Financial Fragmentation Despite Arbitrage

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`Preliminary`

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Abstract: If there were no impediments to the flow of capital across space, then the returns to capital should be equalized. We provide evidence to the contrary. There are large differences in the return to comparable investments across different towns in the state of Tamil Nadu in South India. We explore why these differences are not arbitraged away – and suggest that if one investor has monopoly power in arbitraging across towns then it is in his profit-maximizing interest to reduce but not eliminate the differences in returns to capital.

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1 Introduction

Many economists believe that financial market inefficiencies are a cause of underdevelopment and poverty (Aghion and Bolton, 1997; Banerjee and Newman, 1993; King and Levine, 1993; Townsend 1997). There is a growing recent empirical literature documenting that capital does not always flow to its highest use. For instance, de Mel, Woodruff and Mckenzie (2009) and Paulson,Townsend and Karaivanov (2006) find that finance does not flow to high return entrepreneurs in Sri Lanka and Thailand respectively. Banerjee and Munshi (2004) suggest that finance does not flow across ethnic lines in India. In the aggregate, the misallocation of capital across firms can explain low total factor productivity in Indian and Chinese manufacturing (Banerjee and Duflo, 2005, Hsieh and Klenow, 2009).

In this paper we provide some striking evidence of financial market inefficiencies across space. We find large and significant differences in the returns to comparable financial investments across local financial markets in the state of Tamil Nadu, India. The mean rate annual rate of return ranges from 5.5 percent to 12.6 percent. If finance flowed to its highest use, such differences would not exist.

The natural question then arises: If there is money to be made because of financial fragmentation, is somebody doing it? We find that despite the presence of an investor who arbitrages across locations these differences in returns are not eliminated. We explore, theoretically, how financial fragmentation may persist if there are barriers to entry into arbitrage. The monopolist arbitrager in our setting makes profits by preserving the spread in returns at the expense of market efficiency. Our findings contribute to the large literature initiated by Shleifer and Vishny (1997) on the limits to arbitrage in financial markets. While much of this literature studies how risk aversion, transaction costs or agency difficulties can impede arbitrage, Borenstein et al (2008) explore a similar market power (cum transaction costs for smaller traders) explanation for price differences despite arbitrage opportunities in California's electricity market.

There is a related literature on differences in US deposit and borrowing rates. In this literature, several possible explanations for inter-regional interest rate differences have been advanced. Gendreau (1999) cites individuals' lack of access to national capital markets, transaction costs, local monopoly power due to legal barriers, differences in statuatory interest rate ceilings and differential borrower risk. Further, according to the same author, differences in bank risk may explain differences in bank deposit rates. The institutional setup we study allows us to exclude several of these factors as an explanation of differences in interest rates across space, namely local monopoly power due to legal barriers, differences in interest rate ceilings and differences in bank risk. Furthermore, the data allows us to evaluate the effect of borrower risk as we have access to spatially disaggregated data on borrower risk. The explanations for the differences in interest rates that we observe then are individual lack of access to national capital markets (or other forms of formal finance in our case) and transactions costs, which limit arbitrage possibilities.

The financial markets we study are organized through bidding Roscas (Rotating Savings and Credit Associations). Roscas are financial institutions in which the accumulated savings are rotated among participants (Anderson and Baland, 2003; Besley, Coate and Loury, 1994). The Roscas we study are anonymous and do not rely on internal social enforcement. Since Rosca interest rates are determined by local auctions – and not set centrally as they would be in a bank with several branches – this dataset provides an ideal opportunity to investigate financial fragmentation. Further, unlike the anecdotal evidence summarized by Banerjee and Duflo (2005) of differences in risk-adjusted borrowing interest rates, we use interest rates on local savings to measure fragmentation. The advantage of doing so is that the savers in the bidding Roscas we study all face the same riskiness regardless of the market in which they save – but adjusting for default risk or other unobservable loan terms with borrowing interest rates is difficult.

The paper proceeds as follows. In Section 2 we provide background on bidding Roscas in South India and on our dataset. In Section 3 we outline some of the testable implications from a simple model. We discuss our preliminary results in Section 4.

2 Institutional Background

This study uses data on Rotating Savings and Credit Associations (commonly referred to as Roscas). Roscas match borrowers and savers but do so quite differently from banks. They are common in many parts of the world (Besley et al, 1993). In this section we provide some background on how the Roscas in our study operate. We also describe the sample of Rosca participants that we will use in our subsequent empirical analysis.

Rules

Roscas are financial institutions in which the accumulated savings are rotated among participants. Participants in a Rosca meet at regular intervals, contribute into a "pot" and rotate the accumulated contributions. So there are always as many Rosca members as meetings. In random Roscas, the pot is allocated by lottery and in bidding Roscas the pot is allocated by an auction at each meeting. Our study uses data on the latter.

More specifically, the bidding Roscas in our sample work as follows. Each month participants contribute a fixed amount to a pot. They then bid to receive the pot in an oral ascending bid auction where previous winners are not eligible to bid. The highest bidder receives the pot of money less the winning bid and the winning bid is distributed among all the members as an interest dividend. The winning bid can be thought of as the price of capital. Consequently, higher winning bids mean higher interest payments. Over time, the winning bid falls as the duration for which the loan is taken diminishes. In the last month, there is no auction as only one Rosca participant is eligible to receive the pot. We illustrate the rules with a numerical example:

Example (Bidding and Payoffs) *Consider a* 3 *person Rosca which meets once a month and each participant contributes* \$10*. The pot thus equals* \$30*. Suppose the winning bid is* \$12 *in the first month. Each participant receives a dividend of* \$4*. The recipient of the first pot effectively has a net gain of* \$12 *(i.e. the pot less the bid plus the dividend less the contribution,* $30 - 12 + 4 - 10$*). Suppose that in the second month,* *when there are 2 eligible bidders, the winning bid is* \$6. *And in the final month, there is only one eligible bidder and so the winning bid is zero. The net gains and contributions are depicted as:*

Month	*1*	*2*	*3*
Winning bid	*12*	*6*	*0*
First Recipient	*12*	*-8*	*-10*
Second Recipient	*-6*	*16*	*-10*
Last Recipient	*-6*	*-8*	*20*

The first recipient is a borrower: he receives \$12 *and repays* \$8 *and* \$10 *in subsequent months, which implies a* 30% *monthly interest rate. The last recipient is a saver: she saves* \$6 *for* 2 *months and* \$8 *for a month and receives* \$20, *which implies a 28% monthly rate. The intermediate recipient is partially a saver and partially a borrower.*

The Sample

The bidding Roscas we study are large scale and organized commercially by a non-bank financial firm. The data we use is from the internal records of an established Rosca organizer in the southern Indian state of Tamil Nadu.[1] Our sample comprises Roscas that started on or after January 1, 2002 and ended by November 2005. These Roscas took place in 78 branches of a non-bank financial firm.

