Does Credit Rationing Reduce Defaults?
Evidence from South Indian ROSCAs

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Abstract: In 1993, a government law exogenously imposed an interest rate ceiling on funds allocated in South Indian bidding ROSCAs. We use this natural experiment to test between two prominent models of credit markets with opposite implications for the effect of credit rationing on defaults. In response to such a policy, the model of Stiglitz and Weiss (American Economic Review 71(3): 393-410) implies a decrease in defaults by attracting relatively more safe borrowers, while De Meza and Webb (Quarterly Journal of Economics 102(2): 281-92) predict an increase in defaults because a lower interest rate attracts relatively more risky borrowers. We compare default rates before and after the interest rate ceiling is imposed in Rosca groups of various durations and values. We find statistically significant evidence in favor of the hypothesis of Stiglitz and Weiss that return and riskiness of borrowers are positively correlated. Empirically, the extent of this correlation depends on the income of the borrower and the size of the project into which the funds are invested.

1 Introduction

Many economists believe that credit markets are plagued by information asymmetries. But since the precise nature of the information asymmetry matters so crucially, there is little consensus on how credit markets operate or how best to intervene. In

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the models of Stiglitz and Weiss (4), henceforth SW, and De Meza and Webb (1), henceforth DW, entrepreneurs privately observe their expected return as well as their riskiness. The crucial difference between these two models, however, is that expected return and riskiness are positively correlated in the former and negatively in the latter. As a result, these models have starkly contrasting implications. First, there is underinvestment in SW in the equilibrium of the credit market: socially productive but risky entrepreneurs do not receive funding. On the other hand, there is overinvestment in DW: risky low return entrepreneurs who would be denied loans in a full information economy do receive funding. Second, SW demonstrate the possibility of credit rationing in equilibrium: to attract safe borrowers, lenders charge a lower than market clearing interest rate and use a lottery to determine who receives a loan. In the DW model, in contrast, there is no possibility of equilibrium credit rationing. Third, subsidizing credit to lower interest rates is desirable in a SW world while taxing credit to raise interest rates is desirable in DW.

In this paper we attempt to empirically sort between these two models of credit market failure. We use data from bidding ROSCAs (Rotating Savings and Credit Associations) in South India. This institution matches borrowers and lenders with interest rates being determined by competitive bidding for loans. In 1993, a government imposed ceiling on bids effectively rationed credit to those borrowers who are willing to incur a high interest rate in return for receiving funds from the Rosca earlier than their fellow Rosca members. This exogenously imposed credit rationing should reduce default rates in the SW model but should increase default rates in the DW model. We test this prediction by comparing default rates of early and late recipients of funds over a Rosca cycle before and after the ceiling was imposed.

We find that the observed change in the pattern of defaults is largely consistent with SW’s hypothesis, though not always in a significant way. Moreover, according to our findings, the relationship between expected return and riskiness systematically
depends on characteristics of the Rosca group which are correlated with the income of Rosca members. Our results imply that SW’s assumption holds in particular for individuals with middle to high incomes while, for Roscas that are popular among individuals with comparatively low incomes, we find no sizeable change in the pattern of defaults, which implies that riskiness and return are not related in a significant way for such borrowers.

While we do not directly test any of the three implications of the models of SW and DW stated above, our results do indirectly call into question the DW view of credit markets. Overlending should not be a major concern in these South Indian credit markets, and taxing credit is not a sensible policy intervention. We are also unable to distinguish the SW adverse selection model from asymmetric information models of credit markets (such as the SW moral hazard model), which would also predict that default rates will fall as a result of exogenous credit rationing.

The rest of this paper is organized as follows. Section 2 first illustrates the different implications for defaults of the SW and DW models of the credit market. Subsection 2.2 develops a model of bidding Roscas which incorporates the elements of the credit market models of SW and DW and derives equilibrium allocations before and after the policy shock. In 2.3 a set of testable implications is derived. In Section 3, the institutional setting in which the Roscas of our sample operate as well as the nature of the policy shock are discussed in detail and descriptive statistics are provided. Section 4 presents the results of some tests based on the implications of Subsection 2.3. The final section summarizes and discusses the findings.
2 Theory

2.1 The Credit Market Models of Stiglitz-Weiss and DeMeza-Webb

In this section we use a simple model to illustrate the contrasting implications of SW and DW for default rates in a credit market. Though safer borrowers cross-subsidize risky borrowers in both models, the crucial difference is that in SW the marginal project financed is the safest of those financed, while in DW the marginal project financed is the riskiest of those financed. Consequently lowering interest rates as well as rationing credit reduces defaults in SW but increases defaults in DW.

There are a large number of risk neutral agents indexed by $\theta_i$, the probability of failure of their project $i$, or riskiness for short. Each agent needs $1$ to invest. Projects yield output $r_i$ when successful and $0$ when unsuccessful. Agents have an outside option of $w$ if they choose not to invest (e.g. wage income). Banks cannot observe agent types and simply offer a standard loan contract of $1$ with repayment $Q$, which includes principal and interest.

**Stiglitz-Weiss Credit Rationing Reduces Defaults**

In Stiglitz and Weiss’ model the key assumption is that the expected return of projects is non-decreasing in agents’ riskiness. Here we consider a simple example, where all projects have an identical expected return of $\mu$, i.e., for all $i$, $(1 - \theta_i)r_i = \mu$. If all agents have sufficiently productive projects ($\mu > w$), an agent will only apply for a loan if

$$(1 - \theta_i)(r_i - Q) \geq w$$

or equivalently if $\theta \geq \theta^*$, where

$$\theta^* = 1 - \frac{\mu - w}{Q}.$$
In words, for given $Q$, only sufficiently risky types will apply for a loan. This threshold probability is, moreover, increasing in $Q$. As interest rates, and thus $Q$, fall, the threshold $\theta^*$ decreases, and so safer borrowers are attracted in. Consequently the average probability of success of loan applicants increases.

**DeMeza-Webb Credit Rationing Increases Defaults**

In DeMeza and Webb’s model the key assumption is that borrowers’ payoff distributions can be ranked according to first-order stochastic dominance. To give a simple example, suppose all projects have the same output when successful; so for all $i$, let $r_i$ be constant and equal to $\tau$, say. Projects now differ in their expected returns, with riskier projects (higher $\theta$) having lower expected returns than safer projects. Then an agent will only apply if

\[(1 - \theta_i)(\tau - Q) \geq w\]

or equivalently if $\theta \leq \theta'$, where

\[\theta' = 1 - \frac{w}{\tau - Q}.\]

Here, for given $Q$, only sufficiently safe types will apply and this threshold probability is decreasing in $Q$. As interest rates fall, the threshold $\theta'$ rises, and so riskier agents are attracted in. Consequently the average probability of success of loan applicants falls.

### 2.2 A Model of Defaults in Roscas

#### 2.2.1 Equilibrium with Unrestricted Bidding

Consider a bidding Rosca administered by a chit fund company with $n$ rounds and $n$ participants, each of which agrees to contribute $\$1$ in each round, where one round corresponds to one time period. Thus, in each round, the collected contributions, also
called the 'pot', amount to \( n \). According to the fundamental principle of a Rosca, each participant receives exactly one pot over the life of the Rosca. In the bidding Roscas we study the recipient of each, except the last, pot is determined by an oral ascending bid auction, where the winner receives the pot minus \((n - 1)/n\) times her last bid and all other Rosca participants receive one \( n \)'th of that bid.

It is assumed that each participant is initially endowed with a riskless income stream of $1 per period and has access to an investment project that costs \( n \). Once undertaken, the project yields an income stream of \( r > 1 \) per Dollar invested per period with probability \((1 - \theta)\) and an income stream of zero Dollars per period with the complementary probability of \( \theta \). Thus, in this model, a Rosca participant can be viewed as a wage earner who has the opportunity to become an entrepreneur at a cost of \( n \). Being an entrepreneur, however, is risky and, once the investment is undertaken, there is no way back into wage employment, no matter whether the project succeeds or fails.

