Collateral Substitutes in Microfinance[1]

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Abstract

We study the use of *collateral substitutes* in microfinance. In general, collateral serves to reduce the risk of strategic default in circumstances where borrower cash flows can be diverted. Microfinance institutions (MFIs) are widely perceived to face the twin disadvantages of operating in environments where collateral is scarce *and* diversion is easy. Two much-used techniques of microfinance lending are the use of social sanctions and credit denial as punishments to be imposed on defaulting borrowers. We interpret these punishment mechanisms as serving the role of collateral substitutes. However, they are unlikely to be perfect substitutes: Successfully imposing social sanctions requires the successful navigation of a delegation problem, while credit denial lacks a market value and so may be prone to a severe adverse selection problem. Moreover, the use of credit denial as a punishment sets up the possibility of a bad non-repayment equilibrium, which we term a "debtor run". We find some empirical support for the main predictions of our approach.

1 Introduction

Contract enforcement is widely perceived to be a central problem in developing countries.[1] This problem is particularly severe in credit relationships, where the obligations imposed by the contract are especially one-sided, falling as they do almost exclusively on the borrower. Arguably the most common response, in developed and developing economies alike, is the use of collateral — in the event of non-repayment of a loan, the lender can seize the collateral. However, limited wealth, limited property rights and (once again) poorly functioning legal systems all combine to reduce the possession of collateralizable assets by large segments of the populations of many developing countries.

One response to the absence of collateral assets is for an individual to borrow from someone who can invoke some other punishment, such as social ostracism and/or exclusion from access to other goods and services. Thus much credit has historically been provided by family members, village leaders, landlords and moneylenders.[2] However, loan sizes on such loans are likely to be small, and interest rates high. It is in this context that microfinance appears to hold such promise. Microfinance institutions (henceforth, MFIs) appear to have succeeded in replicating village mechanisms for loan provision, and are thus able to increase the supply of funds and reduce dependence on local monopolistic lenders.

The existing microfinance literature[3] has focused on the informational problems that prevent loan repayment. Typically, successful lending is posited to be hard either because some borrowers have risky and/or low quality projects (adverse selection), or because effort is unobservable (moral hazard).[4] Under this viewpoint, explaining the success of microfinance boils down to explaining how a lender can induce truthful revelation of information. Enforcement is not an issue — a borrower can always be relied on to make all contractually specified repayments, at least when he has sufficient funds.

In this paper we develop what we believe is a complementary view: A central problem in lending is ensuring that a borrower repays resources he actually has, and a key part of microfinance's success lies in the ability to make use of substitutes for physical collateral. In practice, this is achieved in two main ways. First, the MFI can exploit the *social sanction* opportunities that exist between potential borrowers. Second, the MFI can threaten a defaulting borrower with the *denial of future credit*.

Focusing on the role of limited enforcement gives an immediate explanation of what is perhaps the biggest problem of *micro*finance — as implied by the name, the loans remain very small. Under limited enforcement, loans will be small because the total punishment — counting both physical assets as well as the collateral substitutes discussed above — that a defaulting borrower can be threatened with is limited, and so repayments will be small.[5] Of course, one could also account for a small loan size by appealing to the demand side — but this would imply that MFI

[1] See, e.g., Laffont and Meleu (2002) for one of many recent expressions of this view.

[2] See, e.g., Aleem (1990) and Udry (1990).

[3] See Ghatak and Guinnane (1999) and Morduch (1999a) for surveys.

[4] An exception is the strategic default model of Besley and Coate (1995), which we will discuss later in the introduction.

[5] A few information based models, such as Conning (1999) and Ghosh and Ray (1996) have also discussed reasons for limited loan size and outreach.

borrowers are currently un-credit constrained, which is unlikely to generally the case.[6]

Closely related, limited enforcement can account for why microfinance remains so unprofitable. Despite the widespread microfinance rhetoric of self-sustainability, most MFIs are not self-financing commercial entities, but instead are subsidized NGOs. Clearly it is easy to appreciate why MFIs may have high per-borrower lending costs. The central point to understand is then why lenders do not just increase the loan size to a point where these per-borrower costs are relatively negligible. But as discussed above, limited loan size is a direct consequence of a limited enforcement model.

Taking enforcement seriously as a central problem also enables us to account for what Ray (1998) refers to as the lack of vertical links between MFIs and informal lenders. When MFIs make use of social sanctions to replicate the enforcement role of more conventional types of collateral such as land and jewelry, they are forced to rely on a third-party (e.g. a friend, neighbor, village member etc.) to actually impose these social sanctions. Doing so exposes them to the possibility of collusion between this third-party and borrower, which may undercut the borrower's incentives to actually repay. Thus the substitution of physical collateral by alternatives such as social sanctions leads to a delegation problem in which the MFI must concern itself with whether or not the third-party charged with imposing social sanctions will actually carry out this task. The potential for collusion can explain why MFIs make such little use of moneylenders and village leaders who might be thought of as the natural intermediaries in rural credit provision. It can also account for the attention that MFI practitioners devote to preventing corruption by loan officers.

Finally, differences between physical collateral and the substitutes used by MFIs may also lie behind two features of microfinance that strike many economists as puzzling: MFI loans are predominantly production loans, and MFIs place great emphasis on repayment rates. Absent physical collateral, the main punishment that an MFI is able to *directly* threaten is the denial of future credit.[7] While credit denial is not subject to the delegation problem of social sanctions discussed above, it is nonetheless prone to two problems of its own. First, the actual value of future credit to the borrower may not be at all clear to the MFI. This results in an adverse selection problem in collateral values, where the severity of the problem is plausibly greater for production than for consumption loans. An efficient response to severe adverse selection difficulties is for MFIs to reduce their loan size and their dependence on credit denial, thereby increasing their repayment rates. Second, if the MFI fails, all borrowers will be subject to the punishment of credit denial, independent of whether or not they have repaid. This leads to the possibility of what we term a "debtor run", a close analogue of the well-known deposit run:[8] If an MFI borrower expects other borrowers to default, he should default too. So we can explain the MFI emphasis on publicizing high repayment rates in two ways: as a response to the adverse selection problem in collateral values and as a way to prevent debtor runs.

