $\frac{\partial b_s'(y)}{\partial m}_{|m=0} \geq 0$, which violates the requirement that $b_s(\cdot)$ be strictly decreasing for all y.

QED

It can be shown that, for preferences whose coefficient of temporal risk aversion is uniformly higher than the coefficient of static first-period risk aversion, participation in a bidding Rosca with a strictly increasing equilibrium bidding function is advantageous. All of the qualitative empirical evidence (see, e.g., Calomiris and Rajaraman, 1998), however, suggests that such bidding behaviour does not occur in reality and is therefore not discussed further in this chapter. A particularly important specification of intertemporal utility involves additive separability of the utility contributions from the first and second period, $u(x_1, x_2) = v_1(x_1) + v_2(x_2)$, with $v_t' > 0$ and $v_t'' < 0$, $t = 1, 2$. For all such utility functions, $u_{12} = 0$ and thus, within the present framework, additively separable utility functions induce participation exclusively in bidding Roscas.

Empirically, participation in both random and bidding Roscas is observed among ex ante identical individuals. This contradicts both (i) the present result that, when individuals are exposed to risk and reasonable assumptions on preferences, namely (16), are imposed, only participation in bidding Roscas occurs, and (ii) the predictions of deterministic Rosca models (Besley et al., 1993; Kovsted and Lyk-Jensen, 1999), where, when there is no income risk and individuals desire to purchase a lumpy good, only participation in random Roscas occurs. In practice, however, decision-makers are simultaneously affected by the two factors, which are separately analysed in the present stochastic Rosca model and the deterministic Rosca models. Thus a plausible interpretation of the coexistence of bidding and random Roscas among ex ante identical individuals is that, for those who join a random Rosca, the advantages of the latter arrangement for facilitating an earlier purchase of a lumpy good override the desire to insure, while the insurance motive is stronger when participation in a bidding Rosca occurs.

To conclude this section, a remark on the optimal value of m, m* say, in the case of a bidding Rosca is in order. Since, in reality, a Rosca is planned before the first meeting, the appropriate perspective is the ex ante stage, where participants have not yet observed their first-period incomes. Formally, their problem is to maximise ex ante expected utility $E[U] \equiv E_{Y_1}[E[U|\, Y_1]]$ by choice of m, where expected utility for the realisation y_1, $E[U|\, y_1]$, is given by (17). Since this problem has no explicit solution, we consider a numerical example where $u(x_1, x_2) = log(x_1) + \delta\, log(x_2)$ and income within each period is uniformly distributed on the interval [1, 2]. If there is no discounting, i.e. $\delta = 1$, the optimum contribution is 0.083. For strong discounting, that is $\delta = 0.5$, the corresponding value is 0.109. Thus, about six to eight percent of the expected income is contributed to the Rosca in each period.

1.4 The Rate of Time Preference and the Intertemporal Pattern of Bids

In empirical studies, it is observed that winning bids exhibit a decreasing trend from period to period. For a specific family of utility functions, we now explore how risk aversion and the individual rate of time preference affect the intertemporal pattern of bids and observed prices. This has important implications for empirical research, since, in most studies, the latter is the only statistic available. Since a two-period Rosca involves only one auction, an appropriate framework for this section is a three-period Rosca. As before, it is assumed that each of the three participants contributes m to each period's pot, which consequently now amounts to $3m$. Since the winning bid is distributed among three participants, each receives a third of it. To keep the analysis tractable, we restrict our attention to income shocks distributed uniformly on the unit interval (i.e. $F(y) = y$, $y_l = 0$, $y_u = 1$) and the family of CARA utility functions with temporal risk aversion equal to zero:

(23) $u(c_1, c_2, c_3) \equiv v(c_1) + \delta v(c_2) + \delta^2 v(c_3)$ with $v(y) \equiv -(\exp[-ay] - 1)/a$, $a > 0$, $0 < \delta \leq 1$.[14]

Define $b_t(y_t)$, $t = 1, 2$, to be the standing bid at which an active bidder with period t income y_t intends to quit the period t auction. It can be shown that, in a symmetric equilibrium, $b_t(\cdot)$ satisfies

(24) $$\frac{db_t}{dy_t}(y_t) = 3\frac{f(y_t)}{F(y_t)}\left(\frac{v(y_t + 2m - \frac{2}{3}b_t(y_t)) - v(y_t - m + \frac{1}{3}b_t(y_t)) + \delta\Delta_t}{v'(y_t - m + \frac{1}{3}b_t(y_t))}\right)$$ and

[14] The familiar result that, for the family of CARA utility functions, individual decisions are independent of the level of the income variable, is also applicable in the present case. Thus the analysis of this section remains unchanged for any shift of the income random variable.

(25) $$v(y_l + 2m - \frac{2}{3}b_t(y_l)) - v(y_l - m + \frac{1}{3}b_t(y_l)) = \delta\,\Delta_t$$ with

(26) $\Delta_1 \equiv E[U^{1L} - U^{1W}]$

$\Delta_2 \equiv E[v(Y + 2m) - v(Y - m)]$.

$E[U^{1W}]$ is defined as the expected future utility (i.e. the utility contributions of the payoffs in the second and third period) of the winner of the first pot before observing her second-period income, while $E[U^{1L}]$ is the expected future utility of a first-period 'loser' before observing her second-period income. Analogously, Δ_2 is the difference between the expected future utility (i.e. the utility contributions of the payoffs in the third period) of the 'loser' of both the first and second auction and the winner of the second pot, before observing y_3. Thus Δ_t can be interpreted as the (undiscounted) future utility costs of winning pot t. The next proposition concerns the relationship between the degree of impatience and the bids submitted.

<u>Proposition 4:</u> $\frac{db_t(y_t)}{d\delta} < 0$ for all admissible values of a, δ, m, t and y_t.

<u>Proof:</u> See section 1.6.3 of the Appendix to this chapter.

The higher her degree of impatience, the less a participant cares about the future costs of winning an early pot, and thus, for any realised first or second-period income, the higher the bid she submits. An interesting case arises whenever a and δ are such that $\Delta_1 = \Delta_2$. Then, by (24) and (25), $b_1(y) = b_2(y)$ for all y.

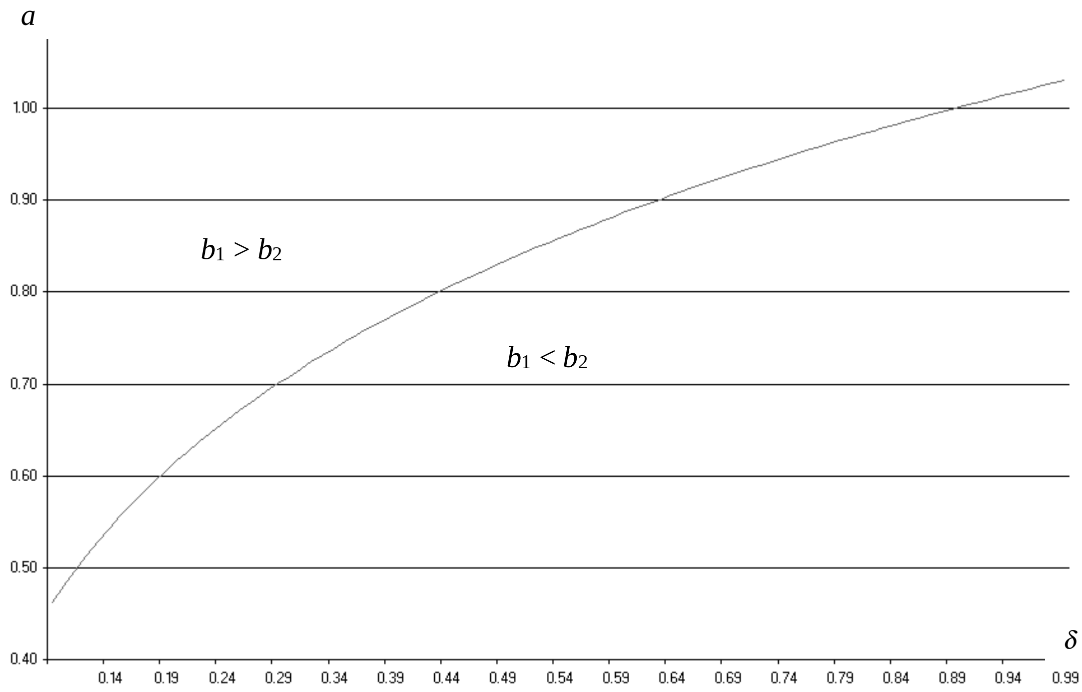

Figure 1. The intertemporal discount factor, δ, the coefficient of absolute risk aversion, a, and bids in period one and two for a three-period Rosca with contribution 0.1

The concave line in Figure 1 is the locus of pairs (δ, a) that yield identical future utility costs of winning in the first or second period. Since an increase in δ increases Δ_1 and leaves Δ_2 constant, it is easily established that a departure from the separating locus to the right affects b_1 more strongly than b_2 and thus, for any given income y, yields $b_2(y) > b_1(y)$. Concerning a, we did not succeed in establishing analytically what Figure 1 reveals, namely that an upward departure from the separating locus (i.e. an increase in the coefficient of absolute risk aversion, a) affects first-period bids more strongly than second-period bids. There is, however, an intuitive explanation for this. First note that the future utility costs of pot one can be decomposed into a contribution from the second period, Δ_{12}, and a contribution from the third period, which equals the future utility costs of pot two multiplied by half the discount factor δ:

(27) $\Delta_1 = \Delta_{12} + (\delta/2)\,\Delta_2$.[15]

On the separating locus, we thus have $\Delta_{12} = (1-(\delta/2))\Delta_2$. Since the second pot is allocated to that active participant who suffers the bigger income shock in the second period, Δ_{12} involves transfers that go, at least partly, from the better to the worse off participant, whereas, for the third period, Δ_2 involves transfers that are independent of that period's incomes. Consequently, increasing *a* from a level where an individual is indifferent between Δ_{12} and $(1-(\delta/2))\Delta_2$ should yield a preference for Δ_{12} and thus a lower value of Δ_{12} than $(1-(\delta/2))\Delta_2$ because, as mentioned, the Δ's have the character of utility costs. In summary, we expect that, when $\Delta_1 = \Delta_2$, $\frac{d\Delta_1}{da} < \frac{d\Delta_2}{da}$. Finally, it is easily verified that $\frac{d\Delta_2}{da}$ is strictly negative and that $\frac{db_t(y)}{d\Delta_t}$ is strictly negative for all *y*. Hence we obtain the desired result that, when $b_1(y) = b_2(y)$ for all *y*, $\frac{db_1(y)}{da} > \frac{db_2(y)}{da}$ for all *y*.

Turning to the observed prices which each period's winner pays, first note that, even in the case where first and second-period bidding strategies are identical, on average, the winner of the first pot pays more than the winner of the second pot because the number of active participants and thereby the auction's competitiveness decreases. Instead of comparing the expected values of the observed prices directly, we focus on a related statistic that facilitates an intuitive interpretation of the effects of both risk aversion and the rate of time preference. As a benchmark, consider a three-period bidding Rosca with risk neutral participants with utility function *u* as given by (23) with $a = 0$. Since, in this case, income uncertainty does not affect bidding, a bidding equilibrium is uniquely defined by that pair

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[15] See section 1.6.3 of the Appendix to this chapter for explicit formulae.

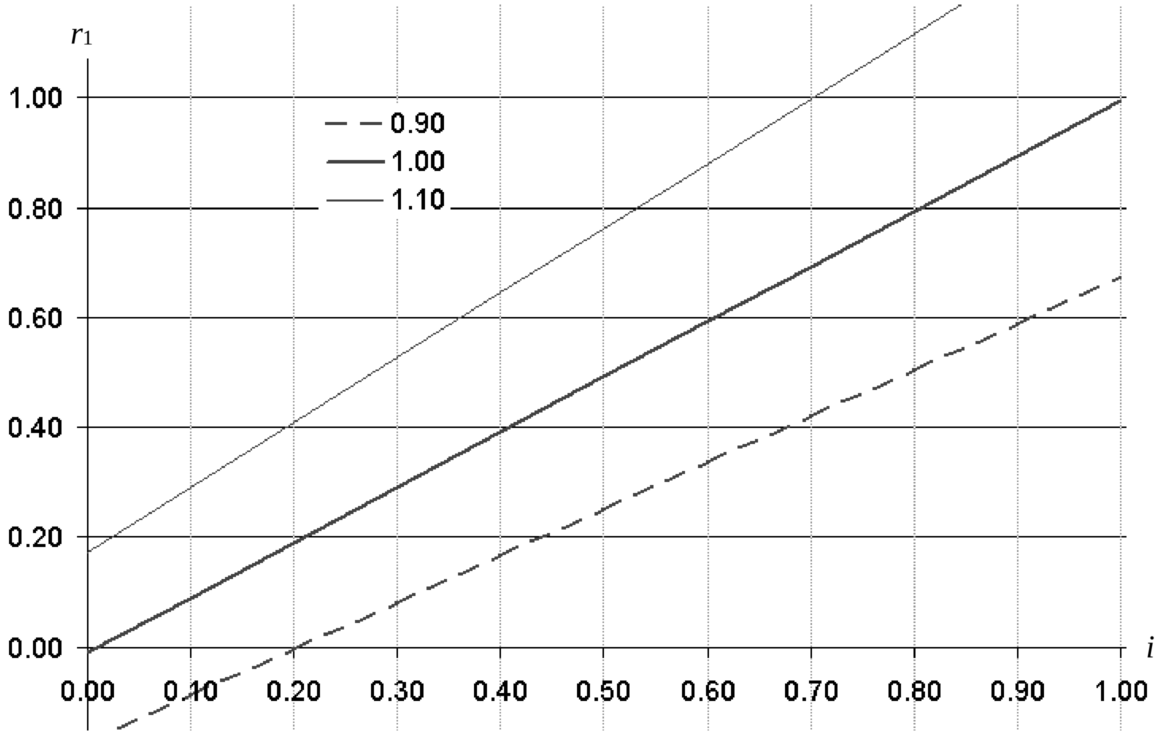
(b_1, b_2) which, in each period, equalises the winner's and the losers' expected utilities. This yields

(28) $b_t = 3m\left(1-\delta_t^{3-t}\right)$, $t = 1, 2$,

where, in the risk-neutral case, δ_t in (28) is equal to δ from (23) for $t = 1, 2$. Now, for any observed b_t, the statistic we consider is $\rho(b_t) \equiv (1/\delta_t) - 1$, which can be interpreted as the rate of discount implicit in the observed price b_t. In the risk-neutral case, this quantity is, of course, equal to the rate of time preference. Since bids become income-dependent once risk aversion enters the stage, we substitute the expected value $E[B_t]$ for b_t and thus obtain

$$r_t \equiv \rho(E[B_t]) = \left(1-{E[B_t]}\big/{3m}\right)^{-t/2} - 1.$$

Figure 2 depicts r_1 as a function of the rate of time preference $i \equiv (1/\delta) - 1$ for different values of a. As a consequence of Proposition 4, r_1 is increasing in i. Note that, for a equal to unity, on average, the discount rate implicit in b_1 is incidentally just about equal to the rate of time preference. Turning to a, it is in line with standard SIPV auctions, that *ceteris paribus* more risk averse individuals bid more aggressively and thus generate a higher rate of discount r_1. In contrast to standard SIPV auctions, however, this result does not hold uniformly in the sense that $\frac{db_1(y_1)}{da} \geq 0$ for all y_1. In fact the slope of $b_1(y_1)$ is becoming steeper as a increases, and for large values of a (1.9 and bigger), we find that $\frac{db_1(y_u)}{da} < 0$. The reason for this are two effects pulling in opposite directions: on the one hand, higher risk aversion increases the desire to compensate a contemporaneous (i.e. first-period) income shock by winning pot one and thereby stimulates higher bids particularly for low values of y_1. On the other hand, winning pot one leaves no potential for the compensation of a shock in the two remaining periods. As risk aversion increases, an individual values the possibility of compensating a future income shock higher, which in turn lowers the willingness to pay for pot one, especially at high levels of y_1.



Broken line: *a* = 0.90, thick line: *a* = 1.00, thin line: *a* = 1.10

Figure 2. The rate of time preference, i, and the rate of discount implicit in b_1, r_1, in a three-period Rosca with contribution 0.1 for different degrees of risk aversion, a.