We now model the bidding Rosca in more detail. To simplify the exposition, we consider such a Rosca in continuous time, where time is denoted by \( t \). The Rosca starts at \( t = 0 \) and ends at \( t = n \). At each \( t \in [0, n] \), all Rosca participants who have a positive income pay their contributions and the recipient of the pot is determined through an auction among those participants who have not received a pot previously. The auction determines a price, \( b(t) \) say, and the rules of the game are that the company pays the winner of the auction an amount equal to the pot minus the price and one \( n \)'th of the price to all those participants who have paid their contribution at \( t \). The recipient of the pot at time \( t \) cannot receive another pot of that Rosca and is thus not a bidder in any of the auctions after \( t \). We will refer to a Rosca member as "active" at time \( t \) if she has not received a pot up to that date. Toward the end of the Rosca, i.e. as \( t \) approaches \( n \), only one participant is active, i.e. eligible to receive the last pot. Therefore, at \( t = n \), there is no auction and the price, \( b(n) \), equals
zero. It is assumed that participants do not save outside the Rosca and that each participant has access to (presumably costly) external funds to finance the difference between the amount received from the Rosca upon winning an auction, \( n - b \), and the cost of the project, \( n \). Each Dollar borrowed from this source causes an instantaneous disutility of \( c > 1 \).

At any time \( t \), all participants who have not received a pot before \( t \) pay their contribution since, by assumption, they have a riskless income stream. A participant stops to pay her contribution when she has received a pot, undertaken the project and the project has failed. This will be referred to as a default and, therefore, \( \theta \) will also be called the default probability.

All participants are assumed to have additively separable, risk-neutral intertemporal preferences and a common discount rate \( \gamma \). The success of the project, the probability of success, and the profitability in case of success of the recipient of the pot at time \( t \in [0, n] \) are denoted by \( Y_t \), \( \theta_t \) and \( R_t \), respectively. The convention is that \( Y_t \) equal to zero (one) marks a success (failure) and that the probability thereof is \( 1 - \theta_t \) (\( \theta_t \)). All \( Y_t \) are distributed independently over the participants. Further, \( \theta \) is distributed over the participants according to the continuously differentiable cumulative distribution function \( H(\theta) \) and the continuously differentiable function \( \phi(\theta) \) assigns an \( r \) to each value of \( \theta \).

When information on \( H(\theta) \) and \( \phi(\theta) \) is public, an equilibrium in such a Rosca constitutes of a price path \( b(t), 0 \leq t \leq n \), such that for each \( t \) one, and only one, participant finds it optimal to obtain the pot.\(^1\) Consider a participant of riskiness \( \theta' \) and profitability \( r' = \phi(\theta') \) who receives the pot at time \( t' \). Before obtaining the pot,

\(^1\)In effect, we model each recipient of a pot as a price taker, where this price is equal to her valuation of that pot. If information in an open ascending auction is public and losing bidders receive a share of the price obtaining in the auction, this is also the only non-cooperative bidding equilibrium.
that is for \(0 \leq t \leq t'\), her consumption is equal to \(b(t)/n\) and afterwards, that is for \(t > t'\), to \((1-Y_t)(r-(1-b(t)/n))\) when \(t \leq n\) and \((1-Y_t)r\) when \(t > n\). We can write the equilibrium expected utility of that participant at the beginning of the Rosca as

\[
E[\Pi(t'|r',\theta')] = \int_{0}^{t'} \frac{b(\tau)}{n} e^{-\gamma \tau} d\tau - c b(t') e^{-\gamma t'} + (1 - \theta') \left( \int_{t'}^{n} \left( r' n - \left( 1 - \frac{b(\tau)}{n} \right) \right) e^{-\gamma \tau} d\tau + \int_{n}^{\infty} r' n e^{-\gamma \tau} d\tau \right). \tag{1}
\]

More generally, if we index each winner of a pot and the values of \(\theta\) and \(r\) corresponding to her by the value of \(t\) at which she receives the pot in equilibrium, a necessary condition for an equilibrium is

\[
t = \arg\max_{t} E[\Pi(\rho|t,\theta(t))] \text{ for all } t \in [0,n], \tag{2}
\]

where \(r(t) = \phi(\theta(t))\). Equation (2) implies that

\[
\frac{\partial E[\Pi(\rho|t,\theta(t))] }{\partial \rho} \bigg|_{\rho=t} = 0 \text{ for all } t \in [0,n], \tag{3}
\]

which yields the following differential equation:

\[
b'(t) = \gamma b(t) - \frac{1}{c} \left[ \theta(t) \left( 1 - \frac{b(t)}{n} \right) + (1 - \theta(t)) r(t)n - 1 \right], \tag{4}
\]

which, together with the terminal condition

\[
b(n) = 0 \tag{5}
\]

defines the equilibrium bid path \(b^*(t)\). Let \(E[\Pi^*(\rho|t,\theta(t))]\) denote \(E[\Pi(\rho|t,\theta(t))]\) as defined in (1) with \(b^*(\cdot)\) substituted for \(b(\cdot)\). To determine in which order Rosca participants receive pots in equilibrium, we turn to a sufficient condition for an equilibrium, namely pseudoconcavity of \(E[\Pi^*(\rho|t,\theta(t))]\) in \(\rho\). Algebraically this requires that, for all \(t \in [0,n],\)

\[
\frac{\partial E[\Pi(\rho|t,\theta(t))] }{\partial \rho} > (\leq) 0 \text{ for all } \rho < (>) t,
\]
which can be rearranged to the inequality

\[ \mu(\rho) > (\theta(t) - \theta(\rho)) \left(1 - \frac{b(\rho)}{n}\right) \text{ for all } \rho < (>)t, \quad (6) \]

where \( \mu(\tau) = (1 - \theta(\tau)) r(\tau)n \) is the expected per period profit of the investment project of the recipient at time \( \tau \). Since \( \mu \) is of order \( n \) and \( b(t) \) is smaller than \( n \) for any \( n \), the term \((\theta(t) - \theta(\rho))(1 - b(\rho)/n)\) in (6) becomes negligible as \( n \) grows large. In that case (6) implies that \( \mu'(t) < 0 \) for all \( t \). We thus have

Proposition 1: For every pair \((H(\theta), \phi(\theta))\), there exists an \( \bar{n} \) such that for all \( n > \bar{n} \) the equilibrium of a bidding Rosca implies that pots are allocated to participants in decreasing order of the expected period profit of their investment projects, that is \( \mu'(t) < 0 \) for all \( t \in [0, n] \).

We now turn to the question how the riskiness of participants’ projects is related to the order of receipt. It turns out that this is intimately related to the assumptions made by SW and DW, respectively. In the former it is assumed that borrowers’ expected returns are increasing in their riskiness while the latter assumes that return distributions can be ranked according to first-order stochastic dominance, which implies that expected returns are decreasing in borrowers’ riskiness. In our model, the relationship between riskiness and order of receipt turns out to be determined by the relationship between \( \mu \) and \( \theta \), and thus by the shape of \( \phi(\cdot) \) since \( \mu = (1 - \theta) \phi(\theta)n \). Somewhat loosely speaking, whenever \( \phi \) is sufficiently increasing in \( \theta \) globally, the SW condition holds and risky borrowers receive early pots.

Proposition 2: For \( n > \bar{n} \), pots are allocated to participants in decreasing (increasing) order of their default probabilities if

\[ \frac{\partial \phi(\theta)}{\partial \theta} > (\theta - \theta) \frac{\phi(\theta)}{1 - \theta} \text{ for all } \theta. \]
Proof: Rewrite the sufficient equilibrium condition (6) as

\[ \frac{\partial \mu(t)}{\partial t} = \frac{\partial \mu(t)}{\partial \theta} \frac{\partial \theta(t)}{\partial t} < 0. \] (7)

If participants are to receive pots in decreasing order of their default probability, we have that \( \frac{\partial \mu(t)}{\partial \theta} < 0 \) for all \( t \). This together with (7) implies that \( \frac{\partial \mu(t)}{\partial \theta} = (1 - \theta) \phi'(\theta) - \phi(\theta) > 0 \) for all \( \theta \).