To recap, taking the enforcement problem in loan repayment seriously can help account for the limited loan sizes and profits of microfinance lenders. Explicitly taking account of the differences

[6] There is some evidence that credit constraints persist despite the expansion of microfinance. Paulson and Townsend (2001) find evidence of credit constraints in areas where the Bank for Agriculture and Agricultural Co-operatives, a government-run microlender, operates. Amin, Rai and Topa (forthcoming) find that MFIs in Bangladesh do not reach the credit constrained.

[7] See Morduch (1999a), and also Armendariz de Aghion and Morduch (2000).

[8] See, e.g., Diamond and Dybvig (1983).

between the kinds of physical collateral used in conventional lending and the substitutes deployed by MFIs can further account for limited integration with informal lenders, an emphasis on preventing corruption, a focus on production loans, and the prominence of repayment rates as a performance measure.

In terms of its subject matter this paper is closely related to the extensive microfinance and group lending literature.[9] This literature is well-surveyed by the references cited in footnote 3 above. Perhaps the closest antecedent is the contribution of Besley and Coate (1995). They, like us, study the use of penalties as a way to deter strategic default. They make two main observations. First, by assuming that a lender can impose larger punishments when borrower payoffs are higher,[10] they show that group loans enable the lender to take better advantage of his enhanced punishment abilities when at least one of the borrowers enjoys a high project return. In contrast to their paper, our focus is on the *composition* of the lender punishments — and consequently we abstract from uncertainty in project returns.[11] Second, they observe that social sanctions may be used to further deter strategic default. However, this entails the delegation problem discussed earlier in the introduction: since social sanctions are ex post inefficient, the defaulting borrower and his "punisher" will have an incentive to renegotiate their imposition. This delegation problem inherent in the use of social sanctions is the main focus of Section 3 below.

We are also close to the branch of credit literature that emphasizes the divertibility of cash flows (see in particular Hart and Moore 1994) . Relative to contributions to that literature, we devote much more attention to the form of the punishment that is used to induce a borrower to hand over some portion of the divertible cash flow.

The paper proceeds as follows. Section 2 gives a basic model of collateral and loan repayment. Section 3 extends the model to the case of social sanctions imposed by a delegated insider. Section 4 discusses the use of credit denial and its susceptibility to an adverse selection problem. Section 5 describes a model of debtor runs. In Section 6 we perform a very rough empirical check on some of the main features of our basic model. Finally, Section 7 concludes.

2 A benchmark: Physical collateral

As a benchmark, we consider the following simple problem. A lender (L) lends an amount x to a borrower (B). The borrower invests x at a rate of return $\rho > 1$. We assume, however, that no part of the output ρx can be directly seized by the lender. This assumption is common in much of the credit literature (see, e.g. Hart and Moore 1994) and is often justified by suggesting that the borrower can divert or hide funds. In a developing economy setting, this constraint can also represent an inability of the legal system to enforce even the most elementary terms of a contract. In order to focus on issues of strategic (as opposed to involuntary) default, we

[9] Social sanctions are typically mentioned as a way to enforce side-contracts between group members in this information-based literature. But since side-contracting provides an additional constraint on information revelation, this literature shows how microfinance can work in spite of, rather than because of, social sanctions (Laffont and Rey 2001, Rai and Sjöström (forthcoming)).

[10] They justify this assumption with the idea that at least part of the punishment is to seize the borrower's project, which is a more severe punishment when its returns are high.

[11] Earlier drafts of this paper allowed for uncertainty in returns. The results were substantively the same.

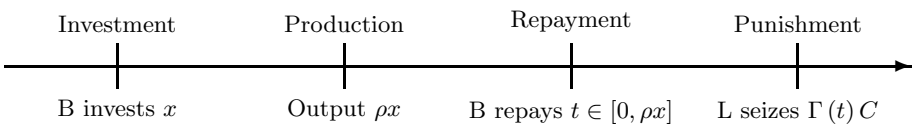


Figure 1: Timeline for benchmark problem

assume that the rate of return ρ is non-stochastic.

While the output ρx cannot be seized directly, we do allow the lender to seize borrower collateral C. We will have much to say about the constituents of this collateral C below. For now, think of C as being the sum of physical collateral, social sanctions that the lender can impose, and the value of future credit to the borrower.

Both the borrower and lender are assumed to be risk neutral, with the borrower's consumption constrained to be non-negative. We normalize the lender's cost of funds to unity.

In this setting, a contract consists of a triple $(x, R, \Gamma(\cdot))$ where x is the original loan size, R is the face value of the debt, and $\Gamma(t) \in [0, 1]$ is the proportion of collateral C seized in the event that the borrower makes a payment t. The timing is as shown in Figure 1.

The contract that maximizes the borrower's welfare subject to the lender receiving an expected payment at least α above the funds loaned is given by the solution to the following problem. In practice we can think of α as either the cost of lending or the lender's market power.

Problem 1

$$\max_{(x,R,\Gamma(\cdot))} \rho x - R - \Gamma(R) C$$

subject to the lender and borrower individual rationality constraints

$$R - x \geq \alpha \tag{1}$$

$$\rho x - R - \Gamma(R) C \geq 0 \tag{2}$$

and the borrower's incentive constraint

$$R \in \arg\min_{t \in [0, \rho x]} t + \Gamma(t) C \tag{3}$$

Since the lender observes the realized return ρ, there is never anything to be gained from in-equilibrium seizure of collateral — rather, the lender uses the threat of seizing collateral only as a means to promote repayment. So an optimal contract must have $\Gamma(R) = 0$. Without loss we can assume that there is maximal collateral seizure in the case of repayments $t < R$, i.e $\Gamma(t) = 1$. So the incentive constraint (3) reduces to $R \leq C$. Clearly the lender's IR constraint (1) must hold at equality, $R = x + \alpha$. Since $\rho > 1$ the largest loan size x that allows a solution is optimal. Finally, the borrower's IR constraint (2) implies the following:

Proposition 1 ***(Loan size in benchmark problem)***
If the borrower's IR constraint (2) holds at the maximum repayment C and the maximum loan size $C - \alpha$, i.e. if

$$\alpha \leq \frac{\rho - 1}{\rho} C \tag{4}$$

then any solution to Problem 1 must feature $x = C - \alpha$, $R = C$. One possibility for the penalty function Γ is $\Gamma(t) = 1$ if $t < R$, $\Gamma(t) = 0$ otherwise. If (4) does not hold then no solution exists, and no loan is made.