Turning to the intertemporal pattern of observed prices, it is of particular interest how risk aversion affects the time path of r_t. As follows from the derivation above, r_t remains constant over time if participants are risk-neutral because, by definition, r_t does compensate for a positive rate of time preference. As Figure 3 illustrates, there is an interesting interaction between impatience and the degree of risk aversion. For sufficiently high levels of absolute risk aversion, r_2 is smaller than r_1 while this relationship is reversed at low levels of risk aversion. In both cases, higher impatience *ceteris paribus* increases the difference between r_1

and r_2. Here, again, the arguments apply which have been advanced for explaining Figure 2: the future utility costs for winning pot two, Δ_2, involve payoffs independent of third-period incomes, whereas the future utility costs for winning pot one, Δ_1, include the term Δ_{12}, which involves transfers that do depend on incomes in the second period. Thus, as *a* increases, the *future* utility costs for winning the second pot increase relative to those for the first pot and so relatively higher *contemporaneous* costs in the form of *r* are observed in the first period. This effect is more pronounced the higher the rate of time preference, because, as *i* increases, the weight of the third-period component Δ_2 in (27) declines and so the effect of income-dependent transfers implicit in Δ_{12} becomes relatively stronger.

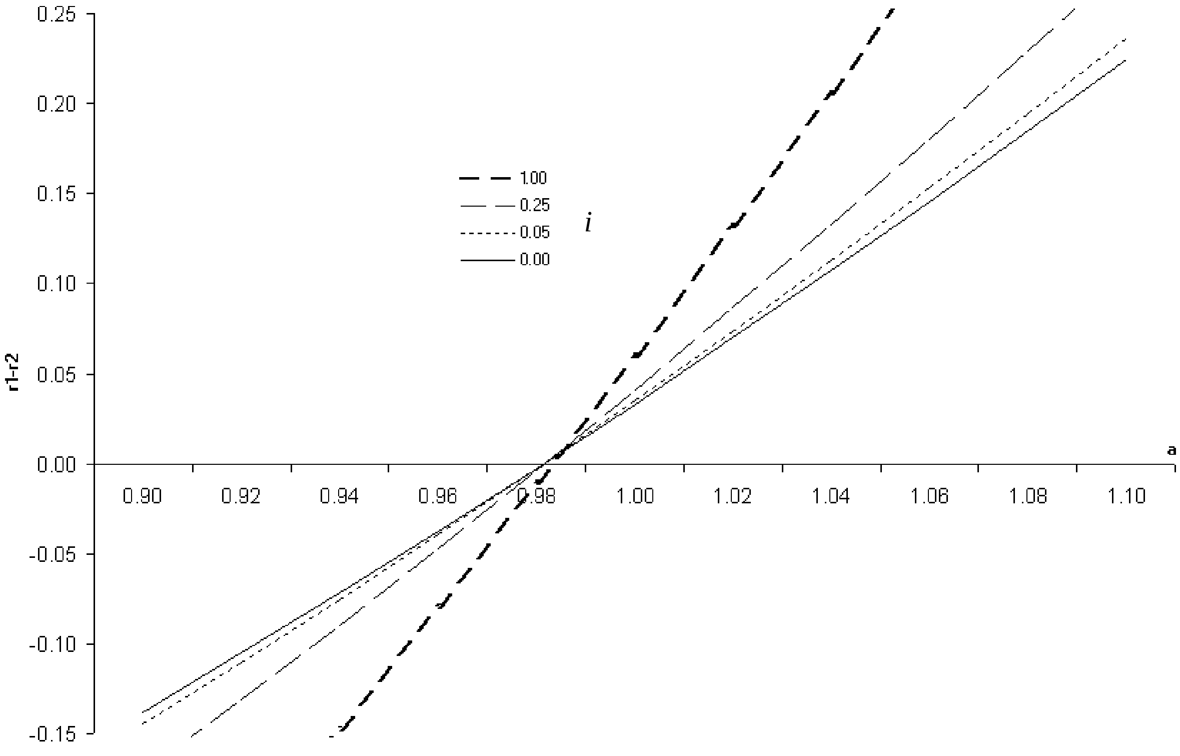


Figure 3. Difference between the rates of discount implicit in the pots' prices as a function of the coefficient of absolute risk aversion, *a*, for different values of the rate of time preference, *i*, in a three-period Rosca with contribution 0.1

In their sample Rosca, Calomiris and Rajaraman (1998) find a declining trend in the statistic r_t. They do not, however, consider the role of risk aversion in this context. As their participants are urban casual labourers who earn incomes close to the subsistence level, the authors argue that risk aversion can be expected to be fairly pronounced. These findings support our model since a decreasing trend in r_t is only supported by levels of risk aversion above a certain threshold.

1.5 Concluding Remarks

Roscas can offer insurance for homogenous, risk averse individuals who have stochastic, privately observed incomes and no access to credit. It has been established that, under the assumptions set out above, participation in a single bidding Rosca is advantageous for a wide class of preferences, namely, when temporal risk aversion is less pronounced than static risk aversion. Under this assumption, participation in a random Rosca does not occur. Roscas impose severe restrictions on the set of feasible allocations among participants within each period, which arise from a fixed transfer in the last period and the strategic behaviour of bidders in prior periods. By doing this, however, they bring about a net transfer from the better to the worse off bidder each time a pot is auctioned and thereby overcome information asymmetries.

The present results suggest that, if reasonable restrictions on preferences are imposed, homogenous individuals prefer a bidding Rosca because it can allocate funds to the participant with the most urgent current need. This finding is supported by empirical studies where bidding Roscas are observed among ex ante identical individuals. On the other hand, our results cannot explain the existence of random Roscas among ex ante identical individuals. For empirical work this suggests that, in the latter case, participation occurs to facilitate the earlier purchase of a lumpy good, as argued by Besley et al. (1993) and Kovsted and Lyk-Jensen (1999). They prove that, for a group of homogenous individuals, a random Rosca is always preferred, and that bidding Roscas are only preferred when individuals are sufficiently heterogeneous. In their setting, heterogeneity is a permanent individual characteristic and bidding serves to accommodate those with the highest willingness to pay first, which in turn generates a gain for the other members through the distribution of the winning bid. In the models presented in this chapter, in contrast, individuals are identical ex ante and it is individual-specific uncertainty that generates potential gains from intertemporal trade.

The transactions observed in many actual Roscas are better explained by the present approach, where, in contrast to deterministic Rosca models, the price paid for a period's pot does not decrease monotonically with the number of rounds played, although, on average, observed transfers to recipients of pots increase if there is a sufficiently high rate of time preference. Moreover, if risk aversion is high, the time path of the rate of discount implicit in a pot's price is decreasing on average. The realisations of both of these quantities, however, fluctuate significantly in the model presented here.

1.6 Appendix to Chapter 1

1.6.1 Supplement to the Proof of Proposition 1

This appendix discusses sufficient conditions for the optimality of bidding $b_s(y)$ as defined by (5) and (6), given that the other participant bids according to $b_s(\cdot)$. Towards this end, we substitute $b_s(\cdot)$ for $b(\cdot)$ and $b_s(\psi)$ for b in $E[U(b)|\, y]$ as defined by (3) to obtain

(29) $E[U|\, y,\, \psi] \equiv \tilde{u}(y-m+b_s(\psi)/2, Y+m)\, F(\psi) + E[\tilde{u}(y+m-b_s(Y_j)/2, Y-m)|Y_j > \psi]\,(1\text{-}F(\psi))$,

which is the equilibrium interim expected utility of a participant who actually observes first-period income y but acts in the auction as if his first-period income was ψ instead. Note that, by the necessary conditions (5) and (6), $b_s(\cdot)$ is such that $\left.\frac{\partial E[U|\, y, \psi]}{\partial \psi}\right|_{\psi = y} = 0$ for all y. Consequently, as in the analysis of standard SIPV auctions, pseudoconcavity of $E[U|\, y,\, \psi]$ in ψ for all y is sufficient for the optimality of bidding $b_s(y)$, given that the other participant bids according to $b_s(\cdot)$. Formally, the said pseudoconcavity requires that

(30) $\frac{\partial E[U|\, y, \psi]}{\partial \psi} \geq 0$ for all $\psi < y$ and $\frac{\partial E[U|\, y, \psi]}{\partial \psi} \leq 0$ for all $\psi > y$.

For notational convenience, we define

(31) $\Delta(y) \equiv m - b_s(y)/2$.

Differentiating $E[U|\, y,\, \psi]$ as defined in (29) w.r.t ψ gives

$$\frac{\partial E[U|\, y, \psi]}{\partial \psi} = f(\psi)\; \tilde{u}_1(y - \Delta(\psi), Y + m)\; g(\psi,\, y) \text{ with}$$

$$g(\psi,\, y) \equiv \frac{\tilde{u}(y - \Delta(\psi), Y + m) - \tilde{u}(y + \Delta(\psi), Y - m)}{\tilde{u}_1(y - \Delta(\psi), Y + m)} - \frac{\tilde{u}(\psi - \Delta(\psi), Y + m) - \tilde{u}(\psi + \Delta(\psi), Y - m)}{\tilde{u}_1(\psi - \Delta(\psi), Y + m)},$$

where the RHS of (5) evaluated at ψ has been substituted for $b_s{'}(\psi)$. Since $f(\psi)\,\tilde{u}_1(y-\Delta(\psi),Y+m)$ is always positive, (30) is equivalent to

(32) $g(\psi, y) \geq 0$ for all $\psi < y$ and $g(\psi, y) \leq 0$ for all $\psi > y$.

Using line integral techniques, we obtain

$g(\psi, y) =$

$$\int_{-1}^{1}\left\{\Delta(\psi)\left(\frac{\tilde{u}_1(\psi-\gamma\Delta(\psi),Y+\gamma m)}{\tilde{u}_1(\psi-\Delta(\psi),Y+m)}-\frac{\tilde{u}_1(y-\gamma\Delta(\psi),Y+\gamma m)}{\tilde{u}_1(y-\Delta(\psi),Y+m)}\right)+m\left(\frac{\tilde{u}_2(y-\gamma\Delta(\psi),Y+\gamma m)}{\tilde{u}_1(y-\Delta(\psi),Y+m)}-\frac{\tilde{u}_2(\psi-\gamma\Delta(\psi),Y+\gamma m)}{\tilde{u}_1(\psi-\Delta(\psi),Y+m)}\right)\right\}d\gamma$$

$$=\int_{-1}^{1}\int_{\psi}^{y}\{\frac{\tilde{u}_1(\delta-\gamma\Delta(\psi),Y+\gamma m)}{\tilde{u}_1(\delta-\Delta(\psi),Y+m)}\Delta(\psi)\left[RA_1(\delta-\gamma\Delta(\psi),Y+\gamma m)-RA_1(\delta-\Delta(\psi),Y+m)\right]$$

$$+\ \frac{\tilde{u}_2(\delta-\gamma\Delta(\psi),Y+\gamma m)}{\tilde{u}_1(\delta-\Delta(\psi),Y+m)}m\left[RA_1(\delta-\gamma\Delta(\psi),Y+\gamma m)-TRA_{12}(\delta-\Delta(\psi),Y+m)\right]\}d\delta\, d\gamma\ ,$$

where the coefficients of static and temporal risk aversion, RA_1 and TRA_{12}, are defined in section 3. A set of sufficient conditions for (32) and thus for (30) is

(i) $RA_1(\delta-\Delta(\psi),Y+m)\leq RA_1(\delta+\gamma\Delta(\psi),Y-\gamma m)$ for all $\gamma\in$ [-1,1] and all δ, $\psi\in[y_l, y_u]$,

(ii) $TRA_{12}(\delta-\Delta(\psi),Y+m)\leq RA_1(\delta+\gamma\Delta(\psi),Y-\gamma m)$ for all $\gamma\in$ [-1,1] and all δ, $\psi\in[y_l, y_u]$.

If the utility function exhibits utility independence[16], the coefficients of static and temporal risk aversion depend on first-period consumption only. In this case, (i) and (ii) respectively become

[16] Utility independence means that the decision concerning consumption in period t conditional on a consumption level c_k in period $k \neq t$ remains the same for all possible values of c_k. With utility independence, $u(x_1, x_2)$ is either additively or multiplicatively

(i)’ $RA_1(\delta - \Delta(\psi)) \leq RA_1(\delta + \gamma\Delta(\psi))$ for all $\gamma \in$ [-1,1] and all δ, $\psi \in [y_l, y_u]$

(ii)’ $TRA_{12}(\delta - \Delta(\psi)) \leq RA_1(\delta + \gamma\Delta(\psi))$ for all $\gamma \in$ [-1,1] and all δ, $\psi \in [y_l, y_u]$.

(i)’ is implied by non-decreasing absolute risk aversion while (ii)’ holds when temporal risk aversion is less pronounced than static risk aversion. Note, however, that non-decreasing absolute risk aversion does not need to hold when (ii)’ holds with strict inequality.

1.6.2 Supplement to the Proof of Proposition 3

1.6.2.1 Proof of Equation (20)

Defining $\Delta(y)$ as in (31), it is shown below that

(33) $$\frac{\partial \Delta(y)}{\partial m}_{|m=0} = \int_{y_l}^{y} \frac{\tilde{u}_2(\rho, Y)}{\tilde{u}_1(\rho, Y)} \frac{2F(\rho) f(\rho)}{(F(y))^2} d\rho .$$

Differentiating (33) w.r.t. y gives

(34) $$\frac{\partial \Delta'(y)}{\partial m}_{|m=0} = 2\frac{f(y)}{F(y)}\left(\frac{\tilde{u}_2(y, Y)}{\tilde{u}_1(y, Y)} - \int_{y_l}^{y} \frac{\tilde{u}_2(\rho, Y)}{\tilde{u}_1(\rho, Y)} \frac{2F(\rho) f(\rho)}{(F(y))^2} d\rho \right).$$

Integrating the integral term in (34) by parts gives

(35) $$\frac{\partial \Delta'(y)}{\partial m}_{|m=0} = 2\frac{f(y)}{F(y)} \int_{y_l}^{y} h(\rho) \left(\frac{F(\rho)}{F(y)} \right)^2 d\rho , \text{ where}$$

$$h(y) \equiv \frac{d}{dy}\left(\frac{\tilde{u}_2(y, Y)}{\tilde{u}_1(y, Y)} \right) = \frac{\tilde{u}_2(y, Y)}{\tilde{u}_1(y, Y)} \left(RA_1(y, Y) - TRA_{12}(y, Y) \right).$$

From (35) and (31) we immediately obtain

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separable, i.e. $u(x_1, x_2) = v_1(x_1) + v_2(x_2)$ or $u(x_1, x_2) = v_1(x_1)\, v_2(x_2)$ when v_1, $v_2 > 0$ or $u(x_1, x_2) = - v_1(x_1)\, v_2(x_2)$, when v_1, $v_2 < 0$. See Richard (1975).

$$\frac{\partial b_s'(y)}{\partial m}_{|m=0} = -2\frac{\partial \Delta'(y)}{\partial m}_{|m=0} = -4\frac{f(y)}{(F(y))^3}\int_{y_l}^{y}\frac{\tilde{u}_2(\rho,Y)}{\tilde{u}_1(\rho,Y)}\left(RA_1(\rho,Y)-TRA_{12}(\rho,Y)\right)(F(\rho))^2 d\rho .$$

Proof of (33):

For any fixed positive *m*, it follows from (5) and (6) that Δ(*y*) satisfies the following differential equation and boundary condition

(36) $$\Delta'(y) = \frac{f(y)}{F(y)}\left[\frac{\tilde{u}(y+\Delta(y),Y-m)-\tilde{u}(y-\Delta(y),Y+m)}{\tilde{u}_1(y-\Delta(y),Y+m)}\right],$$

$$\Delta(y_l) = \Delta^0(y_l),$$

where, similar to (31), $\Delta^0(y) \equiv m - b^0(y)/2$. Evaluating the derivative of (36) w.r.t. *m* at $m = 0$ gives

(37) $$\frac{\partial \Delta'(y)}{\partial m}_{|m=0} = 2\frac{f(y)}{F(y)}\left[\frac{\tilde{u}_2(y,Y)}{\tilde{u}_1(y,Y)} - \frac{\partial \Delta(y)}{\partial m}_{|m=0}\right].$$

Further, since $\Delta(y_l) = \Delta^0(y_l)$ for all values of *m*, $\frac{\partial \Delta(y_l)}{\partial m}_{|m=0} = \frac{\partial \Delta^0(y_l)}{\partial m}_{|m=0}$. The latter term is obtained by differentiating (1) totally. We thus have

(38) $$\frac{\partial \Delta(y_l)}{\partial m}_{|m=0} = \frac{\tilde{u}_2(y_l,Y)}{\tilde{u}_1(y_l,Y)}.$$

The unique solution to the boundary value problem (37), (38) is (33). QED

1.6.2.2 Sufficient Conditions for the Optimality of $b_s(\cdot)$

To establish the pseudoconcavity of $\frac{\partial E[U(b)|y]}{\partial m}_{|m=0}$ in *b*, where $E[U(b)|\, y]$ is defined in (3), we proceed as in section 1.6.1 of this Appendix. The (w.r.t. *m*) infinitesimal version of (30) is

$$\frac{\partial^2 E[U|y,\psi]}{\partial m \partial \psi}_{|m=0} \geq 0 \text{ for all } \psi < y \text{ and } \frac{\partial^2 E[U|y,\psi]}{\partial m \partial \psi}_{|m=0} \leq 0 \text{ for all } \psi > y.$$

Going through some algebra, from (29) we obtain

(39)

$$\frac{\partial^2 E[U|y,\psi]}{\partial m \partial \psi}_{|m=0} = 2f(\psi)\tilde{u}_1(y,Y)\left(\frac{\tilde{u}_2(y,Y)}{\tilde{u}_1(y,Y)} - \frac{\tilde{u}_2(\psi,Y)}{\tilde{u}_1(\psi,Y)}\right)$$

$$= 2f(\psi)\tilde{u}_1(y,Y)\int_{\psi}^{y}\frac{\tilde{u}_2(\rho,Y)}{\tilde{u}_1(\rho,Y)}\left(RA_1(\rho,Y) - TRA_{12}(\rho,Y)\right)d\rho,$$

which, given (18) holds, is clearly positive (negative) whenever ψ is smaller (bigger) than y.