Our sample comprises 2170 Roscas of 34 different durations and contributions. The most common Rosca denomination had 25 participants and a Rs. 400 monthly contribution (with a total pot of Rs. $10,000$). There were also Roscas that met for longer durations (30 or 40 months) and with higher and lower monthly contributions. The average duration of the Rosca in our sample was 29.55 months. These different Rosca denominations serve

[1] Bidding Roscas are a significant source of finance in South India, where they are called chit funds. Deposits in regulated bidding Roscas were 12.5% of bank credit in the state of Tamil Nadu and 25% of bank credit in the state of Kerala in the 1990s, and have been growing rapidly (Eeckhout and Munshi, 2004). There is also a substantial unregulated chit fund sector.

to match borrowers and savers with different investment horizons. Descriptive statistics of the Rosca denominations are in Table 1. Descriptive statistics at the Rosca level are in Table 2.

For each Rosca in our sample, we compute the savings interest rate r as the solution to

$$\sum_{i=1}^{T-1}(-m + div_i)(1+r)^{T-i} + (Tm - c) = 0 \tag{1}$$

where m is the individual monthly contribution, div_t is the dividend in month t paid to each participant, T is the number of rounds/months/participants, and c is commission to the organizer in each round. The commission c is usually fixed at five percent of the value of the pot, i.e. $c = 0.05mT$. According to the rules of these Roscas, $div_1 = div_T = 0$. Moreover, for all $t = 2, ..., T-1$, the dividend is:

$$div_t = \frac{b_t - c}{T},$$

where b_t is the winning bid in the round-t auction. Notice that the minimum winning bid for $t = 2, ..., T-1$ is c. If none of the Rosca participants is willing to bid more than c in a given auction, the round t recipient of the pot is determined through a lottery among the eligible Rosca participants of that round. She receives the pot at a discount of precisely c.

The savers (last-round winners) in these Roscas are insured against winners of earlier pots failing to make contributions by the organizer. Rather than asking for physical collateral, the organizer requires auction winners to provide cosigners before releasing the loans. Cosigners are required to be salaried employees with a minimum monthly income that depends on the Rosca denomination. This is because the organizer has a legally enforceable claim against their future income as collateral for the loan. The organizer may also verify the auction winner's income before releasing the loan. For instance, a self-employed person will be asked for tax returns or bank statements while a salaried employee will be asked for an earning record. Verification is a form of costly screening because it takes time and effort.

The only risk that the saver faces therefore is the risk that the organizer itself may go bankrupt before the Rosca ends. This is indeed a real risk in the Indian context (where numerous chit fund companies have folded), but it is common to all the savers in all the 78 branches in the sample.

The average annual interest rate for a saver in these Rosca is 9.17 percent per year with a standard deviation of 1.18 percent. At each location, interest rates are determined locally through auctions. In contrast, the commercial bank savings rates are determined centrally and are not based on local supply and demand for credit. So there is no variation. We have obtained the rates on 3-6 month fixed deposits from the ICICI Bank, a large and well-networked commercial bank, and those rates were at 6 percent or below for all of the study period (2002-2005) with the exception of a six month period starting April 2002 when the rate was 7.75 percent. The interest rates on commercial bank savings are substantially lower than in the organized Rosca sector. This could reflect a risk premium that the Rosca saver must pay (since the organizer of the Roscas is more likely to go bankrupt than ICICI bank). In addition, there is a uncertainty with the realized interest rate for a Rosca participant (depending on the composition of the Rosca) that is absent in the commercial bank fixed deposits.

Institutional Investors

In what follows we shall pay special attention to institutional investors who behave quite differently from other Rosca participants in the following ways. The institutional investors operate in all 78 branches. They typically take several postions in Roscas in each branch. These insitutional investors have close ties to the organizing company – and are not charged a commission for participation (as a consequence, we will refer to them as "the company" interchangeably in the sequel). Further, institutional investors are not considered default risks and so they do not have to provide cosigners as collateral. Other participants, by contrast, are location-specific, are charged a commission, and need to provide cosigners when they win early pots.

3 A Model of Arbitrage in Roscas

In this section we consider a simple model of arbitrage between Roscas in two locations. Our aim is to clarify how arbitrage can reduce reduce financial inefficiencies but also to point out the incompleteness of such arbitrage when there are barriers to entry.

Consider two spatially separated locations, each with n_1 private agents. Each agent is endowed with a dollar in the first period. Each agent has an investment opportunity with a fixed investment cost of 2 at date 1 and yield $2p$ at date 2. Agents do not discount the future. Agents vary in their productivity p. In each location, agents' types are distributed according to F_i. Denote the corresponding mean by μ_i. Without loss of generality, we assume $\mu_1 > \mu_2$, i.e. agents in location one are on average more productive than in location 2. We assume private information on individual types, i.e. each agent observes only her own type and knows the distribution of types in her location.

In parts of the subsequent analysis, we employ the following additional assumptions:

A1 F_i is symmetric and unimodal

A2 F_2 is a translation of F_1, i.e. $F_2(p) = F_1(p + \mu_1 - \mu_2)$

We model simple Roscas with two participants and hence two rounds. There is at auction only at date 1. Each Rosca participant contributes a dollar at date 1 and the auction is for the repayment amount b that is due at date 2. The winner of the auction receives the pot and invests. There is a fixed commission of c charged for any net transfer in a Rosca. As there are 2 net transfers in a Rosca, one in the first and one in the second period, the total commission is $2c$. We assume that each of the two participants pays a commission of c when the Rosca is over (for simplicity, c is not part of the winning bid).[2] So at date 2,

[2]Remark: The idea why I use a commission of c and not $2c$ for the loan in the first round is that, in a real Rosca with many members, the gross pot is mn and the gross transfer (gross of the bid) from the $n-1$ lenders to the borrower is $(n-1)m$. The total commission in that round is nmc. So the commission per dollar transacted is $nmc/(n-1)m \approx c$. On the other hand, when n is only two, as in the model, and we applied the actual Shriram commission rule, we would have a commission of $2c$ per dollar transacted, which is too much compared to the real Roscas.

the winner pays b to the loser of the first-round auction and c to the organizer. The loser of the first-round auction receives b from the winner and also pays c to the organizer. (In this way, we model how Rosca auctions determine the interest rate but abstract from the specific rules that are used in practice in the Roscas in our sample).