Notice that, in this model, we also have the SW case when all participants have the same \( \mu \) because for riskier types the expected 'benefit' from defaulting, as represented by the term \((\theta(t) - \theta(\rho))(1 - b(\rho)/n)\) in (6), is bigger. Denoting by \( \psi(\theta) \) the average expected return \((1 - \theta) \phi(\theta)n\), we will thus speak of a SW case when \( \frac{\partial \psi(\theta)}{\partial \theta} \geq 0 \) for all \( \theta \) in the population, and of a DW case when \( \frac{\partial \psi(\theta)}{\partial \theta} < 0 \).

### 2.2.2 Equilibrium with Restricted Bidding

The 1983 Chit Fund Act ruled that, in each auction of a Rosca, the price attained may not exceed thirty per cent of the pot’s value. In this section we analyze how this affects the allocations within a Rosca. In response to this regulation, Shriram modified the rules of each auction such that bidding ends when thirty per cent of the pot’s value are reached. Then all bidders of the auction have the opportunity to participate in a lottery with equal odds. The company pays the winner of that lottery the value of the pot minus \((n - 1)/n\) times thirty per cent of that value, and one \( n' \)th of thirty per cent of the pot’s value to each of the other participants.

To study this regulation in the context of a Rosca as modeled in the previous subsection, denote by \( \overline{b} \) the maximum price allowed in each auction of that Rosca.\(^2\) We will also refer to \( \overline{b} \) also as 'ceiling' and, according to the fact that there was no ceiling before the 1983 Chit Fund Act came into place, to a Rosca with unrestricted bidding.

\(^2\)According to the Chit Fund Act, \( \overline{b} \) is equal to 0.3n.
as 'pre ceiling' and to a Rosca with restricted bidding as 'post ceiling'. Naively, one could conjecture that the equilibrium bid path in the presence of a ceiling is given by the unrestricted bid path \( b^*(t) \) if \( n \geq t > b^{*-1}(\bar{b}) \) and by \( \bar{b} \) if \( 0 \leq t \leq b^{*-1}(\bar{b}) \).

Defining \( \tilde{t} = b^{*-1}(\bar{b}) \), this would be true if, with the ceiling, the pool of bidders at time \( \tilde{t} \) is the same as the pool of bidders at \( \tilde{t} \) without the ceiling. This is in general not true, however. To see why, consider first the extreme case of \( \bar{b} = 0 \). With our assumptions about participants, it is immediately clear that, in each round, all eligible participants participate in the lottery. Thus, in effect, such a zero ceiling transforms a bidding into a random Rosca, where, in each round, there is a lottery among all Rosca participants who have not received a pot previously. When this ceiling of zero is marginally lifted and all Rosca participants have a sufficiently high expected return from their investment projects, it is straightforward that again all of them participate in the first lottery. With a chance of \( (n - \tilde{t})/n \), a member who pre-ceiling receives a pot after \( \tilde{t} \) wins this lottery, which implies that, at \( \tilde{t} \), the pool of remaining bidders is not identical pre and post-ceiling. Instead, according to this line of reasoning, post ceiling the pool of bidders at time \( \tilde{t} \) dominates the one pre ceiling in terms of \( \mu \). As will be shown shortly and is illustrated in Figure 1, the equilibrium is in fact such that the post ceiling price path, \( \tilde{b}(t) \) say, continues to coincide with \( b \) for some time after \( \tilde{t} \). After that, \( \tilde{b}(t) \) is strictly decreasing and steeper than the pre-ceiling path \( b^*(t) \).

To fully derive the post-ceiling equilibrium, we first define the cumulative distribution function of expected returns in the population as \( F(\cdot) \), whose support is denoted by \( [\underline{\mu}, \overline{\mu}] \). Notice that when the sharpened SW condition \( \psi'(\theta) > 0 \) holds for all \( \theta \), we have that \( F(\mu) = H(\psi^{-1}(\mu)) \), while with the DW condition, \( \psi'(\theta) < 0 \) for all \( \theta \), \( F(\mu) = 1 - H(\psi^{-1}(\mu)) \). We further denote the joint probability of not having received a pot before time \( t \) and having an expected profit of less than \( \mu \) by \( G(\mu, t) \) pre ceiling and by \( \tilde{G}(\mu, t) \) post ceiling. \( G \) and \( \tilde{G} \) have the following three properties.
First, \( G(\mu, 0) = \tilde{G}(\mu, 0) = F(\mu) \). Second, denoting by \( \overline{\mu}(t) \) and \( \tilde{\mu}(t) \) the highest expected return in the population at time \( t \) pre and post ceiling, respectively,

\[
G(\overline{\mu}(t), t) = \tilde{G}\left(\tilde{\mu}(t), t\right) = 1 - t/n \tag{8}
\]

because, during each time span of length \( \varepsilon \), a fraction \( \varepsilon/n \) of the participants receives a pot, so that, for the highest possible expected return at any time \( t \), \( G \) and \( \tilde{G} \) are just equal to the probability of not having received a pot before time \( t \). Third,

\[
G(\mu, t + \tau) = G(\mu, t) \text{ for all } \mu < \overline{\mu}(t + \tau). \tag{9}
\]

This is because, if members receive pots in decreasing order of their expected returns, the joint probability of not having received a pot and having an expected return of less than \( \mu \) does not depend on \( t \) as long as \( t < \overline{\mu}^{-1}(\mu) \). Figure 2 gives an example of the dynamics of \( G \).

Denote the time when \( \tilde{b}(t) \) starts to drop below \( \overline{\mu} \) by \( \tilde{t} \) and by \( \tilde{G}^{-1}(1 - t/n; t') \), where \( t > t' \), the inverse of \( \tilde{G} \) with respect to its first argument while holding its second argument constant. Post ceiling, the pool of members who have not received a pot before \( \tilde{t} \) is characterized by \( \tilde{G}(\cdot, \tilde{t}) \). When, post ceiling, the active member with the highest realization of \( \mu \) receives the pot at any time \( t > \tilde{t} \), then, by (8) and (9), the expected return of the recipient at any time \( t > \tilde{t} \) is equal to \( \overline{\mu}(t) = \tilde{G}^{-1}(1 - t/n; \tilde{t}) \).

Substituting this into (4), we can characterize \( \tilde{b}(t) \) for all \( t > \tilde{t} \) by

\[
\tilde{b}'(t) = \gamma \tilde{b}(t) - \frac{1}{c} \left[ \psi^{-1} \left( \tilde{G}^{-1} \left( 1 - t/n; \tilde{t} \right) \right) \left( 1 - \frac{\tilde{b}(t)}{n} \right) + \tilde{G}^{-1} \left( 1 - t/n; \tilde{t} \right) - 1 \right]
\]

and the terminal condition

\[
\tilde{b}(n) = 0.
\]

By the argument outlined in the previous section for unrestricted bidding, \( \tilde{b}(t) \) is the only equilibrium for \( t > \tilde{t} \) conditional on the distribution of expected returns at time
\[ t \]. Notice also that, for each \( t < \tilde{t} \), types with the highest initial expected return always belong to the pool of active participants because, if \( F \) is continuous, these types compete with lower \( \mu \)'s in all lotteries occuring before \( \tilde{t} \). Defining \( \tilde{\mu} \equiv \tilde{\mu}(0) \), this implies that \( \tilde{\mu}(t) = \tilde{\mu} \) for \( 0 \leq t \leq \tilde{t} \) and \( \tilde{\mu}'(t) < 0 \) for \( \tilde{t} < t \leq n \).

We can now turn to the dynamics of \( \tilde{G} \). To this end, it needs to be determined which active members join the lottery at any time \( t < \tilde{t} \). To do so, it is useful to define an indifference curve in the \( b-t \) space for each type \( \mu \) conditional on \( \tilde{b}(t) \) for \( t > \tilde{t} \), where, for a member with expected revenue \( \mu < \tilde{\mu} \), indifference shall hold for all \( t \in [0, \tilde{\mu}^{-1}(\mu)] \). To illustrate, suppose a member with expected revenue \( \mu < \tilde{\mu} \) has either not participated or not won in any of the lotteries occuring before time \( \tilde{t} \). In this case, she will receive the pot at time \( \tilde{\mu}^{-1}(\mu) \). The indifference curve we want to derive here assigns a hypothetical price, \( \tilde{b}(t, \mu) \) say, to every \( t < \tilde{\mu}^{-1}(\mu) \) such that her expected utility is independent of the time at which she receives the pot.