1.6.2.3 Proof of Equation (21)

<u>*Step 1:*</u>

Evaluated at $m = 0$, the derivative of $E[U|\, y]$, as given by (17), w.r.t. m can be written as

(40)

$$\frac{\partial E[U|y]}{\partial m}_{|m=0} = u_2(y,Y)(2F(y)-1) + 2u_1(y,Y)g(y), \text{ where}$$

$$g(y) \equiv \int_{y}^{y_u}\frac{\tilde{u}_2(\rho,Y)}{\tilde{u}_1(\rho,Y)}f(\rho)d\rho - \int_{y_l}^{y_u}\frac{\tilde{u}_2(\rho,Y)}{\tilde{u}_1(\rho,Y)}F(\rho)f(\rho)d\rho.$$

<u>Proof of Step 1:</u>

First, rewrite interim expected utility, as given by (17), as

(41) $$E[U|\, y] = \tilde{u}(y - \Delta(y)/2, Y+m)\, F(y) + \int_{y}^{y_u}\tilde{u}(y+\Delta(\rho), Y-m)\, f(\rho)d\rho.$$

Evaluating the derivative of (41) w.r.t. m at $m = 0$ gives

(42) $$\frac{\partial E[U|y]}{\partial m}_{|m=0} = u_2(y,Y)(2F(y)-1) + 2u_1(y,Y)\hat{g}(y), \text{ where}$$

(43) $$\hat{g}(y) \equiv \frac{1}{2}\left(\int_{y}^{y_u}\frac{\partial \Delta(\rho)}{\partial m}_{|m=0} f(\rho)d\rho - \frac{\partial \Delta(y)}{\partial m}_{|m=0}\right).$$

Substituting $\frac{\partial \Delta(\cdot)}{\partial m}_{|m=0}$ from (33) into (43) gives

(44) $$\hat{g}(y) = \int_{y}^{y_u}\int_{y_l}^{\rho} \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)}\frac{F(\gamma)}{F^2(\rho)} f(\gamma)d\gamma\ f(\rho)d\rho - \int_{y_l}^{y} \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)}\frac{F(\gamma)}{F(y)} f(\gamma)d\gamma\,.$$

The double integral term in (44) can be manipulated as follows:

$$\int_{y}^{y_u}\int_{y_l}^{\rho} \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)} F(\gamma)f(\gamma)d\gamma \frac{f(\rho)}{F^2(\rho)}d\rho$$

(45)

$$= \int_{y_l}^{y_u}\int_{y_l}^{\rho} \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)} F(\gamma)f(\gamma)d\gamma \frac{f(\rho)}{F^2(\rho)}d\rho - \int_{y_l}^{y}\int_{y_l}^{\rho} \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)} F(\gamma)f(\gamma)d\gamma \frac{f(\rho)}{F^2(\rho)}d\rho$$

$$= \int_{y_l}^{y_u}\int_{\gamma}^{y_u} \frac{f(\rho)}{F^2(\rho)}d\rho \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)} F(\gamma)f(\gamma)d\gamma - \int_{y_l}^{y}\int_{\gamma}^{y} \frac{f(\rho)}{F^2(\rho)}d\rho \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)} F(\gamma)f(\gamma)d\gamma$$

$$= \int_{y}^{y_u} \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)} f(\gamma)d\gamma - \int_{y_l}^{y_u} \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)} F(\gamma)f(\gamma)d\gamma + \int_{y_l}^{y} \frac{\tilde{u}_2(\gamma,Y)}{\tilde{u}_1(\gamma,Y)}\frac{F(\gamma)}{F(y)} f(\gamma)d\gamma\,,$$

where the second equality follows from the application of Fubini's theorem and the third inequality from solving the inner integrals.

Substituting (45) into (44), we find that $\hat{g}(y) = g(y)$, and so (42) is equivalent to (40).

<u>*Step 2:*</u> Establish that

(46) $$g(y) = \frac{1}{2}\left(\frac{\tilde{u}_2(y,Y)}{\tilde{u}_1(y,Y)}(1-2F(y)) + \int_{y}^{y_u} h(\rho)(1-F(\rho))^2 d\rho + \int_{y_l}^{y} h(\rho)(F(\rho))^2 d\rho \right),$$ where

$h(\cdot)$ is defined as in (35).

<u>Proof of Step 2:</u>

Integrating $g(y)$, as given by (40), by parts and collecting terms gives

$$g(y) = \frac{1}{2}\frac{\tilde{u}_2(y_u,Y)}{\tilde{u}_1(y_u,Y)} - \frac{\tilde{u}_2(y,Y)}{\tilde{u}_1(y,Y)}F(y) - \int_{y}^{y_u} h(\rho)F(\rho)d\rho + \frac{1}{2}\int_{y_l}^{y_u} h(\rho)F^2(\rho)d\rho$$

$$= \frac{1}{2}\left(\left[\frac{\tilde{u}_2(y_u,Y)}{\tilde{u}_1(y_u,Y)} - \frac{\tilde{u}_2(y,Y)}{\tilde{u}_1(y,Y)}\right] + \frac{\tilde{u}_2(y,Y)}{\tilde{u}_1(y,Y)}(1-2F(y)) + \int_y^{y_u} h(\rho)\left((F(\rho))^2 - 2F(\rho)\right)d\rho + \int_{y_l}^{y} h(\rho)(F(\rho))^2 d\rho\right).$$

Substituting $\int_y^{y_u} h(\rho)d\rho$ for the term in square-brackets gives

$$g(y) = \frac{1}{2}\left(\frac{\tilde{u}_2(y,Y)}{\tilde{u}_1(y,Y)}(1-2F(y)) + \int_y^{y_u} h(\rho)\left[(F(\rho))^2 - 2F(\rho) + 1\right]d\rho + \int_{y_l}^{y} h(\rho)(F(\rho))^2 d\rho\right).$$

Applying the second binomial formula to the term in square brackets establishes (46).

<u>*Step 3:*</u> Substituting (46) into (40) we obtain

$$\frac{\partial E[U|y]}{\partial m}_{|m=0} = \tilde{u}_1(y,Y)\left(\int_y^{y_u} h(\rho)(1-F(\rho))^2 d\rho + \int_{y_l}^{y} h(\rho)(F(\rho))^2 d\rho\right).$$

Applying the definition of $h(\cdot)$ from (35) completes the proof of (21). QED

1.6.2.4 Supplement to the Proof of Necessity of Condition (i)

It follows from the discussion in section 1.6.1 of this Appendix that the following two statements are equivalent.

‘Evaluated at $b = b_s(y')$, $\frac{\partial E[U(b)|y']}{\partial m}_{|m=0}$ is convex in b’ and

‘Evaluated at $\psi = y'$, $\frac{\partial E[U|y',\psi]}{\partial m}_{|m=0}$ is convex in ψ’.

From (39) we obtain

$$\frac{\partial^3 E[U|y',\psi]}{\partial m \partial^2 \psi}_{\substack{|m=0 \\ |\psi=y'}} = 2f(y')\tilde{u}_2(y',Y)\left(TRA_{12}(y',Y) - RA_1(y',Y)\right),$$

which is strictly positive if (22) holds. Thus, evaluated at $\psi = y'$, $\frac{\partial E[U|y',\psi]}{\partial m}_{|m=0}$ is strictly convex in ψ.

1.6.3 Proof of Proposition 4

Taking the total differential of (25) gives

(47) $$\frac{db_t}{d\delta}(y_l) = \frac{-3}{2v'(y_l + 2m - \frac{2}{3}b_t(y_l))v'(y_l - m + \frac{1}{3}b_t(y_l))} \frac{d(\delta\Delta_t)}{d\delta},$$

while differentiation of (24) yields

(48) $$\frac{db'_t}{d\delta}(y_t) = -3\frac{f(y_t)}{F(y_t)v'(y - m + \frac{1}{3}b_t(y_t))} \frac{d(\delta\Delta_t)}{d\delta}.$$

Since Δ_2 does not depend on δ, we have $\frac{d(\delta\Delta_2)}{d\delta} = \Delta_2 > 0$. It thus follows from (47) that $b_2(y_l)$ decreases and from (48) that the slope of the bidding function $b_2(y)$ becomes steeper for all y which proves Proposition 4 for $t = 2$. For $t = 1$, it is shown below that

(49) $\frac{d\Delta_1}{d\delta} > 0$ for all values of a and δ.

With this in hand, it follows immediately that $\frac{d(\delta\Delta_1)}{d\delta} > 0$, and thus, by the same arguments as for $t = 2$, $\frac{db_1(y)}{d\delta} < 0$ for all y.

Proof of (49):

We first introduce the following formulae:

$$E[U^{1L}] = E_{Y_2}[\left(E_X[v(Y_2 + 2m - \frac{2}{3}b_2(X)|X > Y_2] + \delta\,\tilde{v}(Y - m)\right)(1 - F(Y_2))$$

$$+ \left(v(Y_2 - m + \frac{1}{3}b_2(Y_2)) + \delta\,\tilde{v}(Y + 2m)\right)F(Y_2)]$$

$$= -e^{am}\int_0^1 e^{-a(\rho + b_2(\rho)/3)}\rho\, d\rho - e^{-2am}\int_0^1 (1 - e^{-a\rho})e^{2ab_2(\rho)/3}\, d\rho / a$$

$$-\delta\, e^{am}\,(1 - e^{-a})/(2a) - \delta\, e^{-2am}(1 - e^{-a})/(2a),$$

$$E[U^{1W}] = E_{Y_2}[E_{X_{2,2}}[v(Y_2 - 2m + \frac{1}{3}b_2(X_{2,2})] + \delta\,\tilde{v}(Y - m)]$$

$$= -e^{am}(1 - e^{-a})\left(\int_0^1 e^{-ab_2(\rho)/3} 2\rho\, d\rho + \delta\right)/a,$$

where $X_{2,2}$ denotes the bigger order statistic of an i.i.d. random sample (X_1, X_2) drawn from the distribution characterised by the cdf $F(\cdot)$, and $\tilde{v}(X) \equiv E_X[v(X)]$. Plugging these terms into (26), we obtain

$$\Delta_1 = E[U^{1L} - U^{1W}] = -e^{-2am}\int_0^1 (1-e^{-a\rho})e^{2ab_2(\rho)/3}\,d\rho / a + \delta(1-e^{-a})(e^{am} - e^{-2am})/(2a)$$

(50)

$$+e^{am}\int_0^1 e^{-ab_2(\rho)/3}\rho\left[(2/a)(1-e^{-a}) - e^{-a\rho}\right]d\rho\,.$$

Recall from Proposition 4 that $\frac{db_2(y)}{d\delta} < 0$ for all y. Consequently, both of the two terms on the RHS in the first line of (50) increase as δ increases. Defining $g(\delta)$ as the term in the second line of (50), it remains to be established that $\frac{dg(\delta)}{d\delta} > 0$:

$$\frac{dg(\delta)}{d\delta} = -(e^{am}/3)\int_0^1 e^{-ab_2(\rho)/3}\frac{\partial b_2(\rho)}{\partial\delta}\rho\left[2(1-e^{-a}) - ae^{-a\rho}\right]d\rho\,.$$

Using the results from above, $\frac{db_2}{d\delta}(y) < 0$, $\frac{db'_2}{d\delta}(y) < 0$, we define

$$h(y) \equiv -\frac{\partial b_2(y)}{\partial\delta}e^{-ab_2(y)/3}, \quad k(y) \equiv y\left(2(1-e^{-a}) - ae^{-ay}\right)$$

and note the following: $h(y) > 0$, $h'(y) > 0$ for all y, while $k(0) = 0$, $k(1) > 0$, and, depending on a, there is at most one strictly positive y on the unit interval, y^* say, such that $k(y^*) = 0$. It follows that

$$\frac{dg(\delta)}{d\delta} > (e^{am}/3)h(y^*)\int_0^1 k(\rho)d\rho = e^{am}h(y^*)(a + e^{-a} - 1)/(3a) > 0,$$

since it is easily verified that the term $(a + e^{-a} - 1)$ is positive for all a.

2 An Empirical Analysis of Rosca Auctions in a South-Indian Village

Abstract

Data from 23 rotating savings and credit associations (Roscas) in an agricultural south-Indian village are used for an empirical analysis of Rosca auctions. We develop a simple SIPV Rosca-auction model. We show that, in contrast to standard SIPV English auctions, bidders overbid relative to their maximum willingness to pay in an oral ascending bid Rosca auction and that less aggressive bidding is socially beneficial. Estimating the structural model by maximum likelihood, we find that (i) aggregate features immanent in agricultural production are reflected by Rosca auction outcomes, (ii) bidding in Rosca groups of experienced organisers is less aggressive than in groups of newcomer-organisers, implying that Rosca organisers play a role in how socially beneficial a Rosca is, (iii) bidding in Rosca groups which have run more than one Rosca before tends to be less aggressive, indicating social gains from enduring relationships, (iv) when Rosca funds are used for productive purposes, bidders usually keep their information private, (v) when a bidder has an ‘emergency’ and this information is revealed, bidding is less aggressive indicating co-operation among bidders based on reciprocity.

2.1 Introduction

While the first essay was motivated by the concern to close a gap in the theoretical literature, which had completely neglected the role of the Rosca as a risk-sharing mechanism, this essay is based on observations during my field study in southern India in January and February 2001. It is thus an empirical study, though markedly different from previous ones. As has been mentioned in the general introduction, empirical studies of Roscas were started by anthropologists (Geertz, 1962) and are much more numerous than theoretical ones. 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, analyses Rosca auctions, but rather treats the auction allocation mechanism as a black box.

This essay is a first attempt to open up this black box. Since Roscas are diverse and provide financial intermediation on a rather small scale,[17] many interesting questions arise in the context of Rosca auctions: How should one compare the outcomes of auctions in Roscas with different numbers of participants and different contributions? Can existing theoretical models adequately explain actual auction outcomes? Do aggregate variables which affect all Rosca participants, like seasonality in agricultural production or in labour markets, have an impact on the auction outcomes? Are auctions with public information different from auctions with private information? Perhaps even more interesting are issues like: Is bidding in groups which have run several Roscas before different from bidding in newly-formed groups? Does a Rosca organiser's experience influence auction outcomes?

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[17] Rosca groups typically have a size of ten to forty participants.

The rest of this essay is organised as follows. In section 2.2, we briefly describe the study village (henceforth referred to as ‘E’), present the two datasets on bidding Roscas, and summarise the salient features of these data together with some qualitative evidence. In section 2.3, 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 are privately observed. In section 2.4, we discuss some implications of the equilibrium of this model and how deviations from the equilibrium affect Rosca participants' welfare. In section 2.5, a structural econometric model, which is derived from the theoretical model, is estimated by the method of maximum likelihood. The structural econometric model is then augmented by additional parameters suggested by the questions posed in the previous paragraph. This gives interesting insights into the determinants of Rosca auction outcomes, justifying the considerable technical and computational effort which the structural estimation requires. section 2.6 summarises the results and offers conclusions.