No Arbitrage

We first show that the interest rate difference across locations is given by differences in average productivity, $\mu_1 - \mu_2$, in the absence of arbitrage. More formally, an agent's willingness to pay is found by equalizing her payoff from winning, $2p - b$, to her payoff from losing, b, which gives

$$b^* = p.$$

In a Rosca, two individuals of a location are randomly matched. In each Rosca, each participant is uninformed about the other participant's type, and hence willingness to pay. We are thus in a situation of an symmetric, independent, private-value auction. Since the Roscas we consider have open-ascending bid auctions, the appropriate bidding equilibrium is most easily found by modelling the auction as a second-price sealed bid auction, which is payoff-equivalent. It can be shown that, in such an auction, each bidder determines her bid by a strictly increasing function $h_i(p)$, where $h_i(p) \geq p$ for all p, hence there is some overbidding relative to one's valuation of the pot. The difference in interest rates between branches, or spread for short, is

$$\Delta_r = E[h_1(P_{2:2}) - h_2(P_{2:2})].$$

Under assumption A2, we have that $h_2(p) = h_1(p) - (\mu_1 - \mu_2)$. Denoting $\mu_1 - \mu_2$ by Δ_μ we then have that

$$\Delta_r = \Delta_\mu$$

Monopolistic Arbitrage, No entry

We next consider the case where the Rosca organizer can arbitrage across locations and has monopoly power. We find that interest rate differences persist but they are smaller than inter-locational differences in average productivity, $\mu_1 - \mu_2$. The arbitrager will borrow in the low interest rate location and save in the high interest rate location – while preserving the spread in order to make profits.

The Rosca company has the choice to become a Rosca member herself in each of the two locations at no cost. We assume that the company's agent enters a Rosca with a private agent. We assume that the private agent knows of his co-participant's identity and that the company's agent plays a pure strategy in each location, i.e. she bids b_i in all Roscas in location i where the company becomes a member. When the private agent in location i knows the company-agent's b_i, he will bid b_i minus an increment whenever $p < b_i$ and b_i plus an increment when $p > b_i$. In both of these cases, the auction price will be roughly b_i.

If the company holds one ticket in each of the branches, its expected profit is

$$\Pi = b_1(1 - F_1(b_1)) + b_2(1 - F_2(b_2)) - [b_1 F_1(b_1) + b_2 F_2(b_2)] \tag{2}$$

Notice that $(1 - F_1(b_1))$ is the expected number of period 1 pots that the company loses in location 1, $F_1(b_1)$ is the number of period 1 pots the company wins in location 1, each of which generates a liability of b_1 in the second period. Hence $b_1(1-F_1(b_1))$ is the company's expected income in the second period from the lost auctions in location 1 and $b_1 F_1(b_1)$ the liability from the won auctions in location 1.

To balance the budget in period one (in expectation), the company cannot lose more period 1 pots than it wins,

$$F_1(b_1) + F_2(b_2) \geq (1 - F_1(b_1)) + (1 - F_2(b_2)) \tag{3}$$

The company maximizes its profits by choice of b_1 and b_2 subject to (3).

Lemma 1 A strictly positive profit of the company implies that she chooses bids such that

$$\mu_1 > b_1 > b_2 > \mu_2, \tag{4}$$

which implies that the difference in interest rates is smaller than the difference in average productivity,

$$\Delta_r < \Delta_\mu.$$

Proof: It is convenient to rewrite the company's profit as

$$\Pi = b_1(1 - 2F_1(b_1)) + b_2(1 - 2F_2(b_2)) \tag{5}$$

and the budget-balance constraint as

$$F_1(b_1) + F_2(b_2) \geq 1 \tag{6}$$

We first proof $\mu_1 > b_1$. To this end, suppose $b_1 \geq \mu_1$. This implies. We take each of the following two cases in turn, (i) $b_2 \geq \mu_2$ and (ii) $b_2 > \mu_2$. Under (i) $1 - 2F_1(b_1) \leq 0$ and $1 - 2F_2(b_2) \leq 0$, which implies $\Pi \leq 0$. This contradicts $\Pi > 0$. Under (ii) $1 - 2F_1(b_1) \leq 0$, $1 - 2F_2(b_2) > 0$, $b_2 > b_1$ and (6) implies that $1 - 2F_2(b_2) \leq -(1 - 2F_1(b_1))$. So we can write

$$\Pi \leq b_1 \left[(1 - 2F_1(b_1)) + (1 - 2F_2(b_2))\right] \leq b_1 \left[(1 - 2F_1(b_1)) - (1 - 2F_2(b_2))\right] = 0$$

Second we proof that $b_2 > \mu_2$. To this end, suppose $b_2 \leq \mu_2$. Based on the previous result, it is sufficient to consider $b_1 < \mu_1$. In this case $F_1(b_1) < 1/2$ and $F_2(b_2) \leq 1/2$, which implies that $F_1(b_1) + F_2(b_2) < 1$. This contradicts (6).
Next we proof that $b_1 > b_2$. To this end suppose that $b_1 \leq b_2$ and employ $\mu_1 > b_1$, which implies $F_1(b_1) < 1/2$ and $1 - 2F_1(b_1) > 0$, and $b_2 > \mu_2$, which implies $F_2(b_2) > 1/2$ and $1 - 2F_2(b_2) < 0$. We may now write

$$\Pi \leq b_2 \left[(1 - 2F_1(b_1)) + (1 - 2F_2(b_2))\right] \leq 2b_2 \left[1 - (F_1(b_1) - F_2(b_2))\right] = 0$$

where the last inequality follows from (6). But this contradicts $\Pi > 0$. $\Box$

This lemma shows that (a) interest rates will vary across locations and (b) arbitrager's rank is positively correlated with the interest rate and (c) if the constraint (6) is binding - that the average rank of the arbitrager is 0.5. The positive correlation between the local interest rate and the arbitrager's rank follows from $\mu_1 > b_1$, which implies $F_1(b_1) < 1/2$, and $b_2 > \mu_2$, which implies $F_2(b_2) > 1/2$. In other words, across locations, the arbitrager is less likely to win the first pot, the higher b.

The following example illustrates the result:.