Analogous to equation (3), which defines \( b^*(t) \), \( \tilde{b}(t, \mu) \) is obtained by making the derivative of

\[
E[\Pi(t|\phi(\psi^{-1}(\mu)), \psi^{-1}(\mu))] = \int_0^t \frac{b(\tau)}{n} e^{-\gamma \tau} d\tau - cb(t)e^{-\gamma t} + (1 - \psi^{-1}(\mu))\left(\int_t^n \frac{\phi(\psi^{-1}(\mu))n - \left(1 - \frac{b(\tau)}{n}\right)}{n} e^{-\gamma \tau} d\tau + \int_n^\infty \phi(\psi^{-1}(\mu))ne^{-\gamma \tau} d\tau\right)
\]

with respect to \( t \) vanish. This gives

\[
\tilde{b}''(t, \mu) = \gamma \tilde{b}'(t, \mu) - \frac{1}{c} \left[ \psi^{-1}(\mu) \left(1 - \frac{\tilde{b}(t, \mu)}{n}\right) + \mu - 1 \right] \text{ for } 0 \leq t < \tilde{\mu}^{-1}(\mu)
\]  

(10a)

Further, such indifference requires that ex ante expected utility when \( \tilde{b}(t, \mu) \) is in place is equal to the ex ante expected utility in equilibrium conditional on not having obtained the pot before time \( \tilde{t} \). This defines the terminal condition

\[
\tilde{b} \left(\tilde{\mu}^{-1}(\mu), \mu\right) = \tilde{b} \left(\tilde{\mu}^{-1}(\mu)\right).
\]  

(11)
Clearly, at any time \( t < \tilde{\mu}^{-1}(\mu) \), a member with expected revenue \( \mu \) would prefer to receive the pot at a price smaller than \( \tilde{b}(t, \mu) \) over receiving it at time \( \tilde{\mu}^{-1}(\mu) \) at a price of \( \tilde{b}\left(\tilde{\mu}^{-1}(\mu)\right) \). As a consequence thereof and the fact that \( \tilde{b}(t, \mu) \) is decreasing in \( t \), this member will participate in all lotteries taking place before the point in time that marks the intersection of \( \tilde{b}(t, \mu) \) and \( \tilde{b} \). Figure 4 illustrates these issues.

From (10a) and (11) it is straightforward to establish that \( \tilde{b}(t, \mu) \) is strictly increasing in \( \mu \). We thus have that participants "exit" consecutive lotteries in increasing order of \( \mu \). For \( 0 \leq t < \bar{t} \), we conversely define \( \tilde{\mu}(t) \) as the expected profitability of the participant who exits at time \( t \). With this in hand, we can identify the law of motion governing \( \tilde{G} \). For \( \mu \leq \tilde{\mu}(t) \), \( \tilde{G} \) remains unchanged because all active members with \( \mu \leq \tilde{\mu}(t) \) have exited by time \( t \) and all changes in \( \tilde{G} \) are driven by those active participants for whom \( \mu > \tilde{\mu}(t) \). All these types participate in the lottery at time \( t \). Consequently, the chance of leaving the pool of active participants is independent of \( \mu \) within this group. Algebraically, this translates into the condition that, as time proceeds, the logarithm of \( \tilde{g}(\mu, t) \equiv \frac{\partial \tilde{G}(\mu, t)}{\partial \mu} \) changes by the same number for all \( \mu > \tilde{\mu}(t) \). Together with the conditions

\[
\frac{\partial \tilde{G}(\tilde{\mu}(t), t)}{\partial t} = 0
\]

and

\[
\frac{\partial \tilde{G}(\bar{\mu}, t)}{\partial t} = -\frac{1}{n},
\]

where the latter immediately follows from (8) and the identity \( \bar{\mu}(t) = \bar{\mu} \) for \( 0 \leq t < \bar{t} \), this gives

\[
\frac{\partial \tilde{G}(\mu, t)}{\partial t} = -\frac{1}{n} \frac{\tilde{G}(\mu, t) - \tilde{G}(\tilde{\mu}(t), t)}{1 - \frac{t}{n} - \tilde{G}(\tilde{\mu}(t), t)} ,
\]

where, as stated in (8), the term \( 1 - t/n \) in the denominator of the second fraction on the right hand side is just \( \tilde{G}(\bar{\mu}, t) \).

Putting all this together, we can now formally characterize the pool of active participants in equilibrium as a function of \( t \), both with unrestricted and restricted
bidding.

Lemma 1: In a Rosca with unrestricted bidding, the joint probability of having an expected return of less than $\mu$ and being active at time $t$ is

$$G(\mu, t) = \begin{cases} 
F(\mu), & \mu < F^{-1}(1 - t/n) \\
1 - t/n, & \mu \geq F^{-1}(1 - t/n) 
\end{cases}.$$  \hfill (12)  

Proposition 3: In a Rosca with a ceiling on bids of $\bar{b}$, the joint probability of having an expected return of less than $\mu$ and being active at time $t$ is governed by the following law of motion:

(i) If $0 \leq t \leq \tilde{t}$, where $\tilde{t} = \{ t : \tilde{\mu}(t) = \bar{b} \}$, $\tilde{\mu}(t) = \max \left( \mu, \{ \mu : \tilde{b}(t) = \bar{b} \} \right)$ and $\tilde{b}(t)$ satisfies

$$\tilde{b}(s) = \begin{cases} 
\gamma \tilde{b}(s) - \frac{1}{\bar{c}} \left[ \theta(\mu) \left( 1 - \tilde{b}(s)/n \right) + \mu - 1 \right], & t \leq s \leq n(1 - \tilde{G}(\mu, t)) \\
\gamma \tilde{b}(s) - \frac{1}{\bar{c}} \left[ \psi^{-1}(\tilde{G}^{-1}(1 - s/n, t)) \left( 1 - \tilde{b}(s)/n \right) + \tilde{G}^{-1}(1 - s/n, t) - 1 \right], & n(1 - \tilde{G}(\mu, t)) \leq s \leq n \n(1 - \tilde{G}(\mu, t))
\end{cases}$$

and $\tilde{b}(n) = 0$, then

$$\frac{\partial \tilde{G}(\mu, t)}{\partial t} = \begin{cases} 
0, & \mu \leq \tilde{\mu}(t) \\
-\frac{1}{n} \frac{\tilde{G}(\mu, t) - \tilde{G}(\tilde{\mu}(t), t)}{1 - \tilde{G}(\tilde{\mu}(t), t)}, & \mu > \tilde{\mu}(t)
\end{cases},$$  \hfill (13)  

(ii) If $\tilde{t} < t \leq n$, then

$$\tilde{G}(\mu, t) = \begin{cases} 
\tilde{G}(\mu, \tilde{t}), & \mu < \tilde{G}^{-1}(1 - t/n, \tilde{t}) \\
1 - t/n, & \mu \geq \tilde{G}^{-1}(1 - t/n, \tilde{t})
\end{cases}.$$  \hfill (14)
A comparison of (12) and (14) confirms that, once competitive bidding determines the price post ceiling, which is the case for $\tilde{t} < t \leq n$, $\tilde{G}$ obeys the same law of motion as $G$ does pre ceiling. An example of the dynamics of $\tilde{G}$ is given in Figure 3.