2.2 The Data and some Qualitative Findings

2.2.1 The Study Village

The village E is located in a fertile river basin in the southern part of Tamil Nadu. The river irrigation facilitates two paddy harvests per year, one in autumn and one in winter. 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.[18]

2.2.2 The Participant Sample

In January and February 2001, I interviewed the 30 households which form the intensive sample in van Dillen's (forthcoming) longitudinal study about their participation in Roscas. One of these 30 households was not willing to respond to my questions and was thus dropped. The remaining 29 households will be referred to as the 'participant sample'. With 53% being scheduled caste households, this sample is not representative for the village, where only 29% of the households belong to scheduled castes. I decided, however, not to select a sample different from van Dillen's because, first, it would not have been possible to collect the extensive information van Dillen had collected on her sample households and, second, her respondents were used to interviews on sensitive matters and, with the one exception mentioned above, co-operative. Despite that it is not representative of the whole village, some important insights can be gained from this sample.

Apart from random Roscas, which are not the subject of this study, two types of bidding Roscas exist in E, monthly bidding Roscas and so called harvest bidding Roscas. The former meet once a month while the latter meet twice a year, after the autumn harvest in November, and after the winter harvest in late February or March. Three of the 29 sample households are participating in monthly bidding Roscas and 21 in harvest bidding Roscas. All three of the former households generate their income primarily outside agriculture. Harvest bidding Roscas, in contrast, are so predominant in E because, as mentioned above, the village is mostly agricultural and both farmers and agricultural wage labourers generate the bulk of

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[18] An in-depth description of various socio-economic aspects of the village can be found in van Dillen (forthcoming).

their yearly income during the two harvests. For this reason, the present study focuses on harvest bidding Roscas and the information in Table 1 and Table 3 refers exclusively to such Roscas.

Table 1 combines some of van Dillen's data with the findings of my own survey. Although there are almost four years between her and my field study, this need not affect the consistency of inference obtained from combining the two datasets because, within this sample, participation in bidding Roscas stretches over 60 to 78 months (with one exception of 132 months), and so it can be argued that the household characteristics reported by van Dillen are well suited for explaining observed Rosca participation of her sample households four years later.

We first deal with those households which do not participate in any harvest bidding Rosca. The three households within this group from the main village (131, 132, 186) are not active in agriculture. Household 131 is a retired widow, 132 is a shopkeeper and 186 a carpenter. Within our sample, all main-village households which are active in agriculture also participate in at least one harvest bidding Rosca. Turning to those five colony households which do not participate in harvest bidding Roscas, only one, 106, a shopkeeper, is not primarily in agriculture, whereas the other four (22, 99, 112, 113) are primarily agricultural labourers, and extremely poor ones at that. The head of household 22 is a widow, while the head of household 99 has to support two wives. Since the heads of households 112 and 113 are attached farm servants, they receive regular incomes, which are less subject to seasonal variations than incomes of agricultural wage labourers. To summarise, the main determinant of participation in harvest bidding Roscas in E is a regular harvest income which has to be high enough to finance the regular contribution, which amounts to at least Rs. 500 in the participant sample (see Table 1).[19] This hypothesis is supported by the respondents, who frequently mentioned the timing of payments in a harvest Rosca as a particular advantage over bank loan schemes.[20]

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[19] By way of comparison: a day's wage of a male agricultural worker, depending on the season, ranges between Rs. 40 and 80.

[20] While, according to respondents in the participant sample, the timing of co-operative loans for agricultural inputs is adapted to the crop cycle, big loans for the purchase of productive assets have to be repaid in monthly instalments.

Table 1. The participant sample and selected household characteristics

Household Number	Caste	Land Property	Leased Land	Livestock	Household Composition 'Gender'	Household Composition 'Labour Force'	Income Diversification	Income Security	Education	Skills	# Roscas	# Roscas active	Contribution 1	Contribution 2	Contribution 3	Sum of Contributions
9	4	0	3	2	0	1	4	3	2	2	2	2	3000	5000		8000
13	2	0	1	0	-1	1	2	1	1	3	2	0	500	1000		1500
19	1	3	0	2	-1	1	3	0	2	1	1	1	1000	1000		1000
21	1	0	1	0	0	0	3	0	2	2	1	0	3000			3000
22	1	0	1	0	-1	1	3	1	3	1	0	0				0
74	4	4	0	0	0	-1	1	0	3	2	1	1	2500			2500
84	2	0	0	0	0	1	1	1	1	3	2	2	500	1000		1500
85	4	0	0	0	0	0	2	0	3	2	1	1	1000			1000
86	4	2	1	2	0	0	3	0	1	2	1	1	1000			1000
88	4	2	0	2	1	1	3	0	3	2	1	0	1000			1000
89	1	0	0	1	-1	1	2	0	1	1	1	0	2000			2000
91	1	0	0	2	0	1	3	0	2	2	2	0	1000	2000		3000
99	1	0	0	1	0	1	3	0	1	2	0	0				0
103	1	2	2	3	1	0	3	0	1	1	2	0	1000	2000		3000
106	1	0	0	2	0	0	2	0	0	1	0	0				0
107	1	0	0	0	0	1	1	0	0	1	1	0	3000			3000
108	1	0	1	0	0	1	4	1	2	1	1	1	2000			2000
109	4	3	3	3	0	0	3	0	1	1	3	0	1000	1000	3000	5000
112	1	0	1	0	0	1	3	0	0	2	0	0				0
113	1	0	0	0	0	1	1	0	1	1	0	0				0
116	1	0	0	2	-1	1	2	0	0	2	1	1	1500			1500
118	1	0	2	1	-1	1	2	0	0	1	1	1	1500			1500
120	1	0	2	0	0	1	2	0	0	1	1	0	2000			2000
121	1	3	1	1	0	-1	3	0	2	1	2	2	1000	3000		4000
131	2	2	0	0	-1	0	2	0	1	2	0	0				0
132	2	0	0	0	1	1	4	2	3	3	0	0				0
133	4	4	4	2	1	-1	2	0	2	1	2	1	5000	5000		10000
186	3	0	0	0	0	1	1	1	1	2	0	0				0
214	1	3	0	0	1	0	1	0	3	1	1	1	2500			2500

Source: of columns 2-11: van Dillen (forthcoming)

Table 2. Variable-values in Table 1

Values	0	1		2	3	4
Caste	-	Pallar, Pariah (scheduled castes)		Pandaram (forward caste)	Pillaimar (forward caste)	Maravar (backward caste)
Land property	No land property	-		0.01-0.50 acre	0.51-0.99 acre	1 acre +
Leased land	No leased land	0.01-0.50 acre		0.51-0.99 acre	1.00-1.99 acre	2 acre +
Livestock	No cattle	1-2 cows/buffaloes or bullocks		3-4 cows/buffaloes or bullocks	More than 4 cows/buffaloes or bullocks	-
Household composition 'gender'	Equal number of female and male members	More female members*	More male members	-	-	-
Household composition 'labour force'	Equal number of active and dependent members	More dependent members*	More active members	-	-	-
Degree of income diversification	One source of income	Two sources of income		Three sources of income	Four sources of income	Five sources of income
Degree of in-come security (non-agricul-tural income)	Income only from *unskilled* casual work, unskilled self-employment and home-work	At least one income from *skilled* work, or self-employment based on *skilled* work		At least one minor formal employment (govt., private)	At least one full time formal employment (private)	At least one full time formal employment (government)
Education	No member has any formal education	No member age 14+ studied more than 7^{th} standard		At least one member studied 8^{th} to 10^{th} standard	At least two members studied 8^{th} to 10^{th} standard	At least one member studied more than 10^{th} standard
Skills	-	Ordinary skills		At least one member has skills	At least two members have *different* skills	At least three members have different skills
# Roscas	Number of harvest bidding Roscas in which the respondent household participates					
# Roscas active	Number of harvest bidding Roscas in which the respondent household is an active participant, i.e. in which it has not yet received a pot					
Contribution 1	Full contribution to the first Rosca in which the household participates. When multiple participation occurs, this is the Rosca with the lowest contribution					
Contribution 2	Full contribution to the second Rosca in which the household participates. When multiple participation occurs, this is the Rosca with the second-lowest contribution					
Contribution 3	Full contribution to the third Rosca in which the household participates. When multiple participation occurs, this is the Rosca with the highest contribution					
Sum of contributions	Sum of the full contributions to all harvest bidding Roscas in which the respondent household participates					

* in this case, the indicator in question is set equal to -1
Source of rows 2-11: van Dillen (forthcoming)

Table 3. Frequency table of participation and active participation in the participant sample

# Roscas active→ # Roscas↓	0	1	2	Total
0	8	0	0	8
1	4	8	0	12
2	3	1	4	8
3	1	0	0	1
Total	16	9	4	29

To quantify some determinants of the extent of harvest bidding Rosca participation in the participant sample, I conducted a Tobit analysis with the sum of the Rosca contributions of a household as the dependent variable. The indicators constructed by van Dillen are used as explanatory variables.[21] Not surprisingly, operational landholdings, which approximate the

[21] Inference from such a regression may be flawed by an endogeneity problem which can arise from two sources. First, assets which appear as regressors may have been purchased with funds obtained from a Rosca whose contribution appears in the regressand. In the present sample, however, there is only one single case where a sample household received a pot before van Dillen's survey. This is household 109, which obtained Rs. 5500 after the winter harvest in 1996 from one of the two Roscas where it contributes Rs. 1000 per harvest. The funds were used to replace two old bullocks, which appear in the explanatory variable livestock. Second, the explanatory variables 'leased land' and 'degree of income diversification' may themselves be functions of some not-observed variables in the background, like managerial skills, which also play a role in a household's decision about

income from farming, are the most important determinant followed by the asset variable livestock. Skills of the household members, as well as caste, in contrast, are insignificant. The negative sign on the variable ‘degree of income diversification’ is as expected since diversification usually implies more income from outside the agricultural sector. Harvest Roscas, however, are particularly popular among and suited for villagers who generate their income primarily in agriculture, as has been explained above. Because of the limited number of observations where the dependent variable is different from zero (21 cases), the number of regressors was limited to the ones shown in Table 4. Inclusion of more regressors gives a problem of perfect prediction and no further insights.

Table 4. Tobit analysis of the determinants of the extent of Rosca participation

DEPENDENT VARIABLE	SUM OF CONTRIBUTIONS	
LOG-LIKELIHOOD	-192.570726	
σ	1722.46	
Regressor	**Estimate**	**T-value**
INTERCEPT	179.88	0.15
CASTE	69.27	0.15
LAND PROPERTY	420.28	1.04
LEASED LAND	1561.38	3.00
LIVESTOCK	373.32	0.83
DEGREE OF INCOME DIVERSIFICATION	-335.93	-0.62
SKILLS	163.43	0.18

Rosca participation. In this case, the said explanatory variables are not purely exogenous. In the light that only 7 of the 31 Roscas in the sample have already been operating when the explanatory variables were recorded, we may argue, however, that the explanatory variables in question are, at least for the most part, predetermined, which suffices to guarantee consistent estimates.

2.2.3 The Organiser Sample

Since the aim of this study is to investigate Rosca auctions, information from organisers is indispensable because none of the respondents in the participant sample kept records about his participation in Roscas. At the very most, they could recall those auctions which they had won. Many respondents, 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. As can be calculated from Table 3, of those 31 Roscas in which the participant-sample households were participating at the time of the interview, 14 auctions had been won by sample respondents. Thus, these 29 interviews contain only limited data on just 14 auctions.

Since none of the Roscas which I could observe in E is registered with the government, as Tamil state law requires, organisers are generally unwilling to admit that they administer a Rosca. I therefore pursued the strategy of asking the respondents in the participant sample to convince the organisers of those Roscas in which they participate to respond to my questions. I thus succeeded in interviewing 11 of the 19 bidding Rosca organisers 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. Apart from the modalities of each Rosca, which will be discussed later in this essay, for each auction, I recorded the winning bid, the winner's use of the pot, and whether this purpose was his private information during the auction. The dataset as a whole is reproduced in Table 9 and some summary statistics are provided in Table 5. Note that each line 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 already taken place, this Rosca contributes 6 lines to the dataset. Of course, the variables 'contribution', 'number of participants', and 'fraction of caste Hindus' take the same respective values in all of these six lines.

Table 5. The organiser sample: some descriptive statistics

Variable	Mean	Median	Minimum	Maximum	Std Dev
Contribution	2461.74	2000.00	700.00	5000.00	1544.37
Number of participants in the Rosca	11.80	10.00	10.00	17.00	2.43
Fraction of caste Hindus in the Rosca	0.86	0.90	0.30	1.00	0.17
Round in which the reported auction took place	5.57	5.00	1.00	16.00	3.35
Private (= 0) vs. public (= 1) information before the auction	0.27	0.00	0.00	1.00	0.44

While the participant sample has extensive information on each participant household’s characteristics, organisers did not want to reveal the identity of the participants in their Roscas. Therefore, apart from the few cases where a respondent of the participant sample also appears in a Rosca which is in the organiser sample, we do not have information on the characteristics of Rosca participants in the organiser sample. For this reason, unobserved heterogeneity could pose certain problems at the stage of estimation.

2.2.4 Stylised Facts about Harvest Bidding Roscas in E

We now combine the evidence from the participant and the organiser sample to summarise some key features of harvest bidding Roscas which are important to set up a theoretical model that will serve as a benchmark to explain Rosca auction outcomes in E:

1. Rosca funds are almost never used for consumption or domestic purposes (purpose codes 14 and 31 appear only twice in 128 auctions where the organiser recalled what

an auction's winner used the pot for).[22] Instead Rosca funds are mostly used for productive investment (purpose codes 1 through 9, 80 of 128 cases), e.g. buying a field plot or starting banana cultivation, or what villagers call "emergencies" (purpose codes 10, 11 and 13, 31 cases), which are marriages or the ritual puberty function of a daughter or a close relative. Less frequent uses are buying jewellery, 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.[23]

2. When there is no 'emergency', information on a winner's purpose is mostly private (102 out of 118 cases). This means that if someone intends to obtain a pot to buy a field plot, for example, he does not tell other bidders about his intention before the auction. Organisers 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 make the information on his purpose public or not. Organisers and participants say that bidding is less competitive in such cases. It is claimed, instead,

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[22] See Table 10 for the purpose codes.

[23] Organisers 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, according to the organiser, the winner said before the auction that he needed money without further specifying why.

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 organisers who responded, only one mentioned problems with outstanding contributions.[24] If somebody pays a contribution late, the organiser 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 the participant sample, 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 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 (household 133).
8. In the organiser sample, 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

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

higher winning bid is observed than in the (t – 1)-th round, even when the funds are used for the same purpose.

9. Both organisers and participants of bidding Roscas feel 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 paid by the winner and equally distributed among the losers of the 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-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.

2.3 The Model

We start by formalising the course of a harvest bidding Rosca in E. As in the preceding essay, we will assume that each participant is always able to pay his contribution. This assumption is supported by evidence from the organisers (see observation 5 in section 2.2.4).

Consider a bidding Rosca with n participants, including the organiser. At the beginning of each meeting, each participant pays m Rupees and an amount of z Rupees is deducted from the collected contributions as commission for the organiser (in practice, z ranges between 2 and 5% of nm). Consequently, the pot amounts to $mn - z$. In each round except the second and the last, an oral ascending bid auction among those participants who have not yet received a pot 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 $mn - z - b^w$, where b^w is equally distributed among those bidders who have lost the auction.[25] At the last (i.e. the n-th) meeting, that participant who has not won any of the previous auctions receives the pot without a discount. At the second meeting, the organiser receives the collected contributions nm without a discount. For this reason, he is not a bidder in any of the auctions.[26]

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[25] Other field studies report different rules for the distribution of the winning bid. It may be added to future pots or distributed among all participants of the Rosca, not only the auction participants. See Calomiris and Rajaraman (1998) for a discussion.

[26] 9 of the 23 Roscas in the organiser sample operate somewhat differently. There, the organiser 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'. For the theoretical analysis, we will exclusively focus on the fixed commission regime. When we turn to the estimation, it will be briefly discussed how the results obtained for the fixed commission regime can be modified to accommodate the variable commission cases.

To formalise the ideas developed at the end of 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

$$U_t = \sum_{\tau=t}^{\infty} \delta^{\tau-t} q_\tau \ ,$$

where q_τ denotes consumption measured in Rupees in period τ and $\delta < 1$ is a discount factor for future consumption. Assume that 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 $mn - z$. In each period, the profit which the investment project yields is determined by a random variable, *R*, which is independently and identically distributed over the participants with the smooth cumulative distribution function (cdf) $F(r)$. The profit from an investment creates an instantaneous utility equivalent to consuming $(mn - z)r$, where *r* is the realisation of *R*. Further assume that each individual *i* privately observes his realisation of *R* in period *t*, r_{it}, before the auction in period *t*. We assume that investing $(mn - z)$ is always preferred to consuming $(mn - z)$, i.e. $F(r) = 0$ for $r < 1$. We assume 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, $(mn - z - b^w)$, 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 ensure 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.