3 Social sanctions and intermediation

Social sanctions refer to a variety on non-pecuniary punishments such as shame or ostracism. In practice, such sanctions can only be imposed by insiders (including other villagers, local traders and possibly local loan officers) but not by outside lenders (such as commercial banks or the MFI headquarters). In this section, we shall think of collateral C as comprising two parts: c which the lender can seize directly and s or social sanctions which only an insider can seize. So there are now three agents — a lender (L), an insider (I), and a borrower (B). The lender is both the supplier of funds, and collects repayments, but needs to contract with the insider in order to impose social sanctions. If the insider were perfectly honest, then the lender could simply instruct the insider to seize s if the borrower defaults, and lend $x = C - \alpha = c + s - \alpha$ just as in the benchmark case of Section 2.

But in practice the insider is likely to be opportunistic. Instead of seizing s as stipulated by the lender, the insider can choose to take a bribe and forgive s. So we analyze how collusion of this form can limit lending. In addition to the specification of the borrower's collateral above, we assume that the lender can directly seize collateral worth k from the insider.

We examine two related specifications of what collusion is possible between the insider and the borrower. In the first case that we consider (see subsection 3.2), collusion takes place only after the borrower has chosen the payment t to make to the lender. Following this payment, the loan contract may specify social sanctions that the insider should impose on the borrower. So the insider and borrower have the incentive to strike a deal in which the borrower bribes the lender not to impose social sanctions.

In the second case (see subsection 3.3) we make what at first sight might appear a minor change to the timing. Rather than the borrower and insider renegotiating the imposition of social sanctions only at the point when these sanctions are to be imposed, we instead allow them to change the punishment specification prior to the borrower's repayment. Essentially, we allow the insider to commit in advance to punish the borrower less.

As we will see, this change in the commitment can have a big impact on the equilibrium loan size. When renegotiation of the punishment is restricted to date when the punishment occurs, the lender can exploit the bargaining power of the insider to induce a repayment that is above the total punishment he can directly impose on the borrower-insider coalition, i.e. $c+k$. In contrast, when the insider can commit to reduce the punishment, he is effectively able to "undercut" the lender. In this case, the maximum repayment that the lender can recover is bounded above by

$c + k$.

We begin with some (anecdotal) evidence of collusion in MFIs.

3.1 Collusion in MFIs

In recent years, several cases of corruption have been reported in MFIs that lend using social sanctions. According to the manager at K-Rep, a Kenyan MFI and one of the largest in Africa, "the most common type of fraud is collusion between credit officers and clients" (Mabwa 2001). In one version, the loan officer makes loans to family, friends and close associates. The loans are subsequently not repaid. In a second version, the loan officer simply pockets the money and submits a list of fictitious loans to the MFI headquarters. What makes both these schemes possible is the absence of collateral that headquarters can seize. In the first version, this means that the bank headquarters have no punishment to impose on the friends and family of the loan officer who default on their loans. In the second version, the absence of collateral means that the loan officer can submit a fictitious list of loans without corresponding land titles or other evidence of security.[12]

Table 1 (adapted from Valenzuela 1998) displays a sample of 14 cases of MFI fraud. In most cases fraud would have been either much harder, or impossible, if the loans had been accompanied by evidence of physical collateral. Cases 1, 2, 8 and 10 all involve a loan officer simply making up clients, which would be impossible if he had to display collateral for each loan. Cases 4, 5, 6, 7, 9, 11 and 12 all involve some level of collusion with borrowers.[13] If the MFI headquarters were able to confiscate a colluding borrower's collateral, collusion would have been harder.

Even the Grameen Bank has reported cases of collusion. Todd (1996b) describes how a loan officer in collusion with the borrowers delayed the recording of interest payments for Grameen Bank loans. The loan officer used the on-time interest payments of some borrowers to cover up repayment problems by others. He managed a complicated system of double accounting to maintain a clean repayment record thus increasing his chances of promotion and the collective credit rating of the borrowers. Despite visits by his superiors this interest payment scam was never discovered. Several replications of Grameen have also had difficulties preventing internal corruption. Loan officers in a Grameen replication in the Philippines were found receiving loans from borrowers (Counts 1997). An evaluation of a Grameen replication in Vietnam revealed that staff supervision was a major weakness. A loan officer was found to have colluded with a group of borrowers by giving them double the loan amount and then pocketing some of their repayments. When another loan officer who was president of the local political committee resigned, 100 borrowers defaulted as a result (Todd 1996a). In response, the Grameen Bank and its replications emphasize the prevention of internal corruption (Fugeslang and Chandler 1993 discuss in detail the mechanisms it uses).

[12] There are several examples how collateral can solve the delegation problem in developing countries. Moneylenders in India borrow from outsiders by pledging gold that they received from their borrowers as security, and unofficial pawnshops obtain financing from official pawnshops by pawning articles that were entrusted to them (Ghate 1998). Ghate also describes instances where the insider's physical collateral can be used to support delegated lending on social collateral: wealthier rice traders in Bangladesh obtain outside financing and on-lend to those in their trading network who have no collateral.

[13] Of these, cases 7 and 11 are furthest from involving collusion in that the borrowers claim not to have known about the loan officer's actions.