Example with Uniform Distributions We consider uniform specifications of F_1 and F_2 with an identical range of α,

$$F_i(b) = \frac{(b-\mu_i)}{\alpha} + \frac{1}{2},\ \mu_i - \frac{\alpha}{2} \leq b \leq \mu_i + \frac{\alpha}{2}.$$

We will assume that the two distributions overlap sufficiently, specifically

$$\mu_1 - \mu_2 \leq 2\alpha.$$

Notice that, for an efficient allocation of funds in this economy (which in the current setup implies an identical price of credit in the two locations), an amount of $\mu_1 - \alpha/2 - (\mu_2 - \alpha/2) = \mu_1 - \mu_2$ per private customer in location i (or $n_1 [\mu_1 \mu_2]$ in total) would have to be transferred by the arbitrager from location 2 to location 1 in period 1.

Define

$$g_i(b) = b + \frac{F_i(b) - \frac{1}{2}}{f_i(b)}.$$

In general, the solution to the company's problem of maximizing (5) by choice of b_1 and b_2 subject to (6) can be charcterized by the two equations

$$g_1(b_1) = g_2(b_2), \tag{7}$$

$$F_1(b_1) + F_2(b_2) = 1. \tag{8}$$

For the uniform distributions considered here, this gives

$$b_1 = \mu_1 - \frac{\mu_1 - \mu_2}{4},\ b_2 = \mu_2 + \frac{\mu_1 - \mu_2}{4}.$$

The average rank of the company in the strong and weak location are

$$\frac{1}{2} + \frac{\Delta_\mu}{4\alpha} \text{ and } \frac{1}{2} - \frac{\Delta_\mu}{4\alpha},$$

respectively.

Thus, through the activity of the arbitrager, the interest rate difference is half the average productivity difference,

$$\Delta_r = \frac{1}{2}\Delta_\mu.$$

The amount which is transferred from location 2 to 1 in the first period is $\Delta_\mu/2$. This is just half of the amount that would be transferred in an efficient allocation of funds across the two locations.

The company's profit is

$$\Pi_A = \frac{(\mu_1 - \mu_2)^2}{4\alpha}.$$

Monopolistic Arbitrage, Free Entry

If there is free-entry into arbitrage then the interest rate differences disappear. Suppose the organizer bids any pair (b_1, b_2), satisfying $\mu_2 \leq b_2 < b_1 \leq \mu_1$. Then an entrant can become a Rosca member in the two locations, bid b_2 plus an increment in location 2 and b_1 minus an increment in location 1. The entrant will win for sure in location 2 at a price of b_2 and lose for sure at a price of b_1 in location 1. This will yield the entrant a positive profit of $b_1 - b_2$. When enough such entrants are active, the organizer's profits will become negative because now the company wins too many auctions in location 1 and loses too many in 2. The only equilibrium involves $b_1 = b_2$, i.e. $\Delta = 0$, and zero profits for the organizer. (Note that if the two locations had access to a common financial market, i.e. were integrated, then too such interest rate differences would disappear).

Monopolisitic Arbitrage, Costly Entry

We consider the final case where the Rosca organizer can arbitrage costlessly but entrants to arbitrage must pay the cost c of Rosca membership. We find that the differences in interest rates persist but are smaller smaller than the no-entry case when the difference in productivity is sufficiently large relative to the cost of entry ($\mu_1 - \mu_2 > 2c$), and equal to the no-entry case when the producitivity difference is not sufficiently large ($\mu_1 - \mu_2 \leq 2c$). More specifically, the difference in interest rates is capped by $\max(\mu_1 - \mu_2, 2c)$.

Suppose the company bids any pair (b_1, b_2), satisfying $\mu_2 \leq b_2 < b_1 \leq \mu_1$. Then an entrant can become a Rosca member in the two locations, bid b_2 plus an increment in location 2 and b_1 minus an increment in location 1. The entrant will win for sure in location 2 at a price of b_2 and lose for sure at a price of b_1 in location 1. But now he faces a total cost for the two memberships of $2c$. So the entrant will make a profit of $b_1 - b_2 - 2c$. This is positive only when $b_1 - b_2 \geq 2c$. As a consequence, the company cannot sustain a higher spread than $2c$ in equilibrium. When c is sufficiently large - relative to the difference in average productivity -, there will be no entrants and the outcome will be the same as with monopolistic arbitrage and no entry.

We turn to the question of why arbitrage by outsiders (i.e. not the Rosca organizer) may be costly in practice. First, the cost of arbitrage predicted by our model due to the commission charged by the company will in practice equal 10% between the first and last round. For the sample Roscas, this amounts to comparing the interest rate over the entire duration of a Rosca which is on average 30 months. So a necessary condition for an outsider arbitrageur to make non-negative profits will be that the interst rate spread in months between two locations where she participates is at least (roughly) $10/30 = 0.33\%$. There are, however, two additional factors that complicate arbitrage by an entrant. First, whenever the arbitrageur obtains an early pot she has to provide cosigners, which may cause a (non-monetary) additional cost. Second, the arbitrageur faces uncertainty as he has to subscribe to Roscas in certain branches upfront, i.e. when Roscas start. If locations experience productivity shocks while Roscas are going on, however, the interest rate difference between two locations with an initially large spread may shrink and render the arbitrageur's profits negative. To summarize this point, in our institutional setup we would expect only limited scope for outside arbitrageurs unless interest rate differences between locations substantially exceed 0.33% per month for the majority of pairs of branches.

Testable Implications

The Roscas we have considered in the model are simplifications of those observed in practice. In particular, (i) the auction is not about an extra payment in the last round but instead a discount in the same round and (ii) that the latter have more than two rounds. All of the testable implications derived previously from a two period model generalize in a straightforward fashion to the Roscas of our sample.

Further, while our model above predicts that the arbitrager's rank will be precisely

The testable hypotheses implied by our theory so far:

1. Interest rates do not differ across locations
2. (The monthly) interest rate spread across locations is bounded by does not exceed 1/3% across locations
3. Arbitrager's rank across locations uncorrelated with interest rates across locations

The testable hypotheses are summarized in the following table

		Arbitrage	
	free entry	no entry	costly entry
Interest Rate Variation	0	positive	positive, bounded
Correlation between r and rank	n.a.	positive	positive

Variation: Arbitrager has Access to an Outside Capital Market

We have so far only considered arbitrage between locations. It is entirely possible that the arbitrager has access to financial markets that other Rosca participants do not have access to. For instance, the arbitrager may have significantly more collateral than ordinary Rosca participants and my able to borrow from commerical banks – or the Rosca organizer may have outside investment opportunities. We next present a variation in our basic model in which the arbitrager has access to a perfect capital market, i.e. it can borrow/save a dollar and repay/earn $R \geq 1$ dollars one period later. In this scenario, all testable implications continue to hold except for the company's average rank, which may now be greater or smaller than one half (depending on whether R is closer to μ_1 or μ_2).