While $G$ and $\tilde{G}$ characterize the distribution of active participants at a given time pre and post ceiling, respectively, we are ultimately interested in each recipient’s riskiness, which is linked to her profitability through the function $\psi(\cdot)$, where $\mu = \psi(\theta)$. For unrestricted bidding, Proposition 1 has established that consecutive pots are allocated to members in decreasing order of their profitability and that, as a consequence, the sign of $\psi$’s slope determines whether consecutive pots are allocated to members in decreasing or increasing order of their riskiness. To address this issue when bidding is restricted, we, again, first need to determine the profitability (or more precisely the probability distribution thereof) of a recipient at a given time $t$. Since each lottery has equal odds for all participants in it, the distribution of profitability of a recipient at time $t < \tilde{t}$ is the same as the distribution of profitability of the participants in the lottery at that time. As shown above, all members with profitability greater than the threshold $\hat{\mu}(t)$ participate in the lottery and thus the cumulative distribution function of a winner’s profitability at time $t < \tilde{t}$ is

$$
\tilde{W}(\mu, t) = \begin{cases} 
0, & \mu < \hat{\mu}(t) \\
\frac{\tilde{G}(\mu, t) - \tilde{G}(\hat{\mu}(t), t)}{1 - \frac{1}{n}}, & \mu \geq \hat{\mu}(t) 
\end{cases}
$$

while, pre ceiling, the corresponding cdf, $W$ say, has all mass concentrated on the point $\mu(t) = F^{-1}(1 - t/n)$. For $t \geq \tilde{t}$, however, $\tilde{W}$ also collapses to a distribution where all mass is concentrated on $\tilde{\mu}(t) = \tilde{G}^{-1}(1 - t/n, \tilde{t}) > \bar{\mu}(t)$. Denoting by $\succ$ "first-order stochastically dominates", we then obtain

Proposition 4: If the ceiling is binding, that is if $\hat{\mu}(0) < \bar{\mu}$,

(i) $W(\mu, 0) \succ \tilde{W}(\mu, 0)$;
(ii) $\tilde{W}(\mu, t) \succ W(\mu, t)$ for all $t \geq \tilde{t}$.
It further follows from the continuity of both distribution functions in $t$ that $W$ and $\tilde{W}$ intersect for some $t \in (0, \tilde{t})$. We are now ready to turn to the cdf’s of recipients’ riskiness, $V(\theta, t)$ and $\tilde{V}(\theta, t)$ say.

Proposition 5: If $\tilde{\mu}(0) < \mu$ and $\psi'(\theta) > (\prec) 0$ for all $\theta$,

(i) $V(\theta, 0) \prec (\prec) \tilde{V}(\theta, 0)$;
(ii) $\tilde{V}(\theta, t) \succ (\succ) V(\theta, t)$ for all $t \geq \tilde{t}$.

Loosely speaking, this proposition says that, when the Stiglitz-Weiss assumption $\psi''(\theta) > 0$ holds, defaults are more frequent in early rounds of a Rosca pre ceiling than post ceiling, and more frequent post ceiling than pre ceiling in late rounds.

### 2.3 Testable Implications

In this section we derive some implications of the theory developed above for both the cross section pre ceiling and the change in the structure of defaults from pre to post ceiling.

#### 2.3.1 Cross Section with Unrestricted Bidding

For a Rosca with unrestricted bidding, Proposition 2 has established that, if the SW (DW) assumption holds, defaults become less (more) likely as the Rosca proceeds. To test between these two competing hypotheses in a Roscas with $n$ (discrete) rounds, partition recipients of pots into early and late recipients, where early refers to recipients before some round $s$, where $1 < s < n$. We define

$$Y_{s}^{early} = \frac{1}{s} \sum_{t=1}^{s} Y_t$$
$$Y_{s}^{late} = \frac{1}{n-s} \sum_{t=s}^{n} Y_t, \quad 1 \leq s \leq n.$$  \hspace{1cm} (15)

Recall that $Y_t$ equal to one denotes a failure of the project, and thus a default, of the member receiving the pot in round $t$. We define the test statistic

$$X_s = \left( \frac{Y_{s}^{early} - Y_{s}^{late}}{Y} \right).$$  \hspace{1cm} (16)
where
\[ \bar{Y} = \frac{1}{n} \sum_{t=1}^{n} Y_t. \]

If there is no relationship between profitability and riskiness, the difference between defaults of early and late recipients of pots, and thus \( X_s \), equals zero independent of the choice of \( s \), while, if the SW (DW) assumption is true, \( X_s \) is bigger (smaller) than zero. Notice that the test statistic \( X_s \) has the advantage of eliminating multiplicative Rosca-specific fixed effects on members’ riskiness.

### 2.3.2 Changes in Response to the Ceiling

Here, we first partition recipients of pots into two groups, early and late, where, both pre and post ceiling, the latter receive pots after time \( \tilde{t} \). It follows from Proposition 5 that, if the SW (DW) assumption \( \psi'(\theta) > (<) 0 \) holds, the difference between the expected riskiness of early and late recipients is bigger (smaller) pre than post-ceiling. The intuition behind that is that, pre ceiling, members receive pots in decreasing order of riskiness if the SW assumption holds. Thus, at time \( \tilde{t} \), the \( \tilde{t} \) most risky of the \( n \) members are not any more active. Post ceiling, in contrast, members with riskiness \( \bar{\theta} \) are still active at time \( \tilde{t} \). As a consequence, the difference between the mean riskiness of early and late recipients is bigger pre than post ceiling.

To eliminate multiplicative Rosca-specific fixed effects on members’ riskiness, we will compare the relative difference \( X_{t}^{\text{pre}} \) of groups that were started pre and post ceiling, \( X_{t}^{\text{pre}} \) and \( X_{t}^{\text{post}} \), respectively. Notice that such a comparison is robust to a general aggregate multiplicative change in members’ riskiness.
3 Data and Institutional Setting

We study bidding ROSCAs (or chit funds) that are run by Shriram Chits and Investments Ltd. in branches throughout the state of Tamil Nadu in the Southeast of India. The company offers a variety of chit denominations. Each denomination is indexed by \((n, m)\), where \(n\) refers both to the number of members and the number of months for which the members will meet and \(m\) is the monthly contribution each member must make. At each monthly meeting all active members can bid for the pot (which has value \(n \cdot m\)) using an English (or oral ascending bid) auction. The winner at round \(t\) receives the pot at a price equal to her last bid in the auction, \(b_t\), and this winning bid is shared between all members, including the winner. The winner at round \(t\) therefore receives a net transfer of \((n - 1)m - \frac{n-1}{n}b_t\), while each of the other members pays a net amount of \(m - b_t/n\).

Once a member has received a pot, it may happen that she stops making contributions. Later winners are insured against such a default by the company. In that event, the company makes contributions on the defaulted member’s behalf so that the total amount of the pot remains at \(n \cdot m\). There is little traditional collateral. In general, the winner of an auction or lottery has to provide two to three guarantors with a monthly net income no smaller than approximately fifteen percent of the pot.

\(\text{3 There are some slight wrinkles. First, the company not only serves as the organizer but is also a special member, who is entitled to receive the pot in the first round at a price of zero. Thus, in the first round, the company receives a net transfer of } (n - 1)m - \frac{n-1}{n}b_t, \text{ while all other members pay } m. \text{ Second, the company charges a five to six per cent commission on each pot, which is included in the price. Thus, denoting the commission rate by } \lambda, \text{ in round } t \text{ the winner of the pot receives a net transfer of } (n - 1)m - b_t + (b_t - \lambda nm)/n, \text{ while the company makes a net payment of } m - \lambda nm - (b_t - \lambda nm)/n, \text{ and each of the other } n - 2 \text{ members makes a net payment of } m - (b_t - \lambda nm)/n. \text{ Furthermore, as a consequence, there is a mandatory minimum price of } \lambda nm \text{ in each round and a lottery among all active participants if no bid of } \lambda nm \text{ or higher is made.} \)
amount to actually receive the pot minus the price from the company. During each round \( t \) where \( t \leq n/2 \), the winner has to provide three, and afterwards two such guarantors. Moreover, like many informal lenders, the chit fund company uses alternative enforcement strategies. It hassles defaulters and threatens to deny future chit fund access.\(^4\)

Unlike in their rural informal counterparts, in the Roscas studied in this paper there is little to no connection between the members of a particular group apart from participating in the auctions. Interested individuals sign up to join a group of a certain denomination and it is the company which assigns each of them to a particular group. A new group commences once enough individuals have signed up for a certain denomination in a branch. As a consequence, group pressure and reputation effects outside the Rosca play no role for the incentive not to default. Due to these reasons as well as the fairly light bureaucratic requirements involved when joining a group and receiving a pot, each member’s characteristics, e.g. her default risk or the round in which she intends to obtain the pot, largely remain her private information - as is assumed in the models of SW and DW.