	Case	US$ Lost
1	Loan officer in rural area program makes fictitious loans. Repayment comes from the new loans, although soon the loans become delinquent. Accountant is in collusion.	$100,000
2	Loan officer sets up 18 fictitious loans for personal use. The loans become delinquent.	$2,500
3	Loan officer takes money from petty cash for use over the weekend.	$100
4	Loan officer pays a microentrepreneur to use his name and address to originate a loan for his own use. Loan officer does not make payments.	Unknown
5	Loan officer collects repayments from clients and keeps half for himself. Records only half paid on the books.	$500
6	Loan officer charges his clients a "fee" to apply for a loan. Officer keeps the fee.	$100
7	Loan officer in remote rural area disburses and collects loans in cash. Officer keeps some of the repayments. Argues that he lost loan payment receipts. Most clients do not demand receipts.	$3,000
8	Loan officer, in conjunction with supervisor and regional internal auditor, set up ghost groups in a very "successful" high growth branch. Loans were repaid from new loans.	$ 900,000
9	Highly trusted credit manager makes 13 large loans to microentrepreneurs and takes back a major portion of the loans for personal use. Manager has authority to approve loans.	$6,000
10	MIS specialist issues fictitious loans on smart cards, withdraws the loan funds from participating banks,and records non-existing payments on the information system.	$67,000
11	Cashier steals last group loan repayment of the day. Does not record payment on the system, yet stamps client's receipt.	$100
12	Branch manager (also loan officer) in rural area gives out loans to relatives. As delinquency rises he issues more poor loans to reduce his delinquency rate. As delinquency rises again, begins to steal from petty cash to repay loans.	$10,000
13	Highly trusted administrative officer purchased computers and furniture at higher than market prices - receiving a kickback. Officer leaves to take a better job.	Unknown
14	Highly trusted finance manager, who controls all program accounts, transfers funds to his personal bank account, with the apparent intention of repaying soon.	$10,000

Table 1: A Sample of MFI Fraud Cases from Around the World (adapted from Table 13 in Valenzuela (1998))

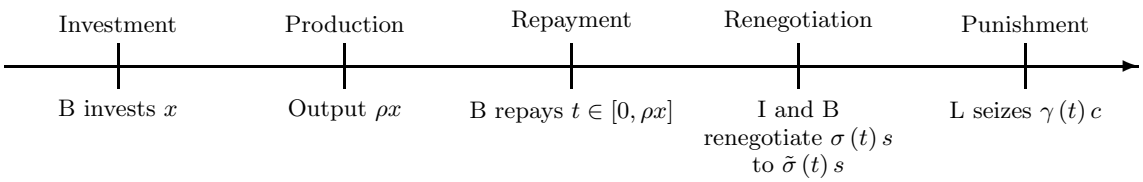


Figure 2: Timeline for renegotiation model of Subsection 3.2

3.2 Renegotiation at the punishment stage

We start with the first of the two cases described above: The borrower and insider can renegotiate the imposition of social sanctions only after the borrower has chosen the transfer t to make to the lender.

A contract now consists of a sextuple $(x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot))$, where $\gamma(t)$ is the proportion of collateral c that is seized when the borrower transfers t to the lender and $\sigma(t)$ is the proportion of the maximum social sanction s that the insider will impose, again as a function of t. Finally $\kappa(t)$ is the proportion of collateral k that the lender takes from the insider and $W(t) \geq 0$ is a "wage" that will be paid to insider, where again both are functions of the borrower transfer t to the lender.

The timing is as shown in Figure 2. We model the renegotiation between the borrower and insider as follows. With a probability $\mu \in [0, 1]$ (respectively, $1 - \mu$) the insider (respectively, the borrower) makes a take-it-or leave-it offer to the borrower (respectively, the insider) that consists of a new specification of the social sanctions to be imposed, $\tilde{\sigma}(\cdot)$, and a bribe b to be paid from the borrower to the insider. Define $V_i(t; x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot))$ to be the expected utility of agents $i = B, I$ in the renegotiation game given that the borrower has made a payment t to the lender.

The maximization problem is now:

Problem 2

$$\max_{(x, R, \Gamma(\cdot))} V_B(R; x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot))$$

subject to the lender, insider and borrower individual rationality constraints

$$R - x - W(R) \geq \alpha \tag{5}$$

$$V_I(R; x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot)) \geq 0 \tag{6}$$

$$V_B(R; x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot)) \geq 0 \tag{7}$$

and the borrower's incentive constraint

$$R \in \arg\max_{t \in [0, \rho x]} V_B(t; x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot)) \tag{8}$$

We start be characterizing the functions V_I and V_B. When the lender makes an offer $(\tilde{\sigma}, b)$ to the borrower, it will be accepted if and only if

$$-\tilde{\sigma}(t)\, s - b \geq -\sigma(t)\, s,$$

and so the lender's best offer is $b = \sigma(t)\, s$ and $\tilde{\sigma}(t) = 0$. When the borrower makes an offer $(\tilde{\sigma}, b)$ to the lender, it will be accepted if and only if

$$b \geq 0,$$

and so the borrower's best offer is $b = \tilde{\sigma}(t) = 0$. Thus

$$\begin{aligned} V_B(t; x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot)) &= \rho x - t - \gamma(t)\, c - \mu\sigma(t)\, s \\ V_I(t; x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot)) &= W(t) - \kappa(t)\, k + \mu\sigma(t)\, s \end{aligned}$$

A contract $(x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot))$ will satisfy the borrower IC condition only if

$$-R - \gamma(R)\, c - \mu\sigma(R)\, s \geq -\gamma(0)\, c - \mu\sigma(0)\, s$$

which in turn will be satisfied only if

$$R \leq c + \mu s$$

As in Problem 1, raising the loan size while holding the lender's payoff fixed will always increase the borrower's welfare. Applying the borrower's IR constraint (7) then gives us:

Proposition 2 ***(Loan size with insider-borrower collusion at enforcement stage)*** *If the borrower's IR constraint (7) holds at the maximum repayment $c + \mu s$ and the maximum loan size $c + \mu s - \alpha$, i.e. if*

$$\alpha \leq \frac{\rho - 1}{\rho}(c + \mu s) \tag{9}$$

then any solution to Problem 2 must feature $x = c + \mu s - \alpha$, $R = c + \mu s$. The insider is not paid any wage in either state, $W \equiv 0$. The penalty functions are not uniquely pinned down: One possibility is $\kappa \equiv 0$, $\gamma(t) = \sigma(t) = 0$ if $x = R$ and $\gamma(t) = \sigma(t) = 1$ otherwise. If (9) does not hold then no solution exists, and no loan is made.