Suppose now that the company has access to a perfect capital market, i.e. it can borrow/save a dollar and repay/earn $R \geq 1$ dollars one period later. In this situation, the company arbitrages not only between branches, but also between Roscas in general and the capital market.

The company's maximization problem (5) subject to (6) now becomes (the unconstrained problem)

$$\max_{b_1, b_2}(b_1 - R)(1 - 2F_1(b_1)) + (b_2 - R)(1 - 2F_2(b_2)).$$

Notice that the term $b_i - R$ is the period two profit for each pot won in location i. The solution can be characterized by the two equations

$$g_1(b_1) = g_2(b_2) = R. \tag{9}$$

Notice that the first equality is the same as in the situation of pure arbitrage; see (7). It hence follows that for an appropriate value of R, R' say, the two scenarios yield the same values of b_1 and b_2, and hence identical testable implications. However, in general the previously derived implication "company's average rank equals one half" will not continue to hold (whenever $R \neq R'$). Denoting the company's average rank by $rk \in [0, 1]$ (i.e. 0 for winning early and 1 one for winning late pots only), recall that

$$rk = 1 - \frac{F_1(b_1) + F_2(b_2)}{2}.$$

One can derive the comparative static result,

$$\frac{d\ rk}{dR} = -\frac{1}{2}\left(\frac{f_1(b_1)}{g_1'(b_1)} + \frac{f_2(b_2)}{g_2'(b_2)}\right).$$

As $g_i'(b_i)$ will usually be positive (a sufficient condition is A1), this multiplier will usually be negative. This is as expected: the higher the interest rate in the capital market, the more likely is the company to be a net borrower in Roscas.

Example with Uniform Distributions

We consider the same uniform specifications of F_1 and F_2 as in the previous example. The conditions (9) imply that

$$b_i = \frac{R + \mu_i}{2},$$

i.e. the company's bid is simply the average of the capital market interest rate and the average productivity in location i. As a consequence,

$$\Delta_r = \frac{1}{2}\Delta_\mu,$$

i.e. the interest rate spread accross branches is precisely the same as with pure monopolistic arbitrage. So, at least in this example, access to a perfect capital market does not affect sptatial price fragmentation in Roscas.

The average rank of the company is now

$$rk = \frac{1}{2}\left[1 + \left(R - \frac{\mu_1 + \mu_2}{2}\right)\right],$$

i.e. for $R = (\mu_1 + \mu_2)/2$, the rank is precisely one half (as with pure arbitrage), while a larger R implies a higher (=later) average rank of the company.

For the company's profits, we have

$$\Pi_{CM} = \frac{(\mu_1 - R)^2 + (\mu_2 - R)^2}{2\alpha}.$$

It can be shown that $\Pi_{CM} = \Pi_A$ iff $R = (\mu_1+\mu_2)/2$ and $\Pi_{CM} > \Pi_A$ iff $R \neq (\mu_1+\mu_2)/2$ (more precisely, Π_{CM} is convex in R and has its minimum at $R = (\mu_1+\mu_2)/2$). So the company will in generally be better off when it can combine inter-locational arbitrage with arbitraging between Roscas and the capital market more broadly.

4 Results

FINANCIAL FRAGMENTATION

We first explore the extent of fragmentation of interest rates accross space. Towards this we estimate

$$r_{dij} = a_i + u_{dij}$$

by OLS, where d indexes denominations, i branches, and j Rosca groups of denomination d in branch i. The interest rate r is computed for each Rosca in our sample according to (1). The resulting branch means $\widehat{a}_i$ are plotted in figure 1, where a numerical branch identifier is on the horizontal axis, and the (monthly) implied interest rate on the the vertical axis. Figure 2 maps branch interest rates. Statistics of the distribution of the $\widehat{a}_i$'s are set out in Table 3, column 1. Accordingly, the coefficient of variation is $0.099/0.76 = 0.13$ and the hypothesis of equality of all a_i's is rejected at the 1% level.

Now we will control for the denomination of a Rosca and the date when a Rosca takes place. This is important because a Rosca of a different denomination is a different financial product and the portfolio of Rosca denominations varies over branches. Moreover, even when there is no difference in interest rates over locations at any given point in time, this interest rate may vary over time. Therefore we also control for the date at which a Rosca was started. Our sample Roscas were started between January 2001 and October 2003. We denote by $quarter^k_{dij}$ a dummy variable which is equal to one for all Roscas that were started in quarter $k \in \{1, ..., 12\}$, where $k = 1$ covers the three months spell Januar to March 2001, and zero otherwise. We estimate

$$r_{dij} = \alpha_i + \gamma_d + \sum_{k=2}^{12} quarter^k_{dij} + u_{dij}. \tag{10}$$

Rather than reporting the point estimates of this regression, column 2 of table 3 reports the properties of the estimated branch intercepts. Accordingly, the standard deviation is reduced by only about 4 percent, from 0,099 to 0.095. The hypothesis of equal interest rates accross branches is still clearly rejected. From this exercise, we conclude that the bulk of spatial variation fails to be explained by differences in Rosca denominations or Rosca dates. It is also interesting to note that the correlation beteween the estimated branch interecepts in columns 1 and 2 is 0.96.

Further Sources of Fragmentation: Borrower Risk, Collateral Requirements and Screening

The interest rate which we is used as the dependent variable in the previous estimations is a pure savings rate. However, de facto it is an increasing function in the winning bids of each rounds from 2 to $n-1$ in the Rosca. Hence it is also a kind of average of the price of funds implicit in all loans made over the course of a Rosca. An important question hence is whether spatial differences in our interest rates are due to fundamentally different borrowing conditions in local credit markets. We capture risk-characteristics of loans by the default rate, the number of cosigners required on a loan and the screening effort of the lender. The latter is captured by an indicator which equals one if the Rosca company verified occupation and income of a borrower, and zero otherwise. Descriptive statistics of these three variables at the Rosca level are set out in table 2. Accordingly, 4.78% of dues have not been repaid by the time a Rosca ends, the company requires an average of 1.1 cosigners per loan and verifies the borrower's income 44% of the time.

As we are particularly interested in explaining *spatial* variation in interest rates, we will not simply add realizations of the variables to estimation equation (10), where each observation is one Rosca. Instead, we first estimate equation (10) with each of the three risk measures as left hand side variable in turn. This yields branch means net of time and denomination effects. In a second step, we use these estimated branch fixed effects as explanatory variables in a regression with the estimated interest-rate branch intercepts from equation (10) as the left and side variable. This latter regression thus has 78 observations, one for each branch.