In setting up this model we have implicitly assumed that, after observing r_{it}, the individual has access to the funds from only one bidding Rosca. A clue whether this assumption is too restrictive can be gained from the participant sample, where information on each individual's active participation in Roscas (i.e. where he can still win a pot) is available.

For our model, only multiple active participation causes a problem while multiple participation alone does not. As can be seen from Table 3, of the 13 sample members who are active participants in at least one Rosca, 4 are simultaneously active in more than one Rosca. Thus our assumption holds at least for the big majority of the participant-sample data. Note that, in the organiser sample, which will be used for the estimation, we do not have any information on multiple participation.

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. The way we analyse OA-Rosca auctions in this essay is the same as in section 1.2, although, in the present case, we also consider Rosca auctions with more than two bidders, which requires additional assumptions. To make this essay self-contained, we repeat the argument of section 1.2 with the modifications needed for the cases with more than two bidders. Since a somewhat lengthy argument is required to derive the bidding equilibrium which will serve as a benchmark for the estimation, we give a brief overview over the course of the argument which follows. As in the first essay, the crucial point is that, in contrast to standard SIPV OA auctions, OA-Rosca auctions do not have a bidding equilibrium in dominant strategies because, in a Rosca auction, the winning bid is distributed among the losers. Thus, to obtain a tractable model of an OA-Rosca auction, we will first establish the payoff equivalence of an OA-Rosca auction and a second-price sealed bid (SPS)-Rosca auction. Then we will analyse the Bayes-Nash equilibrium of a SPS-Rosca auction. In section 2.4 we will discuss how the equilibrium bidding strategy thus derived is different from truth-telling, which is the well-known dominant-strategy bidding equilibrium in standard OA auctions. Note that, throughout this essay, we always make a clear distinction between standard auctions and Rosca auctions.

Since we have to refer to standard auctions at several stages of the theoretical and econometric analysis, it is appropriate to recall 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.

As in the first essay, 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 his last competitor 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.[27] 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

[27] For standard auctions, this particular auction protocol is also known as Vickrey auction.

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.

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.

To derive the bidding equilibrium of a SPS-Rosca auction, suppose that there are K identical bidders, where, at the t-th meeting, $K = n - t + 1$, if $2 < t < n$, and $K = n - 1$, if $t = 1$. Before the auction, each bidder observes the revenue of his investment project, r_{kt}, $k = 1,\ldots,K$. Let us consider a bidder, k' say, who is confronted with $K - 1$ other bidders who all bid according to the bidding function $b_t(r)$, which is strictly increasing in r. Suppose k' also adopts the bidding function $b_t(\cdot)$, but that he has the option to pretend not to have observed $r_{k't}$ but ρ, say.

If he submits $b(\rho)$ given his actual $r_{k't}$ and wins the auction, his expected utility from the Rosca participation is $U_t^w(\rho|r) \equiv (nm - z)r - cE[b(R_{K-1:K-1})|R_{K-1:K-1} < \rho]$, where, for notational convenience, we have written r instead of $r_{k't}$ and dropped the subscript t. $(nm - z)r$ is his utility from engaging in the investment project with profit r.[28] $R_{j:l}$ denotes the j-th lowest order statistic from a sample of size l. Thus $E[b(R_{K-1:K-1})|b(R_{K-1:K-1}) \leq b(\rho)]$ is the expected value of the highest bid submitted by the $K - 1$ other bidders conditional on the event that none of these $K - 1$ bidders bids higher than $b(\rho)$. Of course, if $b(\cdot)$ is strictly increasing, as we have assumed, the events $b(R_{K-1:K-1}) \leq b(\rho)$ and $R_{K-1:K-1} \leq \rho$ are identical. Since, on average, k' has to take a loan of $E[b(R_{K-1:K-1})|R_{K-1:K-1} \leq \rho]$ to finance the costs of the investment, we have to subtract $cE[b(R_{K-1:K-1})|R_{K-1:K-1} \leq \rho]$ from the profit of the investment project. If k' wins the auction, then in the remaining rounds, he can neither receive a pot, nor enjoy a fraction of the winning bid. Thus, in this case, his expected utility from future Rosca rounds is zero.[29] The probability of winning the auction is $P^w(\rho) \equiv P(R_{K-1:K-1} \leq \rho)$.

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[28] At this stage, we assume that it is always advantageous to invest the funds obtained from the Rosca instead of consuming them. This does not need to hold in general and will be checked for the present data in section 2.5.

[29] 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 $U^w(\rho|r)$. 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.

If k' submits $b(\rho)$ and this turns out to be the second highest bid submitted, his expected utility is $U_t^{l1}(\rho|r) \equiv b(\rho)/(K-1) + EU_t^l$. In this case, k''s bid is the price the winner pays and this price is equally shared by the $K-1$ losers of this auction. EU_t^l is the expected utility from future rounds in which the auction's loser can still enjoy a fraction of the winning bid and win a pot. A discussion of this term follows at the end of this section. The probability of submitting the second highest bid, if k' pretends to have observed ρ, is $P^{l1}(\rho) \equiv P(R_{K-1:K-1} > \rho \cap R_{K-2:K-1} \leq \rho)$.

Finally, if $b(\rho)$ turns out to be smaller than the second highest bid submitted, k''s expected utility is $U_t^{l2}(\rho|r) \equiv E[b(R_{K-2:K-1})/(K-1)|R_{K-2:K-1} > \rho] + EU_t^l$. This expression is derived along the same lines of reasoning as in the other two cases above. The probability of submitting a bid lower than the second highest bid is $P^{l2}(\rho) \equiv P(R_{K-2:K-1} > \rho)$.

Consequently, k''s expected utility before submitting his bid is given by

$$(51) \qquad U_t(\rho|r) \equiv U_t^w(\rho|r)P^w(\rho) + U_t^{l1}(\rho|r)P^{l1}(\rho) + U_t^{l2}(\rho|r)P^{l2}(\rho).$$

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. Formally, we take the derivative of (51) w.r.t. ρ to obtain

$$(52) \quad \frac{dU_t(\rho|r)}{d\rho} = (K-1)F^{K-2}(\rho)\Big((1-F(\rho))b'(\rho) + f(\rho)\Big(v\big((nm-z)r - EU_t^l\big) - (1+vc)b(\rho)\Big)\Big),$$

where we have substituted $P^{l1}(\rho) = 1 - (P^w(\rho) + P^{l2}(\rho))$, $P^w(\rho) = (F(\rho))^{K-1}$ and $P^{l2}(\rho) = 1-(F(\rho))^{K-2}(K-1-(K-2)F(\rho))$. $v = K-1$ denotes the number of participants who share the winning bid.[30] In equilibrium, nothing can be gained from pretending a different return than the one actually observed. Formally, we equate the RHS of (52) with *r* substituted for ρ to zero. This gives a first-order differential equation:

$$(53) \qquad b'(r)\left(1-F(r)\right)=f(r)\left((1+\nu c)b(r)+\nu\left(EU_t^l-(nm-z)r\right)\right).$$

Obviously, the degree of non-linearity of (53) crucially depends on *F*'s hazard rate, *f*/(1-*F*). To obtain a tractable model for the empirical analysis, consider the exponential distribution with shift parameter 1 and scale parameter θ, $F(r)$ = 1- exp(-(*r*-1)/θ), $\theta > 0$. It is well known that the hazard rate of this distribution is constant and equal to θ^{-1}. In this case, (53) has one linear solution[31],

$$(54) \qquad b_t^e(r_t)\equiv\frac{\nu_t}{1+c\nu_t}\left((nm-z)\left(r_t+\frac{\theta}{1+\nu_t c}\right)-EU_t^l\right),$$

where we have put the subscript *t* again to indicate which terms depend on the round in which the auction takes place. Thus, with the exponential distribution, each auction in the course of the Rosca has a linear equilibrium bidding function which is given by (54).

It has been assumed in the derivations that the equilibrium bidding function is strictly increasing. It is easily verified from (54) that this is indeed the case. Further, as sufficient conditions for the optimality of $b^e(\cdot)$, we need to establish that, for a bidder who observes *r*, it

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[30] We introduce the parameter ν at this point because this will make the results derived for Roscas with a fixed commission regime easily applicable to Roscas with a variable commission. See footnote 26.

[31] Equation (53) has other, non-linear solutions which will not be discussed here because they make the econometric model computationally intractable.

is in fact globally optimal to bid $b^e(r)$, provided the other bidders follow $b^e(\cdot)$. Towards this end, substitute $b^e(\cdot)$ for $b(\cdot)$ into (52). Most terms cancel out and we obtain

$$\frac{dU_t(\rho|r)}{d\rho}_{|b(\cdot)=b^e(\cdot)} = (K-1)F^{K-2}(\rho)v(nm-z)f(\rho)(r-\rho)\begin{cases} >0, \rho<r \\ <0, \rho>r \end{cases}.$$

In words, given that the other bidders follow $b^e(\cdot)$, $U_t(\rho|r)$ is pseudoconcave in ρ for all values of r. Thus a bidder gains from pretending a higher (lower) revenue ρ, whenever ρ is smaller (bigger) than r, which implies that bidding $b^e(r)$ is strictly preferred to bidding $b^e(\rho)$ for all $\rho \neq r$.

We now briefly discuss EU_t^l. In the last but one round, we have

(55) $$EU_{n-1}^l = \delta(mn-z)E[R] = \delta(mn-z)(1+\theta),$$

which is the discounted expected revenue of the investment project which the recipient of the n-th pot realises. More generally, consider the expected utility of a loser in an auction in the (t-1)-th round before he observes r_t. In the following (i.e. the t-th) round, he either wins the pot and invests or he loses the auction and receives a share of the winning bid plus a loser's expected utility, EU_t^l. In the symmetric bidding equilibrium characterised by $b_t^e(\cdot)$, the bidder who observes the highest revenue wins the auction. Thus, on average, the revenue of an investment project realised in round t is $(nm-z)E[R_{K_t:K_t}]$, while the winning bid is determined by the second highest bidder, on average $E[b_t^e(R_{K_t-1:K_t})]$. Before observing r_t, in equilibrium, the probability of being the winner of the auction in round t is $(1/K_t)$ while the probability of losing is $(K_t-1)/K_t$. We thus obtain the recursive relationship

$$EU_{t-1}^{l}=\delta\left(\frac{1}{K_t}\left((nm-z)E[(R_{K_t:K_t})]-cE[b_t^e(R_{K_t-1:K_t})]\right)+\frac{K_t-1}{K_t}\left(E\left[\frac{b_t^e(R_{K_t-1:K_t})}{v_t}\right]+EU_t^l\right)\right),$$

(56)

$3\le t\le n$–1.

Since the organiser receives the second pot without a discount, in the second round, all active participants can be treated like losers and consequently, for the first auction, we have

(57) $EU_1^l=\delta EU_2^l$.

With equations (55) to (57), EU_t^l can be obtained for any t by recursion. Note that ex ante expected utility from joining a Rosca before observing r_1, EU, is just $EU_0^l/\delta-\frac{1-\delta^{n-1}}{1-\delta}m$, where EU_0^l is obtained from (56) with t = 1, and $\frac{1-\delta^{n-1}}{1-\delta}m$ = $\sum_{t=1}^{n}\delta^{t-1}m$ is the disutility from the contribution that has to be paid in each of the following n periods.

With ex ante expected utility derived, a remark on the general approach to Rosca participation taken in this essay is in order. Of course, it is an interesting task to determine an optimal portfolio of Roscas for an individual given certain individual characteristics such as income and assets, and possibly the number of daughters. To analyse observed auction outcomes, however, in this study, we take each Rosca participation as given and set the problem of an optimal Rosca portfolio aside.

2.4 The Notion of Overbidding in Rosca Auctions and the Gains from Lower Bidding

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'. In Proposition 1 of the first essay, it has been shown that, under the assumptions set out there, in the bidding equilibrium, bidders in an OA-Rosca auction overbid relative to their maximum willingness to pay. We will now analyse this question in the context of the present model. Towards 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 buying the item at a price of b^0, $U^w(b^0|\upsilon) \equiv \upsilon - b^0$, with the utility from not getting the item at price b^0, $U^l(b^0|\upsilon) \equiv 0$. Applying this equation to the Rosca case gives

$$(nm - z)r_t - cb_t^0 = (b_t^0 / \nu_t) + EU_t^l \tag{58}$$

and thus $b_t^0(r_t) = \frac{\nu_t}{1 + c\nu_t}\left((nm - z)r_t - EU_t^l\right) = b_t^e(r_t) - \frac{\nu_t(nm - z)}{(1 + \nu_t c)^2}\theta < b_t^e(r_t)$. That is, in the bidding equilibrium, each bidder adds the constant $\frac{\nu_t(nm - z)}{(1 + \nu_t c)^2}\theta$ to his maximum willingness to pay to determine his bid. In this sense, as in the first essay, Rosca bidders 'overbid' (like bidders in a standard SIPV first-price auction underbid). Note that, for $\nu_t \geq 1$, the extent of overbidding is strictly decreasing in ν_t, which means that overbidding becomes more and more pronounced as the Rosca proceeds. The intuition behind this is that, the smaller ν_t, the bigger is the fraction of the winning bid a losing bidder receives, which increases the incentive to overbid. The extent of overbidding is decreasing in c because high costs of credit make the case when one wins at a price higher than $b^0(r)$ more painful.

It is interesting to calculate how frequently an auction's winner ex post regrets that he has overbid. Suppose a bidder observes r^w and wins the auction. Clearly, this winner would prefer not to receive the pot at a price of b^w whenever $b_t^0(r^w) < b^w$, i.e. when the price he has to pay exceeds his maximum willingness to pay. If all bidders follow the equilibrium strategy $b_t^e(\cdot)$, the probability of this event, conditional on r^w, is $P^r(v_t, c| r^w) \equiv P\left(b_t^0(r^w) < b_t^e(R_{K-1:K-1}) | R_{K-1:K-1} < r^w\right)$ and the total probability of a winner's regret $P^r(v_t, c) \equiv \int_1^\infty P(v_t, c|r) f_{K_t:K_t}(r)dr = 1 - \exp(-1/(1+v_t c))$, where $f_{K_t:K_t}(\cdot)$ denotes the density of $R_{K_t:K_t}$. As the extent of overbidding itself, $P^r(v_t, c)$ is decreasing in v_t and c. To give a numerical example, if the disutility from borrowing exceeds the amount of the loan by 50%, i.e. $c = 1.5$, then, in the last auction, where $v = 1$, $P^r(1, 1.5) \cong 0.33$, which means that in about one third of such cases, the winner will regret having overbid. On the other hand, in a Rosca with 10 participants, in the first auction, $v_1 = 8$, and we obtain $P^r(8, 1.5) \cong 0.074$, which means that we have to expect a winner's regret in 7.4% of the cases. The fact that regret occurs with a positive probability is in line with casual evidence from the field study where one organiser reported that, after the end of an auction in one of his Roscas, 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.

One goal of the empirical part of this essay is to detect potential differences of the bidding functions in Roscas with different characteristics. Imposing the assumption of Bayes-Nash equilibrium bidding on all observed auction outcomes, however, obscures such differences. For this reason, let us now consider the (n-2)-vector $\mathbf{b} \equiv (b_1(\cdot), b_3(\cdot), \ldots, b_{n-1}(\cdot))$ and suppose that in a Rosca with n participants, in the auction in round t, all bidders bid according to $b_t(\cdot)$, where b_t is an arbitrary strictly increasing function of r_t. Ex ante, the expected utility from joining such a Rosca is given by $EU(\mathbf{b}) \equiv EU_0^l(\mathbf{b})/\delta - \frac{1-\delta^{n-1}}{1-\delta}m$, where $EU_0^l(\mathbf{b})$ is given implicitly by the recursive equations

$$(59)\quad EU_{t-1}^l(\mathbf{b}) \equiv \begin{cases} \delta(nm-z)(1+\theta),\ t=n \\ \frac{\delta}{K_t}\left((nm-z)E[(R_{K_t:K_t})] - E[b_t(R_{K_t-1:K_t})]\left(c-\frac{K_t-1}{v_t}\right)+(K_t-1)EU_t^l(\mathbf{b})\right),\ t=1,3,4,\ldots,n-1, \\ \delta EU_t^l(\mathbf{b}),\ t=2 \end{cases}$$

which are obtained from (55) to (57) with $b_t(\cdot)$ substituted for $b_t^e(\cdot)$. The following lemma concerns welfare comparisons of two vectors of bidding functions.