The solution to Problem 2 can be interpreted as a group lending contract, where the insider and borrower form the group. Assume for now that the social sanctions that can be imposed by the insider exceed the punishment that the lender can impose on the borrower, i.e. $s > k$. Then by making use of the insider's ability to impose social sanctions, the lender is able to deliver a loan that exceeds the total punishment that he can impose on the group members. (If this property were not satisfied, it would be hard to distinguish the arrangement from one in which the lender simply made individual loans of c to the borrower, and k to the insider.)

The arrangement depends on the insider having the "right" to impose social sanctions on the borrower if, and only if, the loan is made and not repaid. Given the starkness of the model, we have little to say about exactly how the MFI engenders this kind of social norm. But such an effect does appear to exist. MFIs have successfully deployed a technique know as "village banking" in which the groups are large enough (of the order of fifty members) that each

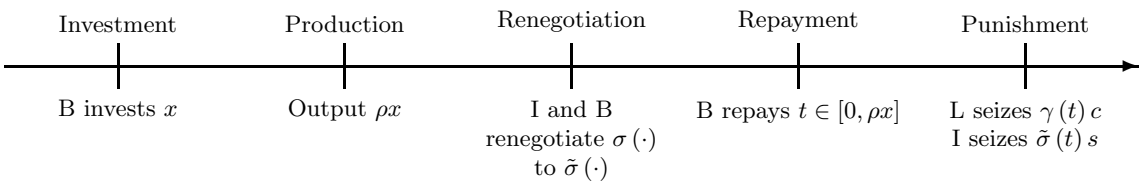


Figure 3: Timeline for renegotiation model of Subsection 3.3

individual villager charged with imposing social sanctions on a defaulting borrower will suffer little punishment from the MFI if he does not impose these sanctions.[14]

Intuitively, the fact that in many group lending schemes all group members receive a loan roughly at the same time, and so are all are exposed to the threat of social sanctions, may help to legitimate the imposition of these penalties. But as the model makes clear, at least theoretically the joint liability aspect of group lending may not be necessary. That is, in Proposition 2 the insider is neither rewarded nor punished based on the repayment made by the borrower ($W \equiv \kappa \equiv 0$), and so the contract is not a joint liability contract. Yet the borrower repays $c + \mu s$ to the lender because of the lender's pressure (to seize c), and because of the insider's pressure (for an expected bribe of μs to avoid the imposition of s). In contrast to a model such as that of Besley and Coate (1995), social sanctions are useful independently of whether the loan contract involves joint liability.[15]

3.3 Renegotiation prior to the repayment stage

We now turn to the case where the imposition of social sanctions is renegotiated prior to the repayment stage. The renegotiation game is exactly as before. The timing is now as shown in Figure 3.

That is, a contract $(x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot))$ sets up the following game:

1. Nature moves. With probability μ the insider is selected to make a take-it-or-leave-it offer $(\tilde{\sigma}, b)$ while with probability $1 - \mu$ the borrower is selected to make the offer.
2. The offer is made.
3. If the borrower (respectively, insider) made the offer, the insider (respectively, borrower) decides whether to accept or reject it.
4. The borrower chooses a repayment t to make to the lender.

[14] Analogously, even in the contemporary US social stigma is widely believed to act as a deterrent to individual borrowers declaring bankruptcy.

[15] Strictly speaking, in the Besley-Coate model social sanctions can only be invoked if the insider has suffered some penalty as a result of the borrower's behavior. It would be straightforward to add this restriction to our framework, with only a slight complication to the analysis and little change to our results.

5. Social sanctions are imposed by the insider as specified by the original contract if the renegotiation offer was rejected, and as specified by the modified contract if the renegotiation offer was accepted.

6. Collateral c and k is seized as specified by the original contract.

The full analysis of this problem is complicated by the fact that the value the borrower and insider place on renegotiation offers depends on the equilibrium repayment t that the borrower is anticipated to make to the lender. But for our purposes it is enough to note the result below: the maximum the lender can recover is bounded above by $c + \min\{s, k\}$.

Proposition 3 ***(Upper bound on loan size with insider-borrower collusion before payment)***
Let $(x, R, \gamma(\cdot), \sigma(\cdot), \kappa(\cdot), W(\cdot))$ be any contract, and consider an equilibrium in which (i) when the borrower makes an offer in the renegotiation he offers $(\tilde{\sigma}_B, b_B)$, the offer is accepted by the insider, and the borrower then repays t_B, and (ii) when the insider makes an offer in the renegotiation he offers $(\tilde{\sigma}_I, b_I)$, the offer is accepted by the borrower, and the borrower then repays t_I. Then

$$\mu(t_I - W(t_I)) + (1-\mu)(t_B - W(t_B)) \leq c + \min\{s, k\}$$

Consequently no loans will be made if

$$\alpha \leq \frac{\rho - 1}{\rho}(c + \min\{s, k\}) \tag{10}$$

(Note: The assumption that the offers are accepted is without loss, since offer rejection is equivalent to accepting an offer with $\tilde{\sigma} \equiv \sigma$ and $b = 0$.)

Proof: See Appendix.

In other words, lending on social sanctions using insiders who can commit is limited by the insider's own collateral k. Moneylenders, almost by definition, have some commitment ability: they must be able to credibly threaten sanctions, for otherwise their loans would never be repaid. Village headmen or close family members may also have an ability to commit. It follows that MFIs will not be able to benefit by including moneylenders and other village leaders in group lending schemes. For the same reason, MFIs may wish to prevent their loan officers from acquiring too much commitment ability. MFIs typically rotate loan officers and hold public meetings in which repayments are collected (Fugeslang and Chandler 1993). These may both be measures to ensure that no renegotiation takes place before repayment.