To start out, in table 4 we have set out some descriptive statistics of the estimated branch fixed effects of three regressions (10) with default rate, number of cosigners, and income verification as the left hand side variable, respectively. According to the resulting coefficients of variation, these risk measures exhibit substantially greater spatial variation than the interest rate (where the CV is 0.13).

Column 1 of table 5 summarizes the results of a linear regression specification of the interest rate branch fixed effects on the estimated fixed effects of the three risk variables. Column 2 adds squared terms of the explanatory variables. According to the results, only defaults are significantly correlated with interest rates, where - as expected in e.g. a Stiglitz-Weiss world - riskier borrowers have a higher willingness to pay for loans. Column 3 of table 3 summarizes the distribution of the residuals from this regression. Accordingly, the standard deviation is reduced goes down to 0.080 after controlling for the risk factors. The null hypothesis of complete market integration fails to be rejected, however.

The lower panel of that table gives p-values of tests for equal variances between pairs of the three samples of estimated fixed effects (or residuals in the case of column 3). While the difference between the first and the second, and the second and third specifications are zero, there is, at least at the 10 percent level, a significant reduction in fragmentation between the first and third specification. Thus risk together with controls for denomination and time significantly explain about 20 percent of spatial differences in interest rates as measured by the standard deviation. The remaining 80% remain unexplained, however.

Arbitrage

We next test if there is systematic arbitrage between locations by the company. We measure the rank (or position) of the winner of a pot on a 0 to 1 scale, where 0 represents a receipt of the first pot – and 1 represents the receipt of the last pot. More preciselz, we define the rank of the winner of the t'th pot in the j'th Rosca of denomination d in location i as

$$rank_{dijt} = \frac{t-1}{T_d - 1},$$

where T_d denotes the duration (in months) of denomination d. Descriptive statistics on the company's participation at the Rosca level are set out in table 2. Accordingly, the company holds about a third of all Rosca memberships and on average occupies a rank of 0.41, which indicates that the company on average wins pots earlier than in the middle of a Rosca. These same variables at the branch level are set out in table 4. According to the coefficient of variation, the company's activities exhibits spatial variation on a similar order of magnitude as the interest rate. The mean rank of the company of .41 indicates that the company is more interested in early than in late pots, and thus, within our theoretical framework, might be arbitraging not only across branches but also against an outside investment opportunity with a higher rate of return than the average in the Roscas. In all but three of the 77 branches, the institutional investor's rank is below 0.5.

Profit maximizing arbitrage by the company (which reduces spatial variation in interest rates without eliminating them) implies a positive correlation between the local interest rate and the company's rank in the respective location. Using only pots won by the company, we first estimate

$$rank_{dijt} = b_i + \gamma_d + \sum_{k=2}^{12} quarter_{dij}^{k} + v_{dijt},$$

where t indexes the round in a Rosca, $t = 2, ..., T_d$. Figure 3 plots the resulting branch fixed effects $\widehat{b_i}$ on the vertical axis against the estimated fixed effects of (10) in its original version (with the interest rate as the dependent variable) on the horizontal axis. Clearly, there is a positive relationship between these two variables. Hence,the institutional investor takes relatively early pots (i.e. borrows) where interest rates are relatively low, and waits to take later pots when interest rates are relatively high. We can also formally reject the null hypothesis of no arbitrage by the company: the correlation coefficient between the two variables is 0.48 and significantly bigger than zero at the one percent level.

As pointed out in the theory section, costless competitive arbitrage would result in a uniform interest rate across locations. The company for whom arbitrage is fairly costless, or at least relatively cheap (as it neither has to pay the 5% participation fee nor provide cosigners at the time of borrowing), has to be regarded as a monopolistic arbitrager, however. In this paragraph, we briefly discuss how the observed interest rate heterogeneity across space largely conforms with the institutional feature of a substantial cost of arbitrage for outsiders. According to the theory, competitive costly arbitrage will drive down the interest wedge between any two locations to twice the entry fee. As our sample Roscas have a duration of more than two months, this fee has to be scaled to a fee per month to make it comparable to the monthly interest rates. Accordingly, the fee amounts to roughly

0.33% per month (two times 5% divided by the average Rosca duration of 30 months). Thus an interest difference of 0.33% between any two branches is largely in accordance with competitive, albeit costly, arbitrage in this institutional setup. According to table 3, column 1, the range of interest rates is larger than that, 0.505. However, when we consider all possible pairs of branches, 97% percent of pairs have a difference not exceeding 0.33. Considering, first, that the entry fee is not the only cost for an outside arbitrager - he also has to provide collateral for loans and employ agents in different locations - and, second, that local interest rates may also be subject to idiosyncratic shocks which are not perfectly predictable (and an outside aribtrager will suffer a loss for any pair of locations where the interest difference is less than his cost), the spatial distribution of interest rates appears to be largely in accordance with a scenario of monopolistic arbitrage with costly entry, where the cost is about as large as the entry fee.

5 Conclusion

The principle of no-arbitrage, so crucial to economic reasoning, implies that risk-adjusted interest rates should be equalized across financial markets. We have presented evidence to the contrary. The financial markets we study are those organized in different towns in the South Indian state of Tamil Nadu. The interest rates we analyze are determined by local auctions. These interest rates accrue to savers who face an identical risk across markets. What is remarkable about this variation in interest rates is that it persists despite the presence of an arbitrager who borrows in low-interest locations and saves in high-interest locations. We provide an explanation for why this arbitrager may deliberately choose to maintain the interest rate spread at the cost of financial efficiency and discuss entry barriers into arbitrage that enable such monopoly profits.

Our results raise questions about the competition between the organized (and regulated) Roscas in our study and the commercial banking sector. One might expect then that the variation in interest rates between financial markets may depend partly on the presence of bank branches in those locations. In ongoing research we are studying whether the presence of bank branches reduces the financial inefficiencies across markets. Relatedly, it would be useful to understand if the liberalization of the Indian economy in the 1990s has promoted more efficient flow of finance across markets. By historically studying the evolution of interest rates across Rosca locations we hope to provide an insight into this question.

References

[1] Aghion, P. and P. Bolton, 1997. A Theory of Trickle-Down Growth and Development. *Review of Economic Studies,* 64(2): 151–172.

[2] Anderson, S. and J. Baland, 2002. The Economics of Roscas and Intrahousehold Resource Allocation, *Quarterly Journal of Economics,* $117(3), 963 - 995$.

[3] Banerjee, A. and A. Newman, 1993, Occupational Choice and the Process of Development. *Journal of Political Economy,* 101: 274–298.

[4] Banerjee, A. and K. Munshi. 2004. How Efficiently is Capital Allocated? Evidence from the Knitted Garment Industry in Tirupur." Review of Economic Studies 71(1):19-42.