<u>*Lemma 2:*</u> *Define the vector of constants* $\boldsymbol{\alpha} \equiv (\alpha_1,\ \alpha_3,\ldots,\alpha_{n-1}) > \mathbf{0}$, i.e. $\alpha_t \geq 0$ *for all* $t \in \{1,3,\ldots,n\text{-}1\}$ *and* $\alpha_t > 0$ *for at least one* $t \in \{1,3,\ldots,n\text{-}1\}$. *Then* $EU(\mathbf{b}) > EU(\mathbf{b}+\boldsymbol{\alpha})$.

<u>Proof:</u>

We proceed by recursion. From the upper term on the RHS of (59), we have

$$(60)\quad EU_{n-1}^l(\mathbf{b}+\boldsymbol{\alpha}) - EU_{n-1}^l(\mathbf{b}) = 0.$$

Further,

$$(61)\quad EU_{t-1}^l(\mathbf{b}+\boldsymbol{\alpha}) - EU_{t-1}^l(\mathbf{b}) = \frac{\delta}{K_t}\left(-\alpha_t\left(c-\frac{K_t-1}{v_t}\right)+(K_t-1)\left(EU_t^l(\mathbf{b}+\boldsymbol{\alpha})-EU_t^l(\mathbf{b})\right)\right),$$

$t = 1, 3, 4,\ldots, n\text{-}1,$

which is strictly negative provided that $\left(EU_t^l(\mathbf{b}+\alpha)-EU_t^l(\mathbf{b})\right)$ is non-positive and c > 1. Finally,

$$(62)\quad EU_{t-1}^l(\mathbf{b}+\alpha)-EU_{t-1}^l(\mathbf{b})=\delta\left(EU_t^l(\mathbf{b}+\alpha)-EU_t^l(\mathbf{b})\right),\ t=2.$$

Taking (60) to (62) together, establishes $EU_0^l(\mathbf{b}+\alpha)<EU_0^l(\mathbf{b})$ and by the definition of $EU(\mathbf{b})$ the claim.

Lemma 2 states that, for a given vector of bidding functions, the expected utility from participating in a bidding Rosca decreases if, in any of the auctions, all bidders add some positive constant to their bid. The reason is that higher bids force an auction's winner to incur extra debt, while the losers of such an auction enjoy extra consumption from the higher amount which is redistributed to them. Since, by assumption, the marginal disutility from borrowing is bigger than the marginal utility from consumption, lower bids are preferred from an ex ante perspective. Lemma 2 implies that a group can increase the benefits from Rosca participation if all members symmetrically overbid less than in the Bayes-Nash equilibrium.

2.5 Structural Estimation of Rosca Auctions

As mentioned above, in the present estimation, we will not force the theoretically computed Bayes-Nash equilibrium on the data because, as will become clear shortly, this potentially obscures interesting insights, which can be obtained from the data. With the considerations from the previous section in mind, it seems appropriate to allow for differences in the extent of overbidding. While still assuming that bidders bid symmetrically, we introduce the parameter ρ to allow for players' deviations from the Bayes-Nash equilibrium as follows:

(63) $$b_t^{\rho}(r_t) \equiv \frac{v_t}{1+cv_t}\left((nm-z)r_t - EU_t^l\right) + \rho \frac{v_t(nm-z)\theta}{(1+v_t c)^2}.$$

If ρ = 1, bidders bid according to the Bayes-Nash equilibrium. If ρ > (<) 1, bidders overbid (underbid) relative to the Bayes-Nash equilibrium. It further follows from Lemma 2 that ex ante expected utility from joining the Rosca is strictly decreasing in ρ.[32]

Since this essay is the first attempt to analyse Rosca auctions econometrically, we first 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 modelled in this essay 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 hypothesised 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

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[32] For Roscas with a variable commission (see footnote 26), we shall assume that the cost of the investment project each participant observes in each round is *nm* and that the participant who receives the last pot has to finance the last round's fixed commission, z_n say, by a loan at the cost of *c*. Then $EU_{n-1}^l = \delta\left(mn(1+\theta) - cz_n\right)$, equations (56), with *z* set equal to zero, and (57) remain valid and it can be shown that there exists the linear equilibrium bidding function $b_t^e(r_t) \equiv \frac{v_t}{1+cv_t}\left(nmr_t - EU_t^l\right) + \frac{v_t nm\theta}{(1+v_t c)^2}$, where $v_t = K_t$. Analogously to the fixed commission case, we define $b_t^{\rho}(r_t) \equiv \frac{v_t}{1+cv_t}\left(nmr_t - EU_t^l\right) + \rho\frac{v_t nm\theta}{(1+v_t c)^2}$.

bids in general depend on covariates and additional parameters, which enter into a bidder's hypothesised bidding function (see Hendricks and Paarsch, 1995). In the present case of OA-Rosca auctions, it is immediately seen from (63) that each observed bid does not only depend on the parameter characterising the hypothesised distribution F, θ, but also on δ, c and ρ. Thus, econometrically, the present estimation of OA-Rosca auctions faces the same problem that was previously encountered in the estimation of standard first-price sealed bid and Dutch auctions. We will thus briefly review some of the literature concerned with this problem.

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, generalised non-linear least squares, advocated by Laffont et al. (1995) for models where the moments of equilibrium bids cannot be computed explicitly, and, second, the method of maximum likelihood, whose non-standard asymptotic properties have been derived by Donald and Paarsch (1996).

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 analysed by Donald and Paarsch (1996), 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 minimum price which is assumed to be bigger than the lower bound of the support of the distribution from which the bidders' values are drawn. Thus, within their framework, the lower bound of the values' distribution poses no problem. However, since they consider distributions whose support has a finite upper bound, α say, the difficulty arises from estimating α, 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 maximise the observed bids' log-likelihood subject to a set of inequality restrictions ensuring 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, b_j^w say, 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 $R_{K_j-1:K_j} \sim G_{K_j-1:K_j}(\cdot;1,\theta)$, where $G_{k:K}(\cdot;\zeta,\gamma)$ 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 (63), B_j^w is distributed according to $G_{K_j-1:K_j}(\cdot;\eta_j,\omega_j)$, where

$$\eta_j = \frac{v_j}{1+cv_j}\left((n_j m_j - z_j)\left(1+\frac{\rho\theta}{1+cv_j}\right) - EU_j^l\right) \text{ and } \omega_j = \frac{v_j(n_j m_j - z_j)}{1+cv_j}\theta .$$

Note that every quantity which depends on the specific characteristics of that Rosca auction from which B_j^w is 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

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

(64)

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

Suppose for a moment that we wanted to estimate η and ω from a sample of J winning bids which are all identically distributed. The log-likelihood for this estimation problem is

$$(65)\quad \ell_K(\eta,\omega) \equiv \begin{cases} -\infty, b_{1:J} \le \eta \\ J\log\left(K(K-1)\right) - J\log(\omega) + \sum_{j=1}^{J}\left((K-2)\log\left(1-\exp\left(-\frac{b_j-\eta}{\omega}\right)\right) - 2\frac{b_j-\eta}{\omega}\right), b_{1:J} > \eta \end{cases}.$$

Note that, for all $K \ge 2$, 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.[33] Consequently, the ML estimator of η in this case is $b_{1:J}$. If, moreover, η is a function of covariates $\boldsymbol{x}_j$ (in our case $\boldsymbol{x}_j = (m_j, n_j, z_j, v_j)$) and a parameter vector $\boldsymbol{\beta}$ (in our case $\boldsymbol{\beta} = (\delta, c, \theta, \rho)$), ML estimation of $\boldsymbol{\beta}$ is technically exactly the same problem as the one considered by Donald and Paarsch (1996) 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. We will now show that, in this case, the theory developed by Smith (1985) applies. He considers probability densities of the form

$$(66)\quad f(y;\eta,\phi) = (y-\eta)^{K-2}h(y-\eta;\phi),\ \eta \le y,\ K > 2,$$

where η and ϕ, the latter a vector, are unknown parameters and the function h tends to a constant $(K\text{-}1)\chi$ as $y \;\; \eta$. To see that Smith's theory is valid for the present application, we need

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

<u>Lemma 3:</u> *Let* $g_{K-1:K}(y;\eta,\omega)$ *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* $h_K(y - \eta;\ \omega) \equiv g_{K-1:K}(y;\eta,\omega)\ (y-\eta)^{2-K}$ *and* $\chi_K \equiv \lim_{y\downarrow\eta} h_K(y-\eta;\omega)/(K\text{-}1)$*. Then, for all* $K \geq 2$, $\chi_K = K\omega^{1-K}$.

<u>Proof:</u>

First note that $g_{K-1:K}(\cdot;\eta,\omega)$ is equal to $f_{B_j^w}(\cdot)$ as given in (64) 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:

$$(67)\qquad \frac{\partial g_{K-1:K}(y;\eta,\omega)}{\partial y} = \omega^{-1}\left(K g_{K-2:K-1}(y;\eta,\omega) - 2 g_{K-1:K}(y;\eta,\omega)\right),\ K \geq 3.$$

Equation (67) may be used to prove the following representation of the *L*-th derivative of $g_{K-1:K}(\cdot;\eta,\omega)$ by induction.

$$(68)\qquad \frac{\partial^L g_{K-1:K}(y;\eta,\omega)}{\partial y^L} = \omega^{-L}\sum_{l=0}^{L}(-2)^{L-l}\binom{L}{l}\frac{K!}{(K-l)!}g_{K-l-1:K-l}(y;\eta,\omega),\ L \leq K-2.$$

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 (68), this implies that $\left.\frac{\partial^L g_{K-1:K}(y;\eta,\omega)}{\partial y^L}\right|_{y=\eta} = 0$, if $L < K - 2$, and $\left.\frac{\partial^L g_{K-1:K}(y;\eta,\omega)}{\partial y^L}\right|_{y=\eta} = K!\omega^{1-K}$, if $L = K - 2$. We can thus apply L'Hôpital's rule $(K - 2)$ times to obtain $\lim_{y\downarrow\eta} h_K(y-\eta;\omega) = \lim_{y\downarrow\eta}\frac{g_{K-1:K}(y;\eta,\omega)}{(y-\eta)^{K-2}} = \frac{K!\omega^{1-K}}{(K-2)!}$. Recalling the definition of χ_K, the result stated in Lemma 3 follows immediately.

Lemma 3 establishes that, abstracting from the presence of covariates, the present estimation problem is a special case of the nonregular class considered by Smith (1985), who shows that,

(i) if K = 3, then the estimators which are obtained from maximising the likelihood, $\hat{\eta}$ and $\hat{\omega}$, are consistent and asymptotically normal. While, for $\hat{\omega}$, the order of convergence is the usual $O(N^{0.5})$, where N denotes the sample size, $\hat{\eta}$ converges faster to the true value of η, namely at an order of $O([N \log(N)]^{0.5})$. 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 $\hat{\omega}$.

(ii) if K > 3, standard asymptotic theory applies to $\hat{\eta}$ and $\hat{\omega}$, i.e. both $\hat{\eta}$ and $\hat{\omega}$ converge at an order of $O(N^{0.5})$, and are asymptotically normally distributed. The asymptotic covariance matrix may be estimated consistently with the inverse of the observed information matrix.

Although Smith only considers scalars η and ω, it is most likely that his results are valid for the present application where η and ω are functions of covariates and further parameters. This conjecture is supported by Monte Carlo experiments which I conducted with artificial data. A formal proof of this conjecture, however, is well beyond the scope of the present study.[34]

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[34] To extend maximum likelihood theory derived for scalar parameters to the case where there are covariates and further parameters can be very tedious, as the history of the Tobit estimator illustrates. While Hald (1949) had derived results for the estimation of a truncated normal distribution, it took another 15 years from Tobin's (1958) suggestion of a

To summarise, for observed bids from auctions with three or more bidders, the likelihood function is continuous and has an interior maximum. Moreover, although the estimation problem is nonregular, usual methods of estimation and inference appear to be applicable. It is only the data from next to last Rosca rounds, which do not allow estimation by standard methods. Since, in the present case, the likelihood is a very complicated function of the parameters δ, c, θ and ρ, it is essential that the likelihood function have an interior maximum. For this reason, we drop the 8 observations from auctions with only two bidders.

In a first step, we use all remaining 141 observations for the estimation including 36 winning bids which stem from auctions where the winner's purpose was known to the other bidders at the beginning of the auction, i.e. where the private information assumption is violated. Table 6 shows the distribution of those winning bids which are used for the estimation 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.

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truncated normal model with covariates to Amemiya's (1973) proof of the asymptotic properties of the Tobit model, which are, in principle, absolutely standard in all respects.

Table 6. The organiser sample: frequency table of recorded auction outcomes used for the estimation

m ↓ date*→	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)

Throughout 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 that, within a given Rosca, bidders bid symmetrically. We will abstract from any problem that potential simultaneous participation in several Roscas and other forms of unobserved heterogeneity among the participants causes. 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 can be tested neither with the organiser sample, which does not contain information on bidders' identities, nor with the participant sample, which, except for one case, does not include simultaneous membership of several respondents in the same Rosca.

For this first estimation, we will, moreover, assume that all participants face the same distribution of returns, which is characterised by θ, and that the extent of overbidding, ρ, is the same in all Roscas.

When both δ and c are taken as free parameters in the likelihood function, the likelihood maximisation does not converge. Instead, irrespective of the starting values, δ approaches zero while c grows without limit. We thus impose some more structure on the model by assuming that the instantaneous disutility from borrowing is equivalent to the disutility from an annuity in which the borrower has to pay an interest of i in all following periods for each Rupee borrowed. Assuming that the principal is never repaid, we thus substitute $i\delta/(1\text{-}\delta) = \sum_{\tau=1}^{\infty} i\delta^{\tau}$ for c, where i is the moneylender interest rate for a spell of one Rosca period, i.e., on average, six months. For bigger loans for investment purposes, 5% per month (with no compound interest within one year) is the going interest rate in E. We thus calibrate our model to the credit market conditions in E by setting i = 0.3 and substituting 0.3δ/(1-δ) for c in (63).[35]

Table 7. Results for the basic model

Parameter	Explanation	Estimate	STD*	T
δ	Individual discount factor	0.853	0.004	230.564
θ	Average profitability of the investment project	0.272	0.018	14.946
ρ	Extent of overbidding	4.599	0.637	7.221

* covariance matrix computed from the inverse empirical Hessian

The estimates of δ and θ appear to have a reasonable order of magnitude. The estimate of δ implies that the individual discount rate amounts to about half of the discount factor implicit in loans when i = 0.3. Moreover, within our modelling framework, the expected return on investment, 1 + θ, is somewhat lower than the cost of credit. The estimate of ρ, which is well above unity, shows that the Bayes-Nash equilibrium cannot be forced onto the data successfully. The likelihood function appears to be pseudoconcave. A gridsearch with several different starting values was undertaken but convergence always occurred at the values given in Table 7.

A thorough analysis of the residuals of this first estimation points to the following, potentially significant determinants of observed winning bids:

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[35] Using a lognormal distribution for bidders' values, Laffont et al. (1995) also encounter convergence problems in their estimation of Dutch auctions for eggplants among wholesalers in Marmande, France. Compared to the ad hoc way in which they fix the shape of the lognormal distribution by using the logarithmic variance of eggplant prices in the retail market, our calibration of the costs of credit is quite innocent.

1) In big Roscas (contribution of Rs. 3000 or more), winning bids are relatively higher and relatively wider dispersed than in Roscas with small contributions.
2) Observed winning bids in winter auctions are, on average, higher than in autumn auctions.
3) Winning bids in Roscas of experienced organisers are smaller than in Roscas of newcomer-organisers.
4) Within groups which have run more than one Rosca before, winning bids appear to be lower.
5) Irrespective of the winner's purpose, winning bids in auctions with public information appear to be lower than in auctions with private information.

Some of these observations can be justified in a straightforward fashion. As to the first observation, there is evidence from the participant sample that the size of the contribution is highly correlated with the operational landholdings of a household (see Table 4). A household which operates a large area can be expected to be more experienced in operating a field plot profitably than a household which is primarily engaged in agricultural wage labour. It is thus plausible to expect that, on average, the revenue from a given field plot is higher for households which participate in Roscas with a big contribution. An increase in the revenue parameter θ, however, also scales up the distribution of winning bids.