Of course, MFIs still have the option of lending $c - \alpha$ directly to the borrower and a further $\min\{k, s\}$ to the insider, with the intent that this latter amount be in turn loaned to the borrower. But the total loan under this scenario is still bounded by the total punishment the MFI can impose. If the MFI attempts to exceed this loan size, they can expect the borrower and insider to collude and not repay the loan — as in many of the examples of subsection 3.1.

The upper bound derived in Proposition 3 is in fact attainable:

Proposition 4 ***(Loan size with insider-borrower collusion before payment)*** *Suppose the borrower and insider can renegotiate the imposition of social sanctions (i.e. σ) before the borrower repays the lender. Then if*

$$\alpha \leq \frac{\rho - 1}{\rho} (c + \min \{s, k\})$$

an optimal contract will feature a loan size of $x = c + \min \{s, k\} - \alpha$ and a repayment of $R = c + \min \{s, k\}$. Otherwise no loan will made.

Proof: We first show that a contract exists with x and R as defined, and such that all constraints are satisfied. Consider the contract with no wage ($W \equiv 0$) and with full collateral seizure in the event of any borrower repayment $t < R$. Without renegotiating with the insider the borrower can always achieve a payoff of $\rho x - R$. Renegotiation can only be worthwhile if the borrower pays less than R to the lender, since otherwise there is no surplus for the borrower and insider to share. But in this case the borrower suffers a punishment of at least c. So the maximum payoff the insider can possibly hope for (net of the punishment k inflicted on him) is

$$\rho x - (\rho x - R + c) - k = R - c - k = \min \{s, k\} - k \leq 0$$

Thus renegotiation cannot be strictly profitable for both the borrower and the lender. From Proposition 3 we know that no higher loan is possible. As before, the borrower always strictly prefers the highest loan (holding insider and lender welfare constant). This completes the proof. ■

Suppose that the social sanctions s can be imposed on the borrower by *any* individual in his community, and that the lender can punish all community members by an amount k. Then if the lender can find a community member such that $\mu s > k$ and who cannot commit before the borrower repayment to reduce the punishment, his best strategy is to employ the "group" arrangement of Proposition 2. On the other hand, if no such individual exists then the lender will better serve the borrower by choosing a community member who can commit, such as a moneylender, and lending at least some of the funds $c + \min \{s, k\} - \alpha$ "through" him.

4 Credit denial and non-tradeability

In Section 3 above we examined the use of social sanctions as a substitute for more traditional forms of collateral. While social sanctions function in a way exactly analogous to physical collateral in some situations, they have an important disadvantage in that they may not be seizable by the ultimate supplier of funds. In such circumstances a delegation problem arises.

The second main form of punishment used in microfinance is the denial of future credit. That is, if a borrower defaults on a loan he is punished by being excluding from future credit. This threat can either be used by itself, as in the case of the Bank Rakyat Indonesia (BRI), or in conjunction with social sanctions, as in Grameen Bank. In the former case, loans are made to individuals, who are denied future credit in the event of non-repayment. In the latter case, loans are made to groups, but the only punishment directly inflicted on the group in the event

of non-repayment by one of the members is again credit denial. That is, the insider's collateral k in the model of Section 3 can be interpreted as the value of credit denial.

Clearly credit denial can function as an effective threat only when access to future credit is actually valued by the borrower. Of course, a similar statement obviously applies to physical collateral, such as land and jewelry. But a lender making a loan based on physical collateral is in a much better situation to judge the value of the collateral to the borrower, for the simple reason that physical collateral is generally tradeable and consequently possesses a market price. In contrast, claims to future credit are not traded, and possess no market price. The lender is forced to rely entirely on his or her own estimate of how much the borrower values access to future credit. This asymmetry of information introduces an adverse selection problem in collateral values.[16]

As discussed above, credit denial is used as a threat both when dealing with an individual borrower (see Section 2), and when dealing with an insider who will then impose social sanctions on the actual borrower (again, see Section 3 above). To avoid excessive duplication we formally analyze only the first case i.e. the loans to an individual borrower model of Section 2. But the reader should keep in mind that a similar analysis could be applied to the lender-insider problem of Section 3.

Formally, suppose now that there are two types of borrower, labeled 0 and 1. The total collateral possessed by type i is C^i, and consists partially of the threat of credit denial.

It is beyond the scope of this paper to give an explicit model of the credit denial mechanism in loan repayment. Instead, we simply summarize the utility loss associated with exclusion from credit markets[17] by the parameters C^0 and C^1. Fully specified models of financial market exclusion can be found in Kehoe and Levine (1993) and Kocherlakota (1996), among others. For our purposes, the important point to note is that in these models the utility loss associated with credit denial is dependent on borrower-specific characteristics such as future rates of investment return, future intertemporal substitution ratios, and the expected remaining duration of the relationship with the lender.[18]

For simplicity, we assume that type 0 borrowers do not care at all about access to future credit, while type 1 borrowers place a value of d on access to future credit. In addition, both types possess physical collateral c. That is, $C^0 = c$ and $C^1 = c + d$. A proportion θ of the borrowers are of type 0, while the remaining $1 - \theta$ are of type 1. To capture the idea that the lender cannot observe the value of credit denial to the borrower, we assume that the type of a borrower is private information to each borrower.

In this environment, a lender will offer a menu of contracts $\left\{\left(x^i, R^i, \gamma^i, \delta^i\right) : i = 0, 1\right\}$ where x^i is the loan size, R^i is the face value of debt, $\gamma^i(t)$ is the proportion of collateral c that will be seized if the borrower makes a payment t, and δ^i is the proportion of the total available credit denial sanctions that will be invoked upon payment t.

[16] Note that this is a distinct adverse selection problem from the one discussed in Ghatak (1999, 2000) and Armendariz and Gollier (2000).

[17] As emphasized by Bulow and Rogoff (1989), strictly speaking it is the threat of exclusion from all financial markets — i.e. asset markets as well as credit markets — that induces repayment. On this point, see also Chari and Kehoe (1993), Krueger and Uhlig (2000) and Bond and Krishnamurthy (2002).

[18] A closed form solution for the case of production loans in a non-stochastic and risk neutral environment can be found in Bond and Krishnamurthy (2002).