[5] Banerjee, Abhijit and Esther Duflo (2005), "Growth Theory Through the Lens of Development Economics," chapter 7 in the Handbook of Economic Growth Vol. 1A, P.Aghion and S. Durlauf, eds., North Holland.

[6] Besley, T., S. Coate and G. Loury. 1994. Rotating Savings and Credit Associations, Credit Markets and Efficiency. *The Review of Economic Studies,* 61(4): 701-719

[7] Borenstein, Severin, Knittel, Christopher R. and Wolfram, Catherine D., 2008. Inefficiencies and Market Power in Financial Arbitrage: A Study of California's Electricity Markets. The Journal of Industrial Economics, Vol. 56, Issue 2, pp. 347-378.

[8] de Mel, S., Mckenzie, D. and C. Woodruff, Returns to Capital in Microenterprises: Evidence from a Field Experiment. forthcoming, *Quarterly Journal of Economics.*

[9] Klenow, P. and C-T Hsieh, forthcoming "Misallocation and Manufacturing TFP in China and India" Quarterly Journal of Economics

[10] Eeckhout, J. and K. Munshi, 2004. Economic Institutions as Matching Markets. Manuscript, Brown University.

[11] King, R. G, and R. Levine, 1993. Finance and Growth: Schumpeter Might be Right. *Quarterly Journal of Economics,* 108(3): 717–737.

[12] Paulson, Anna L., Robert Townsend and Alex Karaivanov 2006. Distinguishing Limited Liability from Moral Hazard in a Model of Entrepreneurship," Journal of Political Economy Vol. 114. No. 1, pp. 100 -144

[13] Shleifer, A. and R. Vishny 1997. The Limits to Arbitrage. *Journal of Finance,* 52:1, 35-55.

[14] Townsend, R. 1997. "Microenterprise and Macropolicy" in Kreps, D. and K. Wallis eds. *Advances in Economics and Econometrics: Theory and Applications, Seventh World Congress of the Econometric Society,* Cambridge University Press, II:160-209.

Table 1. Descriptive Statistics, Rosca Denominations

Duration (Months)	Contribution (Rs./month)	Pot (Rs.)	Frequency	Relative Frequency
25	400	10,000	488	23.74
25	600	15,000	8	0.39
25	800	20,000	9	0.44
25	1,000	25,000	278	13.52
25	2,000	50,000	214	10.41
25	4,000	100,000	80	3.89
25	8,000	200,000	2	0.10
25	12,000	300,000	1	0.05
25	20,000	500,000	3	0.15
30	500	15,000	282	13.72
30	1,000	30,000	98	4.77
30	1,500	45,000	2	0.10
30	2,000	60,000	22	1.07
30	2,500	75,000	11	0.54
30	3,000	90,000	7	0.34
30	4,000	120,000	1	0.05
30	5,000	150,000	53	2.58
30	10,000	300,000	22	1.07
30	20,000	600,000	4	0.19
30	25,000	750,000	1	0.05
30	30,000	900,000	2	0.10
40	250	10,000	176	8.56
40	375	15,000	1	0.05
40	500	20,000	3	0.15
40	625	25,000	85	4.13
40	750	30,000	2	0.10
40	1,250	50,000	77	3.75
40	1,500	60,000	3	0.15
40	2,500	100,000	99	4.82
40	3,750	150,000	2	0.10
40	5,000	200,000	4	0.19
40	7,500	300,000	4	0.19
40	12,500	500,000	4	0.19
40	12,500	500,000	3	0.15
40	15,000	600,000	1	0.05
40	25,000	1,000,000	4	0.19

Table 2. Descriptive Statistics, Sample Roscas

	Mean	Std. Dev.	Minimum	Maximum
Duration (months)	29.64	5.99	25.00	40.00
Contribution (Rs./month)	1,468.12	2,462.76	250.00	30,000.00
Pot (Rs.)	44,277.72	81,223.17	10,000.00	1,000,000.00
Date of first auction	August 30, 2002	181 (days)	Jan 2, 2002	Sept 13, 2003
Monthly Interest Rate (%)	0.74	0.22	0.00	1.59
Default Rate (%)	4.78	2.55	0.00	19.68
Cosigners	1.10	0.62	0.00	3.89
Income Verification	0.44	0.25	0.00	0.97
Company Participation	0.32	0.19	0.00	0.95
Company Rank	0.41	0.10	0.08	0.83

Number of observations: 2,056

Table 3. Monthly savings rates, summary of estimated fixed effects/residuals

	Without Controls	With Controls (time, denomination)	Net of Defaults, collateral, screening
	(1)	(2)	(3)
Mean	0.760		
Standard Dev.	0.099	0.095	0.080
Range	0.505	0.475	0.463
Test for Equality (p)	0.000	0.000	0.000
Test for Equal Variances (p-value):			
(1) and (2)	0.716		
(1) and (3)	0.069		
(2) and (3)	0.147		

Number of observations: 78

Table 4. Distribution of Estimated Fixed Effects of other Variables

	Mean	Range	Std	Coeff. of Var.
Default Rate (%)	4.185	6.839	1.374	0.328
Cosigners	1.140	2.224	0.421	0.369
Income Verification	0.455	0.758	0.191	0.420
Company Participation	0.343	0.331	0.078	0.228
Company Rank	0.410	0.202	0.043	0.105

Notes:
The mean is the average over all Roscas in the sample
Range and standard deviation are calculated from estimated branch fixed effects
CV is the standard deviation divided by the mean as reported in this table

Table 5. Explaining Spatial Interest Rate Differences
Dependent Variable: Branch intercepts from interest rate regression

	(1)		(2)	
Intercept	0.666	***	0.805	***
	(0.045)		(0.093)	
Defaults	0.028	***	-0.042	
	(0.007)		(0.030)	
Defauts Squared			0.009	**
			(0.004)	
Cosigners	0.034		-0.003	
	(0.023)		(0.131)	
Cosigners Squared			0.016	
			(0.045)	
Screening	-0.083		-0.122	
	(0.052)		(0.359)	
Screening Squared			0.036	
			(0.313)	
R-Squared	0.23		0.24	
Number of observations	78		78	

Notes:
all explanatory variables are estimated branch fixed effects
from a regression of the explanatory variable on branch FEs
denomination and time dummies