Turning to observation 2, if one wins a winter auction, the money can be used for productive investment in the autumn crop. According to farmers and paddy merchants, the autumn crop in E is about 50% more profitable than the winter crop. Thus, returns on investment after the winter harvest should, on average, be higher than after the autumn harvest. Of course, the extent of this effect depends on how long-lived the investment is and on the degree of individual impatience. Ideally, one would want to introduce a fixed effect not only for seasonality but for each harvest to control for potential macro factors, such as crop failures and price fluctuations in the market for paddy. As Table 6 reveals, however, this would require another 16 dummies, which costs too many degrees of freedom. For the time period in question, severe deviations from usual harvest yields were only reported for the harvests in autumn 1993, winter 1994 (due to insect damage) and autumn 1997 (due to heavy rains during the harvest).

As to observation 3, all organisers whom I interviewed pointed out that high bidding is bad for an organiser's reputation (see also observation 9 in section 2.2.4). Also, according to organisers, a high winning bid decreases a winner's motivation to follow up his obligation to pay future Rosca contributions and thus causes the organiser trouble. Experienced organisers often explained that, when a Rosca ends, they would not invite those participants to new Roscas who regularly drive up the bid more than usual.

Observation 4 is particularly interesting because, if one is willing to believe that the average revenue from investment projects is the same for Rosca groups which have been existing for several years and those which have newly formed, it suggests that, as a group gathers experience, social gains from lower bidding can be realised that new groups miss by bidding more excessively. As to observation 5, note that, in our data, of the 36 observations with public information, 23 were 'emergencies', i.e. the marriage or puberty function of a daughter or a close relative. In only one of these 36 cases did the winner buy a field plot.

Ideally, one would want to determine whether each of the factors mentioned in the previous paragraphs affects auction outcomes through the revenue distribution or through the extent of overbidding, or through both. Unfortunately, such an identification is not possible with the present data. Instead, when e.g. a dummy for seasonality is included both for θ and for ρ, these dummies start to build each other up. Therefore, based on the above reasoning, we impose some structure on the dummies and slope coefficients which will now be introduced by admitting only either θ or ρ to be a function of each of them.

In particular, we will assume that the amount of the contribution to a Rosca and seasonality matter only for the revenue of an investment project, whereas the number of Roscas a group has run before and the experience of the organiser matter only for the extent of overbidding. All these factors will be included into the structural model as *permanent* characteristics of a Rosa, i.e. the said features alter the bidding function in each auction and participants include these features into their expectations about future auctions. On the other hand, when unforeseen macro shocks such as crop failures are concerned, we will assume that any resulting changes in observed bids are *transitory*, i.e. expectations about future auctions are not affected by such events. The same will be assumed to detect whether overbidding is more or less pronounced in auctions where the winner's purpose was publicly known before the auction. Formally, let us write the bidding function and the expected utility of an auction's loser as functions of possibly different sets of the model parameters, i.e.

$$b_t^{\rho}(r_t,\delta,\theta_1,\rho_1) \equiv \frac{v_t}{1+c(\delta)v_t}\left((nm-z)r_t - \widehat{EU}_t^{\,l}\right) + \rho_1 \frac{v_t(nm-z)\theta_1}{(1+v_t c(\delta))^2}, \tag{69}$$

where, as defined above, $c(\delta) = 0.3\delta/(1-\delta)$ and

$$\widehat{EU}_t^{\,l} \equiv EU_t^l(\delta,\theta_2,\rho_2). \tag{70}$$

Permanent characteristics are reflected by θ_1, ρ_1 and θ_2, ρ_2, while transitory characteristics only affect one auction and are thus only reflected by θ_1, ρ_1. We can now define

$\theta_1 = \theta_0 + \theta_m\,(m/1000\text{-}1) + \theta_{seas} + \theta_{972}$,

$\theta_2 = \theta_0 + \theta_m\,(m/1000\text{-}1) + \theta_{seas}$,

where 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. We do not include dummies for the failed harvests in autumn 1993 and winter 1994 because, as Table 6 reveals, only three winning bids belonging to these latter harvests are in the data. We further define

$\rho_1 = \rho_0 + \rho_{cb}\,RB + \rho_{cbsq}\,RB^2 + \rho_{org}\,OE + \rho_{nocomm} + \rho_{publ,nomarr} + \rho_{publ,marr}$,

$\rho_2 = \rho_0 + \rho_{cb}\,RB + \rho_{cbsq}\,RB^2 + \rho_{org}\,OE + \rho_{nocomm}$, where *RB* is the number of bidding Roscas the group in question has run before (ranges between zero and three), *OE* is the number of Roscas the organiser reports to have organised before having started the Rosca in question (ranges between zero and eight), $\rho_{publ,nomarr}$ 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 a productive purpose, and $\rho_{publ,marr}$ 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. ρ_{nocomm} is a dummy for Roscas where the organiser does not receive a fixed commission in each round but instead shares the winning bid with the auction's losers in each round (see footnotes 26 and 32). We introduce ρ_{nocomm} to see whether our model accommodates both commission regimes satisfactorily.

Table 8. Results for the augmented model

Parameter	Explanation	Estimate*	STD**	T
δ	Individual discount factor	0.843	0.003	261.175
θ_0	Average profitability of investment project	0.168	0.016	10.508
θ_m	Change in θ as a function of the Rosca contribution	0.017	0.007	2.385
θ_{seas}	Dummy on θ for winter auctions	0.027	0.012	2.295
θ_{972}	Dummy on θ for the 1997 autumn auction	0.054	0.026	2.102
ρ_0	Extent of overbidding	6.012	0.766	7.852
ρ_{cb}	Change in ρ as a linear function of the number of Roscas the group had before	2.520	1.086	2.320
ρ_{cbsq}	Change in ρ as a quadratic function of the number of Roscas the group had before	-1.141	0.460	-2.480
ρ_{org}	Change in ρ as a function of the organiser's experience	-0.622	0.199	-3.125
$\rho_{publ,nomarr}$	Dummy on ρ for public information and purpose other than marriage	-2.895	1.086	-2.666
$\rho_{publ,marr}$	Dummy on ρ for public information and purpose = marriage	-1.393	0.816	-1.708
ρ_{nocomm}	Dummy on ρ for Roscas where the organiser shares the winning bid	-1.412	0.720	-1.962

* The estimation results from the basic model were used as starting values for δ, θ_0, ρ_0. All other parameters were initially set equal to zero.

** covariance matrix computed from the inverse empirical Hessian

Before we discuss 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 intertemporal structure of our model is capable of explaining the intertemporal pattern of observed bids successfully. Further, we repeated the estimation for several values of *i* within a range of 0.15 and 0.60 without obtaining qualitatively different results. Another issue which needs to be clarified is whether it is indeed advantageous for a winner to invest the funds obtained from the Rosca instead of using the money for consumption. Recall that, for investment, the amount of the winning bid has to be financed by a loan. If we consider the worst case for a winner, namely that the rate of return he observes is only marginally higher than that of the second highest bidder, we find that an investment's net profit, $(n_j m_j - z_j)(b_j^{\rho-1}(b_j^w) - 1) - c b_j^w$, is negative in about 17% of the cases in our data. Note that the inverse function $b_j^{\rho^{-1}}(b_j^w)$ gives the return on investment of the second highest bidder. In contrast, if we calculate the expected net profit of a winner conditional on the observed winning bid, i.e. if we replace $b_j^{\rho^{-1}}(b_j^w)$ by $E[R_{K_j:K_j}|R_{K_j:K_j} > b_j^{\rho^{-1}}(b_j^w)]$, we find that it is advantageous to invest in all cases in our data. Thus, although the expected net profit is always positive, one assumption of our model may be violated with positive probability, although in a rather limited number of cases.

We now turn to the estimation results. At conventional levels, there is statistically significant evidence that, on average, participants who pay a higher contribution face higher revenues from investment. The estimate of θ_m suggests that the average net profit from investment is about 40% higher in Roscas with a contribution of Rs. 5000 than in Roscas with a contribution of Rs. 1000. Seasonality shows the expected sign, as does the dummy for the crop failure in the autumn of 1997. On the one hand, after such a failure, money expected from the harvest is missing which individuals might have planned to use for several purposes, be it agricultural inputs or the repair of one's house. Thus, provided that the marginal product of such expenditures is sufficiently high, θ can be expected to be higher than after an ordinary autumn harvest. On the other hand, after such a failure, there may be particularly profitable opportunities in the market for field plots because some farmers may be forced to sell some land to compensate the crop failure, which would also increase θ. According to the winners' purposes after the said harvest, agricultural inputs do not appear but, instead, productive investment is recorded in ten of eleven cases where the winner's purpose is known (purchase of a field plot, 6 times, repair of the winner's house, 3 times, purchase of bullocks, once, daughter's marriage, once, unknown, once).

The experience of an organiser appears to be an important determinant of the extent of competitiveness reflected by winning bids. This relationship is likely due to both the selection of participants based on the organiser's experience and a certain skill many organisers have pointed at to influence people to bid reasonably. One means to influence bidders could stem from the fact that organisers often have more information than other bidders because it was frequently reported that bidders tell the organiser before an auction for what they need money and how much they would be willing to pay, while they keep this information hidden from the other bidders.

The fact that ρ_{nocomm} is borderline significant at common levels indicates that our model may not be capable of fitting both commission regimes, fixed and variable, satisfactorily. If we do not construe the likelihood of the variable commission outcomes (57 observations) as described in footnote 32, but, in a rather descriptive fashion, treat them as generated by a fixed commission regime, ρ_{nocomm}'s T-value becomes even smaller than –2 indicating that there are welfare-relevant differences associated with the commission regime. This finding is counterintuitive at first sight because one would expect a conflict of interest for an organiser who receives a share of the winning bid. As mentioned above, on the one hand, there are various reasons for an organiser to try to keep winning bids at a moderate level. If, on the other hand, he receives a share of the winning bid, then, in each auction, his payoff is increasing in the winning bid. We suspect that lower bidding in variable commission Roscas reflects another factor in the background, which does not appear explicitly in our data. This is indicated by the fact that – although winning bids tend to be lower - the variable commission amounts to an average of 5.5% of the collected contributions while this figure ranges between 2 and 5% in the Roscas with a fixed commission. While a fixed commission of more than 5% is considered unacceptable in the village, a variable commission is widely accepted and not questioned. It could thus be that, on average, those organisers who are more capable and/or experienced realise that a variable commission regime is more profitable for them, but that, at the same time, the said organisers perform better in keeping bidding at moderate levels by the means mentioned in the previous paragraph. In this case, the organiser's conflict of interest would be resolved in favour of keeping the bidding less aggressive because experienced organisers are aware of the negative long-term consequences of unrestrained bidding for their Rosca business.

An interesting finding is the inverted U-shape of the relationship between the number of Roscas a group had run before and the extent of overbidding. The estimates of ρ_{cb} and ρ_{cbsq} imply that, when a group had three Roscas before, the extent of overbidding is less than half of that of a group which had one Rosca before. Following the estimates, overbidding is more pronounced in groups which had one Rosca before, than in newly formed groups. When more than one Rosca has been run before, the extent of overbidding decreases sharply.[36] This finding can be interpreted in two ways. First, it could be the outcome of a learning process which involves bounded rationality. According to this story, after the first Rosca, participants speculate that something can be gained from bidding more aggressively. As they find that this is not the case, observed bids become lower in future Roscas.[37] Second, it could point at differences between a one shot and a repeated game scenario. In this interpretation, the group gathers experience during the first two Roscas. As the members observe each other in many auctions, punishment by exclusion or social pressure for

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

[37] There is a growing literature on learning in repeated auctions. For first-price common value auctions, Garvin and Kagel (1994) find that inexperienced bidders suffer from the winner’s curse while experienced bidders approximate the Nash equilibrium. On the other hand, in repeated independent private value auctions, Güth et al. (1999b) do not find convergence to a risk neutral Nash equilibrium. Further topics concerning learning directions and cognitive versus non-cognitive learning (see Güth et al., 1999a; Roth and Erev, 1995; Selten and Buchta, 1998) cannot be explored with the present data since they do not contain information on each bidder’s identity.

excessive bidding becomes feasible and enforceable.[38] By that way, a group can realise social (i.e. ex ante) gains from lower bidding.

Another permanent characteristic of each Rosca group, its composition with respect to caste, was originally also included as an explanatory variable for the degree of overbidding. As in the estimation of the determinants of Rosca participation (see Table 4), however, the corresponding coefficient was highly insignificant. To save degrees of freedom, the variable 'caste' is not included in the estimation results presented in Table 8.

The dummy for auction outcomes when the winner needs money for a publicly known marriage or puberty function has a negative sign but is only on the borderline of significance at conventional levels. Lower winning bids in such cases indicate that Rosca participants show a co-operative behaviour, 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). Organisers pointed out that it is considered improper behaviour to raise the bid as usual when some other bidder has an ‘emergency’.[39] In one case, an organiser explained a particularly high winning bid as retaliation against a participant who,

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[38] It is beyond the scope of this paper to elaborate on the gains from repeated Rosca participation rigorously. There is, however, a considerable literature on the gains from enduring relationships under private information in the context of consumption insurance (see Wang, 1995, for a recent contribution).

[39] Bouman (1979) reports such 'crafty' bidding practices when information on a bidder's need of funds is public.

in previous rounds, used to take advantage of other bidder's need but then declared that he needed a pot urgently himself.

On the other hand, the pronounced negative dummy for the 13 observations with a publicly known purpose other than a marriage or puberty function is puzzling on first sight because it runs against 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 13 observations in more detail. As mentioned above, only in one case was the pot used for the purchase of a field, which is the most common use in the private information category. The bulk of winners in the public information case, instead, needed money to repair their house (6) or settle debt (3). 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 those cases also reflect the co-operative behaviour, which Rosca participants show in the case of publicly known marriages.[40]

2.6 Concluding Remarks

In this essay, the symmetric, independent private value bidder framework for the analysis of auctions has been applied to develop a stochastic model which reflects the basic features of bidding Roscas in a typical agricultural village of south India. Using the Bayes-Nash equilibrium of the theoretical model as a benchmark, the addition of a parameter which reflects the extent of

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[40] 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 appears to be similar to the more frequently mentioned purposes under private information such as buying a field plot or livestock.

overbidding, a notorious phenomenon in Rosca auctions, makes the theoretical model flexible enough to fit the data from 141 Rosca auctions satisfactorily. The stochastic nature of the theoretical model allows an econometric specification without introducing an ad hoc error term. In the case of Rosca auctions, structural estimation seems inevitable because, at least when data from informal Roscas are used, typically not any two observations are identically distributed, flawing any attempt to conduct reduced form inference.

We have found that aggregate factors like seasonality in agriculture and harvest failures are reflected by Rosca-auction outcomes and that bidding in Roscas with a big contribution is substantially different from bidding in Roscas with a small contribution. We have shown that, theoretically, if a Rosca group can adopt less aggressive bidding, social gains can be realised. In this connection, we have found evidence that groups of experienced organisers bid less aggressively than groups of newcomer-organisers. Moreover, groups which have operated more than one Rosca before bid less aggressively than Rosca groups with no or only a short history.

We find evidence that, when a bidder has a pecuniary emergency like the marriage of a daughter or the need to repair his house and this information is revealed before the auction, auction outcomes are more favourable for the winner, which indicates a certain degree of co-operation based on reciprocity among Rosca participants when information is public.

This essay is the first attempt to open up the formerly black box of Rosca auctions with econometric methods. Many questions, however, remain for future research, e.g.: What are the determinants of auction outcomes of Roscas in other settings, e.g. of urban Roscas? When investment opportunities are correlated between Rosca participants, can a common value approach also be successfully applied to Rosca data? Are less restrictive probability distributions or even semi-parametric methods, which yield models that cannot be calculated explicitly, practically feasible for the analysis of Rosca auctions?