We start by considering the case of an altruistic lender (say, a MFI) who designs a menu of loan contracts to maximize aggregate borrower welfare, subject to covering operating costs of α per borrower. That is, the menu of contracts is chosen to solve the following problem:

Problem 3 [19]

$$\max_{(x^0,R^0,\gamma^0,\delta^0),(x^1,R^1,\gamma^1,\delta^1)} \theta\left(\rho x^0 - R^0 - \gamma^0\left(R^0\right)c\right) + (1-\theta)\left(\rho x^1 - R^1 - \gamma^1\left(R^1\right)c - \delta^1\left(R^1\right)d\right)$$

subject to the lender individual rationality constraint

$$\theta\left(R^0 - x^0\right) + (1-\theta)\left(R^1 - x^1\right) \geq \alpha$$

and to the individual rationality constraints of both borrower types

$$\begin{aligned} \rho x^0 - R^0 - \gamma^0\left(R^0\right)c &\geq 0 \\ \rho x^1 - R^1 - \gamma^1\left(R^1\right)c - \delta^1\left(R^1\right)d &\geq 0 \end{aligned}$$

and to the incentive constraints on the repayments,

$$\begin{aligned} R^0 &\in \arg\min_{t\in[0,\rho x^0]} t + \gamma^0(t)\,c \\ R^1 &\in \arg\min_{t\in[0,\rho x^1]} t + \gamma^1(t)\,c + \phi^1(t)\,d \end{aligned}$$

and to the self-selection constraints on contract choice,

$$\begin{aligned} \rho x^0 - R^0 - \gamma\left(R^0\right)c &\geq \max_{t\in[0,\rho x^1]} \rho x^1 - t - \gamma^1(t)\,c \\ \rho x^1 - R^1 - \gamma^1\left(R^1\right)c - \delta^1\left(R^1\right)d &\geq \max_{t\in[0,\rho x^0]} \rho x^0 - t - \gamma^0(t)\,c - \delta^0(t)\,d \end{aligned}$$

The formal solution to Problem 3 is given in the Appendix. Informally, the fact that the 0-type borrowers can always pretend to value future credit, even when they do not, implies that the lender must make loans of equal size to each type — so $x^0 = x^1$. Note also that, as in the solution to Problem 1, there is nothing to be gained from in-equilibrium imposition of collateral seizure or credit denial.

Under full information, the lender would lend $x = c - \alpha$ to the 0-types and collect total repayments c, while lending $x = c + d - \alpha$ to the 1-types and collect total repayments of $c + d$. The resulting average loan size is $c + (1-\theta)\,d - \alpha$. Under incomplete information, the lender can preserve this average loan size provided that the type-1 borrower still ends up with positive utility, that is, if

$$\rho\left(c + (1-\theta)\,d - \alpha\right) - (c+d) \geq 0 \tag{11}$$

[19] Note: As formulated, Problem 3 implicitly assumes that a positive loan will be made to both types. This is without loss. On the one hand, if a contract delivers positive utility to a type 1 borrower, it will be attractive to type 0 borrowers also — so there can be no solution with lending only to type 1 borrowers. On the other hand, if a contract delivers positive welfare to type 0 borrowers, the same contract would deliver positive utility to type 1 borrowers. So it would be possible to increase the objective by offering both agents the same contract, with $\delta^1 \equiv \delta^0 \equiv 0$.

So when (11) holds, the solution is

$$x = c + (1-\theta)\, d - \alpha,\ R^0 = c,\ R^1 = c + d \tag{12}$$

Under this solution, the type 1 borrowers subsidize the type 0 borrower. That is, for every dollar that is loaned above $c - \alpha$, the a 1-type borrower must repay $1/(1-\theta) > 1$ dollars, in order to make up for the fact that the 0-types will never repay more than c. Because of the linearity of investment opportunities, if he is happy to pay this amount for each marginal investment unit, he will do so to the maximum degree possible, giving solution (12).

On the other hand, if $\rho < 1/(1-\theta)$ a 1-type borrower is actually made worse off as the loan size is increased above $c - \alpha$. Consequently, there are two remaining cases in the case that (11) does not hold. First, suppose that borrowers have positive utility with a loan size of $c - \alpha$ and repayments $R^0 = R^1 = c$, i.e. the lender simply ignores the existence of credit denial as a possible sanction. Formally, the condition for positive utility is

$$\rho\,(c - \alpha) - c \geq 0, \tag{13}$$

In this case the problem has a solution of the following type. Since increasing the loan size and 1-type repayment increases aggregate welfare (though it decreases 1-type welfare), the lender will do this up to the point where the 1-type is indifferent between accepting and refusing the loan. That is, the lender chooses

$$x = \frac{\theta c - \alpha}{1 - \rho\,(1-\theta)},\ R^0 = c,\ R^1 = \frac{\rho\,(\theta c - \alpha)}{1 - \rho\,(1-\theta)} \tag{14}$$

On the other hand, if borrower welfare is negative at the loan size $c - \alpha$ and repayment level c (that is, (13) does not hold), then the problem has no solution. No loans will be made. These observations are summarized in the following proposition, in which we have rewritten the inequalities (11) and (13) as bounds on α:

Proposition 5 ***(Loan size in adverse selection problem)***
If

$$\alpha \leq \frac{\rho - 1}{\rho}\,(c + d) - \theta d \tag{15}$$

then the solution to Problem 3 features a common loan size $x^0 = x^1 = c + d - \alpha$, and 0-type repayment $R^0 = c$ and a 1-type repayment $R^1 = c + d$. If (15) does not hold but

$$\alpha \leq \frac{\rho - 1}{\rho} c \tag{16}$$

then the solution features a common loan size $x^0 = x^1 = \frac{\theta c - \alpha}{1 - \rho(1-\theta)}$, and 0-type repayment $R^0 = c$ and a 1-type repayment $R^1 = \frac{\rho(\theta c - \alpha)}{1 - \rho(1-\theta)}$. Otherwise there is no solution to Problem 3.

Proof: See Appendix.