In September 1993 the Supreme Court enforced the 1983 Chit Fund Act, which stipulates a 30% ceiling on bids in chit fund auctions, i.e. \( b_t \leq 0.3nm \). This ruling can reasonably be interpreted as an unanticipated policy shock (see Eeckhout and Munshi (2)). It effectively introduced credit rationing: when, in a given round, several active members express their willingness to obtain the pot at a price of \( 0.3nm \), only one of them actually receives it. In such a case, a lottery with identical odds for all active members who express their willingness to obtain the pot at that price

\(^4\)When a member stops making contributions before receiving a pot, she is excluded from the group, reimbursed her net contributions minus a stipulated fee, and substituted by a new member, who is willing to join the chit and make an initial lump payment equal to the cumulative net contributions accrued up to the round in which he joins.
determines the recipient. This constraint on bidding, moreover, acts like an interest rate ceiling. According to Eeckhout and Munshi (2), interest rates fell from 14–24% pre-ceiling to 9–17% post ceiling. The third and fifth column of Table 1 give the number of groups of each denomination in our sample pre and post ceiling. The sample comprises those seven denominations that were most popular around the time the ceiling was introduced.

Figure 5 shows the percentage of winning bids at least as high as the ceiling stipulated by the 1983 Chit Fund Act pre and post ceiling for the seven most popular denominations. The pre and post-ceiling figures are for groups that started around April 1993 and October 1993, respectively. Clearly, this type of credit rationing affects denominations of longer duration more than shorter duration chit funds. To illustrate, consider Panel A, which refers to denomination (50; 1000). It is not before the 34th round that competitive bidding instead of a lottery determines the recipient in more than ninety per cent of the cases. Panel E, in contrast, refers to a denomination of shorter duration (20; 500), where the ceiling binds in less than ten per cent of the auctions from round six onward. Thus, measured this way, the ceiling is effective in 66 per cent of the auctions in the former, but only in 25 per cent in the latter denomination.

Another issue that needs to be addressed is the presence of institutional investors. As documented in Table 1, about every fifth membership in the chit funds in our sample is held by one of several finance companies. These companies entertain a close business relationship with the organising company and never default. The fourth and sixth column of Table 1 give the percentage of memberships held by finance companies for each denomination in our sample. Since, in this paper, we are interested in the properties of a loan portfolio of non-institutional borrowers, all pots allocated to an

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5 The extent of participation of finance companies pre versus post ceiling is the subject of Eeckhout and Munshi (2).
institutional investor are excluded from the analysis when defaults are concerned.

We now turn to the measurement of default. In the theoretical model of the previous section, a member either completely defaults or not at all. In the data, however, the former occurs only rarely and instead partial defaults are frequently reported, which means that a fraction smaller than one of the total obligation owed is repaid. To approximate the variable $\theta$ in the theoretical model, we calculate a default rate as follows. Consider a particular chit fund of denomination $(n, m)$ and index participants by the round $t$ in which they obtain the pot. Participant $t$ then owes $(n - t)$ net contributions, where each of these contributions equals $m - b_\tau/n$, $\tau = t + 1, \ldots, n$. The company records till which date each participant paid her contributions. Denote that date for participant $t$ by $\hat{t}(t)$. We define that participant’s default rate as

$$
\hat{y}(t) = \frac{n - \hat{t}(t)}{n - t},
$$

which is just the share of net contributions not repaid in total net contributions owed after receiving the pot. To illustrate, Figure 6 depicts the cumulative distribution functions of default rates for denomination $(40, 250)$. The left (right) diagram depicts data from pre (post) ceiling groups, where the two curves refer to default rates of recipients of the second and 21st pot, respectively. According to the location of the curves, defaults of early recipients are more frequent for all default rates (when compared according to first-order stochastic dominance) pre as well as post ceiling. With the introduction of the ceiling defaults appear to have increased for early as well as for later recipients. Moreover, when measured by the area between the curves, defaults of early and later recipients are less similarly distributed pre than post ceiling.
4 Empirical Results

In this section we test the implications derived in Section 2.3 with data from groups of the seven most frequently administered denominations. With a cross section of pre-ceiling groups, Subsection 4.1 attempts to test whether members with a higher willingness to pay for a pot are also riskier borrowers. This exercise, however, potentially suffers from a measurement problem because the relationship between a borrower’s riskiness and an observed default is not immediately clear in the context of borrowers in a Rosca when defaults can be partial. This is because each pot allocated over a Rosca cycle is associated with a particular repayment scheme, which is manifested by the number of instalments through which each recipient of a pot repays her debt. Thus, each recipient over a Rosca cycle receives a loan on different terms. The question then is how to infer members’ riskiness from observed defaults. The concept that we will use is the default rate as defined in (17). It is not clear, however, whether this is a consistent measure of a borrower’s riskiness. Consistency requires that, for a Rosca member with a given riskiness, the measure’s distribution (or at least some statistic of centrality thereof) be independent of the round in which that member receives the pot. This problem is overcome in Subsection 4.2, where we measure how the change of the default rate over a Rosca cycle changes through the introduction of the ceiling.

Another issue that needs to be addressed is \( t \), the round at which the last lottery takes place in a post-ceiling chit fund. As Figure 5 illustrates, that round is far from being the same for all groups within a given denomination. Moreover, the percentage of groups in which a lottery occurs in a given round is not even monotonically decreasing for some denominations (see Panels A, B and E, and denomination (25,1000) of Panel D). To approximate \( \tilde{t} \), we define \( t' \) as the earliest round in which less than 20% of the auctions in the sample groups are ended by a lottery. The empirical
values of $t'$ are set out in the third column of Table 2. Taking different cutoff levels essentially does not change any of the results that will be discussed shortly.

4.1 Cross Section pre Ceiling

In this subsection, we use the test statistic $X_{t'}$ (see equation 16) to empirically determine the relationship between Rosca members’ profitabilities and default rates with data from a cross section of Roscas with unrestricted bidding. The choice of $t'$ as the cut-off is somewhat arbitrary but it facilitates a straightforward comparison with the results of the next subsection, where the impact of the introduction of the ceiling is dealt with. Each recipient’s riskiness is measured by $\hat{\gamma}$ (see equation 17).

The results are set out in Table 2. Column 4 gives the value of the test statistic for a sample of Roscas that started within six months before the ceiling came into place, while column 9 is based on a larger sample with all groups that started within one year before the ceiling was enforced. Qualitatively, both approaches give the same result, namely that default rates of early recipients are bigger than those of late recipients throughout all denominations in the sample, but only significantly at the 5% level in long groups of 30 and more rounds. If the default rate as measured by $\hat{\gamma}$ indeed reflects a member’s riskiness, this can be taken as evidence for the SW hypothesis where individuals with more profitable projects are at the same time the riskier borrowers.

4.2 Changes in Defaults in Response to the Ceiling

Recall once more that, according to the SW (DW) assumption, the difference between early and late recipients’ riskiness decreases (increases) in response to the introduction of the ceiling. To determine whether the said difference has decreased or increased empirically, we first compute $X_{t'}^{pre}$ and $X_{t'}^{post}$ for each group in the sample, $X_{ti}^{k}$, where
$k = \text{pre, post}; i$ denotes the denomination to which the group belongs, and $j$ indexes the groups within a given denomination, where $j = 1, \ldots, J^k_i$. For each denomination we then compare the distribution of the vectors $X_{i_1}^{\text{pre}} = (X_{i_1}^{\text{pre}, 1}, \ldots, X_{i_1}^{\text{pre}, p_{\text{pre}}})$ and $X_{i_1}^{\text{post}} = (X_{i_1}^{\text{post}, 1}, \ldots, X_{i_1}^{\text{post}, p_{\text{post}}})$ by means of a two sample Wilcoxon rank sum test (see Lehmann (3)). We define the sign of the resulting, asymptotically normally distributed test statistic $Z_i$ to be positive (negative) if the rank sum of $X_{i_1}^{\text{pre}}$ is bigger than its expected value, which, loosely speaking, implies that the location of $X_{i_1}^{\text{pre}}$ is further to the right on the real line than that of $X_{i_1}^{\text{post}}$, which in turn is evidence for the SW hypothesis.