Figure 1. Distribution of Branch Interest Rates

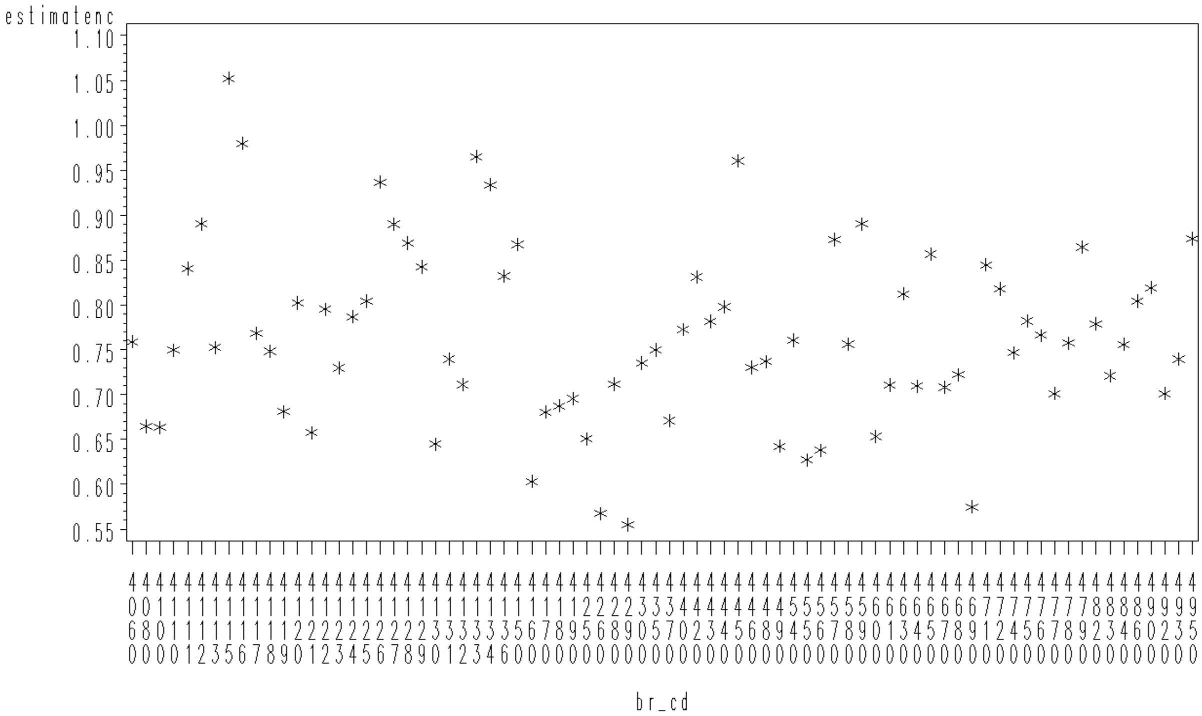

Figure 2. Map of Branch Interest Rates

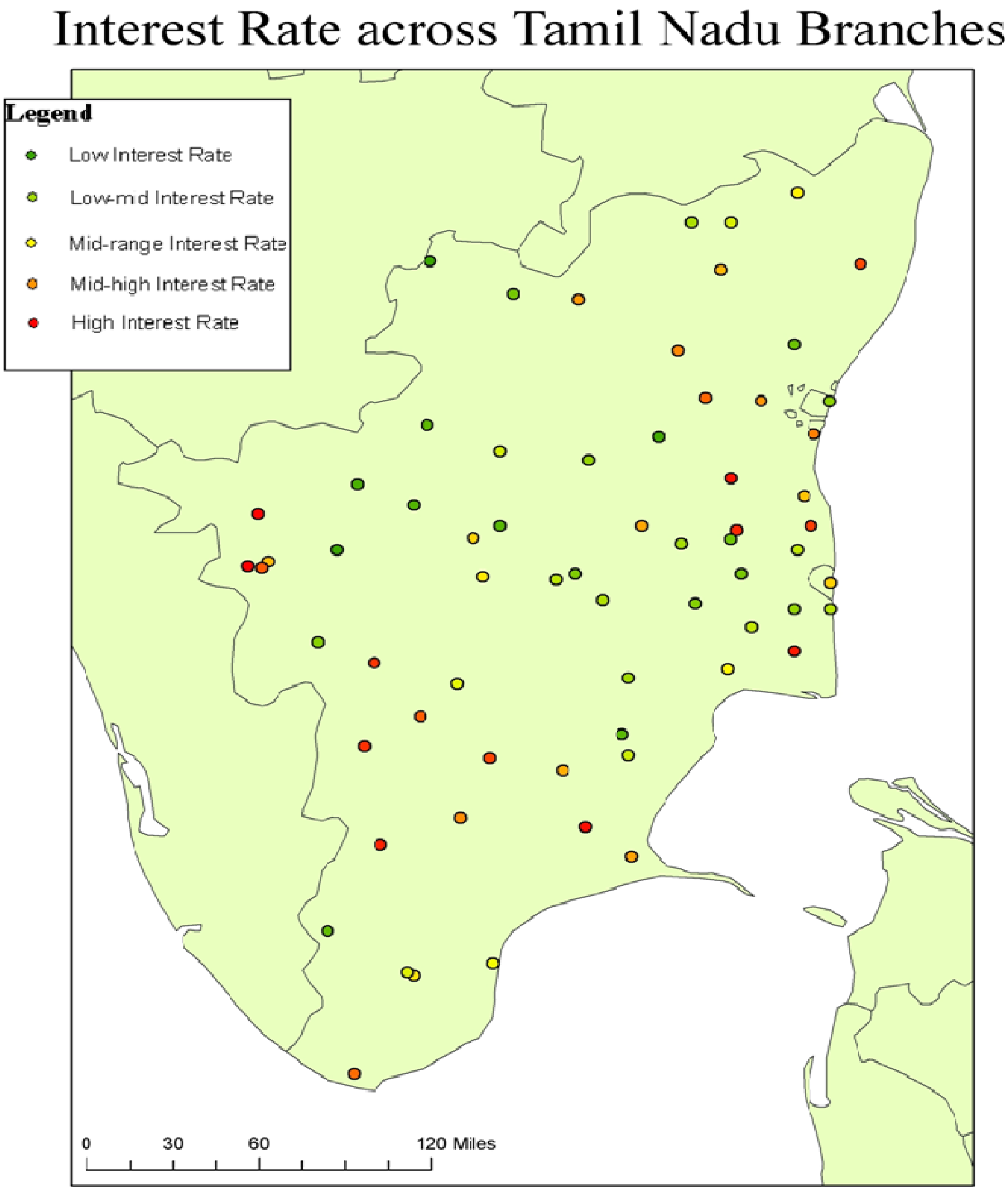

Figure 3. Scatter Plot of Company's Rank and Local Interest Rates