2.7 Appendix to Chapter 2

Table 9. The organiser sample

hh	Rosca number	*m*	*n*	caste	org	*z*	*zl*	date	*t*	purp	publ	b^w
53	1	5000	10	0.9	0	2500	2500	197	1	11	1	27500
53	1	5000	10	0.9	0	2500	2500	198	3	1	0	34300
53	1	5000	10	0.9	0	2500	2500	298	4	10	1	21600
53	1	5000	10	0.9	0	2500	2500	199	5	7	0	18000
53	1	5000	10	0.9	0	2500	2500	299	6	7	0	11000
53	1	5000	10	0.9	0	2500	2500	100	7	10	1	13000
53	1	5000	10	0.9	0	2500	2500	200	8	5	0	12500
53	2	2000	10	0.9	0	1000	1000	296	1	21	1	10350
53	2	2000	10	0.9	0	1000	1000	297	3	3	1	8000
53	2	2000	10	0.9	0	1000	1000	198	4	21	1	7100
53	2	2000	10	0.9	0	1000	1000	298	5	11	1	10500
53	2	2000	10	0.9	0	1000	1000	199	6	11	0	5150
53	2	2000	10	0.9	0	1000	1000	299	7	11	1	3200
53	2	2000	10	0.9	0	1000	1000	100	8	11	1	6000
53	2	2000	10	0.9	0	1000	1000	200	9	7	1	3000
63	1	3000	11	0.318	0	1320	1320	199	1	0	0	21680
63	1	3000	11	0.318	0	1320	1320	100	3	1	0	18180
63	1	3000	11	0.318	0	1320	1320	200	4	1	0	17180
63	2	2000	11	0.636	0	880	880	299	1	3	1	10220
63	2	2000	11	0.636	0	880	880	200	3	3	1	6820
64	1	3000	10	0.3	1	0	1001	297	1	3	1	19000
64	1	3000	10	0.3	1	0	1001	298	3	0	0	11350
64	1	3000	10	0.3	1	0	1001	199	4	0	0	10550
64	1	3000	10	0.3	1	0	1001	299	5	1	0	8000
64	1	3000	10	0.3	1	0	1001	100	6	0	0	8650
64	1	3000	10	0.3	1	0	1001	200	7	1	0	7000
123	1	5000	10	0.85	1	0	0	297	1	1	0	24100
123	1	5000	10	0.85	1	0	0	298	3	7	0	27400
123	1	5000	10	0.85	1	0	0	199	4	3	0	20300
123	1	5000	10	0.85	1	0	0	299	5	1	0	16500
123	1	5000	10	0.85	1	0	0	100	6	10	0	20100
123	1	5000	10	0.85	1	0	0	200	7	3	0	19000
123	2	1000	17	0.8235	1	0	500	292	1	0	0	11750
123	2	1000	17	0.8235	1	0	500	293	3	0	0	10500
123	2	1000	17	0.8235	1	0	500	194	4	14	0	11050
123	2	1000	17	0.8235	1	0	500	294	5	11	0	10200
123	2	1000	17	0.8235	1	0	500	195	6	15	0	9200
123	2	1000	17	0.8235	1	0	500	295	7	10	0	9650
123	2	1000	17	0.8235	1	0	500	196	8	1	0	8800
123	2	1000	17	0.8235	1	0	500	296	9	3	0	8000
123	2	1000	17	0.8235	1	0	500	197	10	1	0	8550
123	2	1000	17	0.8235	1	0	500	297	11	4	0	6800
123	2	1000	17	0.8235	1	0	500	198	12	1	0	6750
123	2	1000	17	0.8235	1	0	500	298	13	1	0	6000
123	2	1000	17	0.8235	1	0	500	199	14	3	0	3500
123	2	1000	17	0.8235	1	0	500	299	15	10	0	3000
123	2	1000	17	0.8235	1	0	500	100	16	1	0	2500
146	1	2000	10	0.6	1	0	1000	198	1	1	0	9000
146	1	2000	10	0.6	1	0	1000	199	3	7	0	6000
146	1	2000	10	0.6	1	0	1000	299	4	2	0	5300
146	1	2000	10	0.6	1	0	1000	100	5	1	0	5700
146	1	2000	10	0.6	1	0	1000	200	6	1	0	4500
146	2	2000	10	0.8	1	0	1000	198	1	0	0	12000
146	2	2000	10	0.8	1	0	1000	199	3	0	0	8100
146	2	2000	10	0.8	1	0	1000	299	4	0	1	6800
146	2	2000	10	0.8	1	0	1000	100	5	0	0	5050
146	2	2000	10	0.8	1	0	1000	200	6	0	0	4500
146	3	2000	10	1	1	0	1000	197	1	1	0	10100

146	3	2000	10	1	1	0	1000	198	3	5	0	6450
146	3	2000	10	1	1	0	1000	298	4	10	1	6800
146	3	2000	10	1	1	0	1000	199	5	3	0	6210
146	3	2000	10	1	1	0	1000	299	6	10	1	4800
146	3	2000	10	1	1	0	1000	100	7	4	0	4200
146	3	2000	10	1	1	0	1000	200	8	30	0	4000
146	4	3000	10	1	1	0	1500	298	1	1	0	14000
146	4	3000	10	1	1	0	1500	299	3	16	0	12000
146	4	3000	10	1	1	0	1500	100	4	10	1	8000
146	4	3000	10	1	1	0	1500	200	5	1	0	6000
156	1	1000	10	0.9	1	0	500	297	1	1	0	6250
156	1	1000	10	0.9	1	0	500	298	3	2	0	5350
156	1	1000	10	0.9	1	0	500	199	4	1	0	5975
156	1	1000	10	0.9	1	0	500	299	5	16	0	4100
156	1	1000	10	0.9	1	0	500	100	6	12	0	3750
156	1	1000	10	0.9	1	0	500	200	7	2	0	2600
156	2	700	10	0.9	1	0	350	298	1	21	0	3250
156	2	700	10	0.9	1	0	350	299	3	9	0	2900
156	2	700	10	0.9	1	0	350	100	4	1	0	2400
156	2	700	10	0.9	1	0	350	200	5	16	0	3400
157	1	5000	11	0.727	0	2500	2500	100	1	1	0	30000
157	2	5000	13	0.846	0	2500	2500	195	1	1	0	40500
157	2	5000	13	0.846	0	2500	2500	196	3	10	1	37500
157	2	5000	13	0.846	0	2500	2500	296	4	13	1	30500
157	2	5000	13	0.846	0	2500	2500	197	5	10	0	30500
157	2	5000	13	0.846	0	2500	2500	297	6	1	0	32500
157	2	5000	13	0.846	0	2500	2500	198	7	10	1	24600
157	2	5000	13	0.846	0	2500	2500	298	8	1	0	26500
157	2	5000	13	0.846	0	2500	2500	199	9	10	1	24500
157	2	5000	13	0.846	0	2500	2500	299	10	11	1	24500
157	2	5000	13	0.846	0	2500	2500	100	11	6	1	10000
157	2	5000	13	0.846	0	2500	2500	200	12	11	1	8000
157	4	3000	14	0.857	0	1800	1800	196	1	32	0	27200
157	4	3000	14	0.857	0	1800	1800	197	3	3	0	26200
157	4	3000	14	0.857	0	1800	1800	297	4	1	0	25200
157	4	3000	14	0.857	0	1800	1800	198	5	3	0	25200
157	4	3000	14	0.857	0	1800	1800	298	6	1	0	19900
157	4	3000	14	0.857	0	1800	1800	199	7	3	0	20200
157	4	3000	14	0.857	0	1800	1800	299	8	10	1	17600
157	4	3000	14	0.857	0	1800	1800	100	9	5	0	16200
157	4	3000	14	0.857	0	1800	1800	200	10	1	0	12200
157	5	5000	13	0.769	0	3000	3000	100	1	10	0	49000
182	2	1000	15	1	0	750	750	193	1	10	1	8000
182	2	1000	15	1	0	750	750	194	3	1	0	8800
182	2	1000	15	1	0	750	750	294	4	22	0	8350
182	2	1000	15	1	0	750	750	195	5	4	0	7750
182	2	1000	15	1	0	750	750	295	6	9	0	7250
182	2	1000	15	1	0	750	750	196	7	3	0	6550
182	2	1000	15	1	0	750	750	296	8	0	0	4250
182	2	1000	15	1	0	750	750	197	9	8	0	6000
182	2	1000	15	1	0	750	750	297	10	10	1	5500
182	2	1000	15	1	0	750	750	198	11	11	1	4600
182	2	1000	15	1	0	750	750	298	12	3	0	3700
182	2	1000	15	1	0	750	750	199	13	3	1	2500
182	2	1000	15	1	0	750	750	299	14	1	0	2000
195	2	1000	10	1	0	400	400	296	1	0	0	5600
195	2	1000	10	1	0	400	400	297	3	0	0	4600
195	2	1000	10	1	0	400	400	198	4	0	0	4100
195	2	1000	10	1	0	400	400	298	5	0	0	3100
195	2	1000	10	1	0	400	400	199	6	0	0	2600
195	2	1000	10	1	0	400	400	299	7	0	0	2600
195	2	1000	10	1	0	400	400	100	8	0	0	2400
195	2	1000	10	1	0	400	400	200	9	0	0	2100
199	1	2000	10	0.9	0	500	500	299	1	10	1	8500
199	1	2000	10	0.9	0	500	500	200	3	1	0	7500
199	2	1000	10	0.9	0	500	500	196	1	4	0	4000
199	2	1000	10	0.9	0	500	500	197	3	9	0	4500
199	2	1000	10	0.9	0	500	500	297	4	1	0	4850
199	2	1000	10	0.9	0	500	500	198	5	5	0	5575
199	2	1000	10	0.9	0	500	500	298	6	21	0	4700

199	2	1000	10	0.9	0	500	500	199	7	9	0	4550
199	2	1000	10	0.9	0	500	500	299	8	11	1	1550
199	2	1000	10	0.9	0	500	500	100	9	31	1	2000
199	3	5000	10	0.9	0	2500	2500	195	1	2	0	28000
199	3	5000	10	0.9	0	2500	2500	196	3	11	1	24100
199	3	5000	10	0.9	0	2500	2500	296	4	0	0	17100
199	3	5000	10	0.9	0	2500	2500	197	5	1	0	32000
199	3	5000	10	0.9	0	2500	2500	297	6	3	0	25000
199	3	5000	10	0.9	0	2500	2500	198	7	21	1	7900
199	3	5000	10	0.9	0	2500	2500	298	8	10	1	9500
199	3	5000	10	0.9	0	2500	2500	199	9	1	0	5500
500	2	2000	12	1	0	960	960	295	1	3	1	11540
500	2	2000	12	1	0	960	960	296	3	3	0	9040
500	2	2000	12	1	0	960	960	197	4	33	0	10040
500	2	2000	12	1	0	960	960	297	5	1	0	8540
500	2	2000	12	1	0	960	960	198	6	10	1	7740
500	2	2000	12	1	0	960	960	298	7	1	1	7040
500	2	2000	12	1	0	960	960	199	8	7	0	6040
500	2	2000	12	1	0	960	960	299	9	30	1	5040
500	2	2000	12	1	0	960	960	100	10	1	0	3540
500	2	2000	12	1	0	960	960	200	11	1	1	2740

<u>Legend</u>

hh: household number of the organiser

Rosca number: consecutive number for the Roscas of each organiser household

m: contribution to the Rosca

n: number of participants in the Rosca

caste: fraction of caste Hindus in the Rosca

org: commission regime (0: fixed commission, 1: variable commission)

z: fixed commission in each round except the last

zl: fixed commission in the last round

date [YXX]: time when the auction took place, Y = 1 winter harvest, Y=2 autumn harvest, XX: Year

t: round in which the auction took place

purp: purpose of the winner (see Table 10)

publ: public (=1) or private (=0) information on the winner's purpose before the auction

b^w: winning bid

Table 10. Purpose codes in Table 9

purp	Purpose
0	**unknown**
1	**buy field or oti***
2	**start moneylender business**
3	**buy or repair house**
4	**buy bullocks or bullock cart**
5	**buy milk animal**
6	**buy motor bike**
7	**start or improve a non-agricultural business, bribe for getting a job**
8	**start banana planting**
9	**agricultural inputs**
10	**daughter's marriage**
11	**other relative's marriage (sister, son, participant himself)**
12	**buy jewels, other jewels had become old**
13	**puberty function**
14	**consumption because of income shortage**
15	**medical treatment**
16	**agricultural inputs to compensate crop failure**
20	**release pawn**
21	**repay debt**
22	**release mortgaged field**
30	**buy jewels**
31	**domestic purposes**
32	**children's education**
33	**household utensils for daughter**

* Oti is a contract where a landowner leases a field plot without receiving a lease payment or a share of the yield. Instead he once receives a lump amount of money from the tenant, which he has to return to the tenant at the end of the contract. Rosca funds are used by tenants to lease in a field on oti.

3 SUMMARY AND CONCLUSION

This dissertation makes both a theoretical and an empirical contribution to the literature on bidding Roscas. What both essays have in common is that they assume a private information environment and build on what we have defined as stochastic models of bidding Roscas, by which is meant that, during the course of a Rosca, participants are affected by random variables which are not yet realised when they join a Rosca. In the first essay, these random variables represent income shocks, and a bidding Rosca generates gains from intertemporal trade by facilitating risk sharing among risk averse individuals. In the second essay, these random variables represent the returns on investment opportunities, and a bidding Rosca enables participants to obtain funds when they observe a particularly profitable investment project. Evidence from the field study underlying the second essay, moreover, suggests that the private information assumption is a good benchmark for the modelling of Rosca auctions - even in a largely closed agricultural village, where information can be expected to flow more freely than in other settings where Roscas are found.

Of the four existing theoretical papers which consider bidding Roscas, only one (Kuo, 1993) employs a stochastic model, while the other three (Besley et al., 1993, 1994; Kovsted and Lyk-Jensen, 1999) use deterministic models to analyse various aspects of random and bidding Roscas. Motivated by evidence in the informal literature on bidding Roscas, which points overwhelmingly to the stochastic form, both chapters of this dissertation aim at redressing this imbalance between the analysis of deterministic and stochastic Rosca models. At this point, we will spare the reader the tedium of a full-scale repetition of the concluding sections of the individual essays, but the following results should be highlighted. In the first essay we have shown that, under plausible assumptions on individual preferences, participation in a single bidding Rosca offers risk sharing among risk averse individuals when they are confronted with independently-distributed, privately-observed income streams. The auctions in the course of a bidding Rosca bring about a net transfer from the better to the worse off bidder each time a pot is auctioned and thereby overcome information asymmetries.

So far, there has not been any econometric analysis of Rosca auctions. This is surprising given the growing number of econometric papers which are concerned with the determinants of participation in Roscas. Perhaps one reason is that Rosca auctions cannot be tackled with basic econometric tools because, typically, all auctions are different from one-another. The existing econometric papers on Roscas, however, do not go beyond the level of using Heckman-type selection models. In this connection, the stochastic approach to bidding Roscas has also served us well in the empirical essay because it allows us to create a structure, which is needed to make the outcomes of heterogeneous auctions comparable. No existing deterministic Rosca model could have accommodated our diverse data without introducing an ad hoc error term. I hope that the third chapter will stimulate more econometric research on Rosca auctions because, as has been shown, such a quantitative analysis reveals many aspects which a qualitatively oriented researcher cannot discover. For example, we have found that observed winning bids in Rosca auctions respond to the experience of the Rosca organiser as well as to the number of Roscas the group in question has run before. Further, any empirical study greatly benefits from the possibility of comparing quantitative with narrative evidence, as the comparison of auction outcomes with private and public information in the second chapter shows.

To conclude, I think that further theoretical research on Roscas has to pay more attention to what has been empirically observed. For example, all four existing theoretical papers on Rosca auctions deal with auction protocols which are not reported in any of the empirical literature. For that reason, the notion of overbidding, which is cited by much empirical research on Rosca auctions, has not been an issue in any of these papers. Actual Roscas have characteristics and properties which still await a thorough theoretical analysis. To give an example, the role played by a Rosca organiser and how he can optimise his Rosca business is still an open issue. Another topic which deserves theoretical attention is the empirically relevant allotment mechanism where the organiser decides which active participant receives the pot. In this case, there is scope for bribing the organiser, which, in turn, could be modelled as an auction.

In this dissertation, we have not analysed Roscas in the context of other financial arrangements which play an important role in many settings where Roscas are frequently observed, like interlinked transactions and loans from moneylenders and pawn brokers. While Besley et al. (1994) have addressed this issue within a deterministic scenario, more research is needed to compare the efficiency of different empirically relevant arrangements in contexts where stochastic Rosca models are appropriate. Another open issue is a household's portfolio decision on how to allocate its financial resources to Roscas and other financial institutions.

On the empirical side, the determinants of Rosca participation have, in my opinion, been investigated quite thoroughly. Existing research, however, treats the course of a Rosca as a black box. Instead, more work is needed on what goes on inside a Rosca. In this connection, other Rosca-auction models than the one presented in the second chapter could be applied to Rosca-auction data. Also, the matter of Rosca-group formation has not yet received the attention it deserves, neither theoretically nor empirically.

At present, the community of Rosca researchers among economists is small but well-connected. I hope that this dissertation will stimulate more research on this institution, which can serve as a fruitful and intriguing field for theorists and econometricians alike.

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