The results are set out in the sixth and seventh, and eleventh and twelfth column of Table 2. $U$ in columns 6 and 11 is one hundred times the difference between the expected value of the rank sum of $X_{i_1}^{\text{pre}}$ and the rank sum of $X_{i_1}^{\text{pre}}$, divided by the expected value of the rank sum of $X_{i_1}^{\text{pre}}$. This statistic has the same sign as $Z$ but is replication invariant, i.e. doubling the sample size by replicating each observation in the sample once leaves $U$ unchanged. In contrast, the pivotal test statistic $Z$ in columns 7 and 12 is, of course, not replication invariant. While $Z$ facilitates statements in terms of statistical significance, $U$ allows comparisons of the magnitude of the effect across denominations independent of the sample sizes.

Turning to the results, $U$ and $Z$ are positive for six of the seven denominations, both with a six and a twelve month cutoff around the policy shock. While among the groups that started between six months before and after 09/01/1993, respectively, the (25,400) denomination is the one with a negative sign, it is the (40,250) denomination when the cutoffs are 12 months before and after that date. When comparisons across denominations are concerned, it is worth noting that $U$ and $Z$ give the same ranking in terms of support of the SW hypothesis, that is, although sample sizes vary considerably between denominations (see Table 1), the highest value of $U$ occurs in the same denomination as does the highest value of $Z$, and the same is true for the second highest value and so on.
While the negative realizations of the test statistic $Z$ are far from being significantly different from zero at conventional levels, the (40,625) and the (30,500) denomination are significantly bigger than zero when the 6 month cutoff rule is used, and, with the 12 month cutoff, three denominations, the two just mentioned as well as the (20,500), are significantly bigger than zero at the five percent level. Thus, with this test, we find statistically significant support for the SW hypothesis that borrowers with more profitable projects are also riskier.

Recall that the SW hypothesis states that the expected profitability of a borrower’s project is increasing in the profitability of the project over the entire range of the risk parameter $\theta$. The tests discussed so far are based on one particular implication of this hypothesis, the characteristics of recipients of pots before and after round $t$. It also follows from Proposition 5, however, that the average riskiness of recipients before $\tilde{t}$ is more decreasing in $t$ pre than post ceiling if the SW hypothesis is true. The intuition here, as before, is that at time $t = 0$ ($t = \tilde{t}$) the pool of recipients is more (less) risky pre than post ceiling and that, for intermediate values of $t$ (i.e. $0 < t < \tilde{t}$), the average riskiness is monotonic in $t$ (decreasing pre and increasing post ceiling). Moreover, the riskiness of early recipients is of particular interest to the lender because, in a Rosca, the earlier a pot is received, the higher the amount its recipient can default on. This is because the recipient in round $t$ can default on up to $n - t$ installments. We therefore now take a closer look at defaults of recipients before round $t'$. Toward this, we define

$$X' = \left(\bar{Y}_{early} - \bar{Y}_{late}\right) / \bar{Y'},$$

where

$$\bar{Y}_{early} = \frac{2}{t'} \sum_{t=1}^{t'/2} Y_t, \quad \bar{Y}_{late} = \frac{2}{t' - t'/2} \sum_{t=t'+t'/2}^{t'} Y_t \quad \text{and} \quad \bar{Y'} = \frac{1}{t'} \sum_{t=1}^{t'} Y_t = \bar{Y}_{early}$$

and compare the distribution of the vectors $X^{pre}$ and $X^{post}$ by denomination.
The results are set out in Table 3. As with the previous test, there is no statistically significant support for the DW hypothesis, independent of the choice of the cutoff date. For the twelve month cutoff rule, the resulting Wilcoxon test statistic $Z'$ is bigger than zero for all denominations, which is in line with the SW hypothesis. As in Table 2, the denominations (40,625) and (30,500) give a value of the test statistic that is significantly larger than zero at the ten per cent level. In contrast to the previous results, the (20,500) denomination fails to support the SW hypothesis in a significant way, while the (50,1000) denomination now gives a significant result for both cutoff rules. This result supports what the pre ceiling part (i.e. the broken line) of Panel A in Figure 7 suggests, namely that riskiness is strongly decreasing in recipients profitability only for the quartile of the most profitable recipients, while for the remainder recipients’ riskiness, as measured by the default rate, appears to be rather independent of the time of receipt.

We finally turn to the relationship between the characteristics of each denomination and the results obtained so far, which concern the relationship between profitability and riskiness of Rosca members. This former relationship is of immediate interest if the characteristics of a denomination tell something about the characteristics of the members who join this denomination. If each individual is endowed with a stable income stream and has access to a project that requires a certain investment, then, in terms of the model of Section 2.2, the former determines the contribution and the latter the pot amount of the denomination chosen. The former relationship has been established empirically by Eeckhout and Munshi (2) who find a positive correlation between the contribution and the income of a Rosca member. Given the income endowment and the project size, the duration can then be interpreted as a leverage, the size of the investment project relative to period income.

Can we make a statement about how borrowers’ characteristics as expressed by the contribution, pot amount and duration of the denomination chosen are related
to the test results derived so far? To illustrate, Figure 8 plots $U$ and $Z$ over the duration, contribution and pot amount of each denomination, respectively. For both duration and pot amount there appears to be no clear cut relationship. For example, the (40,625) denomination significantly supports the SW hypothesis while the sign of the $Z$ statistic for the (40,250) denomination supports DW. Turning to the pot amount, when we look at Rs. 10,000, the (20,500) and (40,250) denominations yield opposite results.

It is only Panel B, which depicts $U$ and $Z$ over the contribution, where we do not obtain such contrasting results for identical values on the abszissa. It, moreover, appears that an inverse U governs the relationship between the contribution and the realization of the test statistics. For small (250 and 400) as well as for large (1000) contributions we observe no ((40,250) and (25,400)) or only weak support ((50,1000) and (25,1000)) for the SW hypothesis, while for intermediate values of $m$ ((30,500), (20,500) and (40,625)) we obtain values of $U$ that are all bigger than 5.8 resulting in realizations of the test statistic $Z$ that are all significantly bigger than zero at the two per cent level. According to findings in Eeckhout and Munshi (2), members in such Roscas in the state capital of Chenai have an average monthly income of about Rs. 3,300, while for the denominations with small and large contributions this figure equals about Rs. 2,900 and 4,000, respectively. To summarize, when measured by the contribution made by a Rosca member, a member’s income endowment appears to be the best predictor for the relationship between profitability and riskiness of Rosca members. While at both ends of the income scale we find none to little evidence for the SW hypothesis, the response to the policy shock suggests a substantial positive correlation between profitability and riskiness for intermediate income levels.

\footnote{Notice that, according to the National Sample Survey of 1992-93, mean per capita monthly expenditure of urban households in Tamil Nadu was Rs. 438.29, which suggests that even members of denominations with small contributions have an income that is well above the urban state average.}
When the same exercise is conducted for only those members who receive a pot before $t'$, we arrive at a slightly different result. While, with the twelve month cutoff, there still is a positive relationship between $m$ and $U''$, the rank correlation between the pot amount and $U''$ is now perfect (see Table 3). Thus, for members with comparatively high rates of return (those obtaining pots pre ceiling before $t'$), the size of the project is the best predictor for the relationship between profitability and riskiness, where bigger projects are associated with a higher correlation between profitability and riskiness.

To finish this section, we discuss the robustness of the previous findings in the light of possible resorting of Rosca members in response to the policy shock. There is the possibility that borrowers will resort across denominations as a result of selective credit rationing and this will affect default rates quite independently of the SW or DW models. Endogenous matching into chits of different durations is studied extensively by Eeckhout and Munshi (2). Since high return borrowers have a higher cost of waiting for a loan than low return borrowers, they predict and empirically find that borrowers with very profitable projects switch to the shorter denominations, where credit rationing is less severe post ceiling. We have found, however, that, both when all members or only those who obtain a pot before $t'$ are considered, duration is the worst predictor for $U$ and $U''$. If the nature of resorting is independent of Rosca members’ income endowment (as Eeckhout and Munshi (2) find), this suggests that endogenous resorting does not qualitatively affect the findings of this paper.

5 Conclusion

This paper has used a policy shock to conduct the first empirical test between two prominent hypotheses concerning credit markets with asymmetric information. The 1983 Chit Fund Act of the Indian government, which was enforced in 1993, effectively
rationed credit obtained from Roscas by stipulating a ceiling on bids, which determine the interest rate paid on Rosca funds. In a model of bidding Roscas where Rosca members differ in the return they earn from investing funds from the Rosca, we have shown theoretically that pots are allocated to members in decreasing order of their return when bidding is unrestricted. In the same model with the ceiling in place, however, members with a lower than the highest return obtain early pots with positive probability. When there is a systematic relationship between a borrower’s return and her probability of default, as is hypothesized in the credit market models of Stiglitz-Weiss and DeMeza-Webb, the policy shock implies a change in the pattern of defaults. We use a sample of more than 4,000 Rosca groups organized by a company throughout the Indian state of Tamil Nadu that commenced before and after the ceiling was enforced.

Comparing defaults of recipients of early and late pots for each Rosca in the sample pre and post ceiling, we find that the change in the pattern of defaults is consistent with the assumption made by Stiglitz and Weiss that a borrower’s return and default risk are positively related. This evidence is statistically significant for three of seven types of groups in the sample, where all of these three are characterized by monthly contributions around the median of the distribution of contributions made in the seven types of Roscas in the sample.

We also compare the change in the pattern of defaults among early recipients, who are willing accept a comparatively high borrowing rate in return for obtaining funds early. As before, we find no significant evidence for DeMeza and Webb’s hypothesis. On the contrary, there is again significant evidence (at the 10% level) for the assumption of Stiglitz and Weiss for three types of groups. In contrast to the results on defaults of early and late recipients, where the contribution is the best predictor for the change in the pattern of defaults, here the amount of the pot is the best predictor for the change in the default pattern.
In their majority, the Roscas in our sample serve the financial needs of individuals with regular incomes that are above average in urban environments of a developing country. When the present findings on the characteristics of borrowers in Roscas are extended to credit markets in such settings in general, it can be expected that, first, even without a policy intervention, there can exist equilibrium credit rationing and second, in the equilibrium of the credit market, there likely is underinvestment from a social perspective, which makes subsidies that lower the interest rate a desirable policy. According to our findings these concerns are particularly prevalent in that segment of the credit market where borrowers with medium incomes are served and less for borrowers with relatively low or high regular incomes.

References


Table 1. Frequency of chit denominations and relative frequency of institutional investors in the sample chit funds

<table>
<thead>
<tr>
<th>n</th>
<th>m</th>
<th>number of groups pre ceiling*</th>
<th>percentage of institutional investors pre ceiling</th>
<th>number of groups post ceiling**</th>
<th>percentage of institutional investors post ceiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1000</td>
<td>76</td>
<td>8.9</td>
<td>58</td>
<td>24.0</td>
</tr>
<tr>
<td>40</td>
<td>250</td>
<td>592</td>
<td>19.9</td>
<td>513</td>
<td>23.5</td>
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<tr>
<td>40</td>
<td>625</td>
<td>122</td>
<td>12.5</td>
<td>77</td>
<td>20.4</td>
</tr>
<tr>
<td>30</td>
<td>500</td>
<td>129</td>
<td>8.9</td>
<td>98</td>
<td>24.0</td>
</tr>
<tr>
<td>25</td>
<td>400</td>
<td>72</td>
<td>17.3</td>
<td>85</td>
<td>17.5</td>
</tr>
<tr>
<td>25</td>
<td>1000</td>
<td>51</td>
<td>12.4</td>
<td>54</td>
<td>15.2</td>
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<td>500</td>
<td>67</td>
<td>18.6</td>
<td>108</td>
<td>18.4</td>
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* groups started within six months before the ceiling was put in place (09/01/1993)
** groups started within six months after the ceiling was put in place
Table 2. Test results, all rounds

<table>
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<th>n</th>
<th>m</th>
<th>t'</th>
<th>X</th>
<th>p value</th>
<th>U</th>
<th>Z</th>
<th>p value</th>
<th>X</th>
<th>p value</th>
<th>U</th>
<th>Z</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1000</td>
<td>33</td>
<td>6.10</td>
<td>0.000</td>
<td>4.70</td>
<td>1.08</td>
<td>0.280</td>
<td>6.91</td>
<td>0.000</td>
<td>0.91</td>
<td>0.31</td>
<td>0.760</td>
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<tr>
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<td>250</td>
<td>23</td>
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<td>0.000</td>
<td>1.67</td>
<td>1.05</td>
<td>0.293</td>
<td>10.47</td>
<td>0.000</td>
<td>-1.42</td>
<td>-0.87</td>
<td>0.387</td>
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<td>40</td>
<td>625</td>
<td>22</td>
<td>5.20</td>
<td>0.000</td>
<td>6.45</td>
<td>1.99</td>
<td>0.047</td>
<td>6.92</td>
<td>0.000</td>
<td>5.81</td>
<td>2.35</td>
<td>0.019</td>
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<tr>
<td>30</td>
<td>500</td>
<td>13</td>
<td>4.73</td>
<td>0.000</td>
<td>8.24</td>
<td>2.74</td>
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<td>7.09</td>
<td>0.000</td>
<td>9.04</td>
<td>4.69</td>
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<td>9</td>
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<td>-0.58</td>
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<td>0.02</td>
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<tr>
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<td>0.67</td>
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<td>1.57</td>
<td>0.120</td>
<td>7.56</td>
<td>2.34</td>
<td>0.019</td>
</tr>
</tbody>
</table>

* for X, groups that started between 03/01/1993 and 09/01/1993; for Z, groups that started between 03/01/1993 and 03/01/1994

** for X, groups that started between 09/01/1992 and 09/01/1993; for Z, groups that started between 09/01/1992 and 09/01/1994

Table 3. Test results, rounds before t' only

<table>
<thead>
<tr>
<th>n</th>
<th>m</th>
<th>U'</th>
<th>Z'</th>
<th>p value</th>
<th>U'</th>
<th>Z'</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
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<td>8.73</td>
<td>2.01</td>
<td>0.044</td>
<td>9.27</td>
<td>3.11</td>
<td>0.002</td>
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<td>40</td>
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<td>-1.26</td>
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<td>0.434</td>
<td>-0.54</td>
<td>-0.52</td>
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</tr>
<tr>
<td>40</td>
<td>625</td>
<td>2.72</td>
<td>1.08</td>
<td>0.280</td>
<td>7.00</td>
<td>2.73</td>
<td>0.006</td>
</tr>
<tr>
<td>30</td>
<td>500</td>
<td>3.36</td>
<td>1.18</td>
<td>0.120</td>
<td>3.12</td>
<td>1.72</td>
<td>0.086</td>
</tr>
<tr>
<td>25</td>
<td>400</td>
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<td>1.59</td>
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<td>3.23</td>
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<td>0.778</td>
<td>1.4</td>
<td>0.59</td>
<td>0.555</td>
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</table>

* see the notes at the bottom of Table 2
Figure 1. Equilibrium price paths pre and post ceiling
Figure 2. The function $G$. An example.
Figure 3. The function $\tilde{G}$. An example where $t_1 < t_2 \leq \tilde{t} < t_3 < t_4$.
Figure 4. "Indifference curves" \( \tilde{b}(t, \mu) \), where \( \mu_1 < \mu_2 \).
Figure 5. Percentage of winning bids greater than or equal to the ceiling by round.

A. Denomination (50,1000)

B. Denomination (40,250) and Denomination (40,625)

C. Denomination (30,500)
D. Denomination (25, 400) and Denomination (25,1000)

E. Denomination (20,500)

Figure 6. Cumulative distribution functions of default rates of recipients of the second (black solid line) and 20th pot (red dotted line line), pre (left) and post ceiling (right), denomination (40,250)
Figure 7. Mean default rate by round, pre and post ceiling.

A. Denomination (50,1000)

B. Denomination (40,250) and Denomination (40,625)

C. Denomination (30,500)
D. Denomination (25, 400) and Denomination (25, 1000)

E. Denomination (20, 500)
Figure 8. Plot of Wilcoxon ratio $U$ and Wilcoxon test statistic $Z$ over group characteristics (cutoff 12 months before and after the policy intervention)

Panel A. Duration

Panel B. Contribution

Panel C. Pot amount