4.1 Production versus consumption loans

Above we interpreted c as physical collateral such as land and jewelry. We can also think of c as representing the portion of the welfare loss of credit denial that is not subject to adverse selection. That is, the lender knows for sure that the borrower places a value of at least c on future access to credit, and may place a value as high as $c+d$. The prediction of Proposition 5 is then consistent with the observation that MFIs stress production over consumption loans. The value of future exclusion from consumption loans depends on fluctuations in the marginal utility over time, while the value of exclusion from production loans depends on the fluctuations in the rate of return on investment. To the extent to which the latter is easier to observe, production loans will be less subject to adverse selection (i.e. c is higher, d is lower). So it is more likely that the cost parameter α is low enough to allow an MFI to lend in the case of production credit than in the case of consumption loans.

4.2 Repayment rates

One of the most commonly cited indicators of microfinance success is the achievement of low loan default rates — a success usually interpreted to mean that an MFI has successfully overcome the frictions impeding lending. Here we use the model above to give a somewhat different interpretation.

The precise measure used to determine repayment varies across MFIs. Here we concentrate on the measure used by the Grameen Bank, the *overdues rate*, henceforth abbreviated to ODR.[20] As discussed in detail by Morduch (1999b), the ODR is defined by

$$\text{overdues rate} \equiv \frac{\text{value of loans overdue}}{\text{value of current portfolio}}$$

From Proposition 5 we can see that whenever the loan size is set above $c-\alpha$, the 0-type borrowers end up repaying less than the 1-types. We interpret this difference in payments as loan default. So in our notation, we have

$$\text{ODR} = \frac{\theta\left(R^1 - R^0\right)}{x} \tag{17}$$

Assuming that the lender's individual rationality constraint holds at equality, as it does in the solution of Problem 3, we know that the lender's total income must equal $x+\alpha$ which in turn equals $\theta R^0 + (1-\theta) R^1$. Substituting into (17) gives

$$\text{ODR} = \frac{R^1 - \alpha}{x} - 1 \tag{18}$$

How does the ODR depend on the severity of the adverse selection problem in the value of credit denial? We interpret the adverse selection problem as being more severe when the type 1 value on credit denial, d, is higher, holding the total value of "credit denial collateral" in the economy, $(1-\theta)\, d$, fixed. We then have

[20] The Grameen Bank reports an ODR of over 98%.

Proposition 6 ***(Overdue rates)***
Assume that $\rho(c-\alpha)-c \geq 0$ and $\alpha > 0$, i.e. that Problem 3 is guaranteed to have a solution and that the lender is taking in more in loan repayments than it is giving out in funds (but excluding operating expenses). Then holding the total value of credit denial fixed (i.e. $(1-\theta)d$ constant), the ODR is increasing in the severity of the adverse selection problem when $\rho(c+(1-\theta)d-\alpha)-(c+d) \geq 0$, but is eventually decreasing once the value of credit denial to the 1-types, d, is high enough that $\rho(c+(1-\theta)d-\alpha)-(c+d) < 0$. Finally, as the adverse selection problem becomes infinitely severe (i.e. $d \to \infty$ and $\theta \to 1$)

$$ODR \to \frac{(\rho-1)c-\rho\alpha}{c-\alpha}$$

Proof: Suppose first that $\rho(c+(1-\theta)d-\alpha)-(c+d) \geq 0$. Then

$$\text{ODR}(\theta,d) = \frac{R^1-\alpha}{x} - 1 = \frac{c+d-\alpha}{c+(1-\theta)d-\alpha} - 1$$

which is increasing in d, holding $(1-\theta)d$ constant.

Next, suppose that $\rho(c+(1-\theta)d-\alpha)-(c+d) < 0$. Then

$$\text{ODR}(\theta,d) = \frac{R^1-\alpha}{x} - 1 = \rho - 1 - \alpha\frac{1-\rho(1-\theta)}{\theta c-\alpha}$$

Differentiating with respect to θ gives

$$\frac{\partial}{\partial\theta}\text{ODR}(\theta,d) = -\alpha\frac{\rho(\theta c-\alpha)-c(1-\rho(1-\theta))}{(\theta c-\alpha)^2} = -\alpha\frac{\rho c-\rho\alpha-c}{(\theta c-\alpha)^2}$$

Increasing the severity of the adverse selection problem corresponds to an increase in θ. So if $\alpha > 0$, increasing the severity of the adverse selection problem leads to a fall in ODR. Finally, note that as $d \to \infty$ we have $\theta \to 1$, and so the ODR converges to

$$\rho - 1 - \alpha\frac{1}{c-\alpha} = \frac{(\rho-1)(c-\alpha)-\alpha}{c-\alpha} = \frac{(\rho-1)c-\rho\alpha}{c-\alpha}$$

This completes the proof. ■

Proposition 6 indicates that once the adverse selection problem is severe enough to distort aggregate lending, the ODR is actually lower when the adverse selection problem is more severe. Intuitively, as 1-types become scarcer and the value of credit denial for them increases, the lender reduces the loan size and thus his dependence on credit denial as a means of getting repaid. In this range, a high rate of loan repayment actually indicates that an MFI has responded appropriately to the problem of adverse selection, rather than overcome the underlying friction. Figures 4 and 5 show the ODR and loan size x as functions of θ, the adverse selection parameter. For the graphs, the following parameter values were used: $c = 0.5$, $\rho = 1 + 30\%$, and $\alpha = 0.1$. The parameters θ and d were varied keeping the stock of credit denial collateral $(1-\theta)d$ fixed at 0.5. When $\theta \leq 0.254$, the adverse selection problem does not reduce the average loan size from its benchmark value of 0.9. For $\theta > 0.254$ however, the average loan size is reduced as per Proposition 5. As $\theta \to 1$ the adverse selection problem made credit denial collateral valueless, and the loan size converges to 0.4. It is in this range, $\theta \in [0.254, 1]$ where credit denial reduces aggregate lending, that the ODR rate falls as the adverse selection problem becomes more severe.

Figure 4: ODR as a function of θ. Adverse selection is increasing in θ.

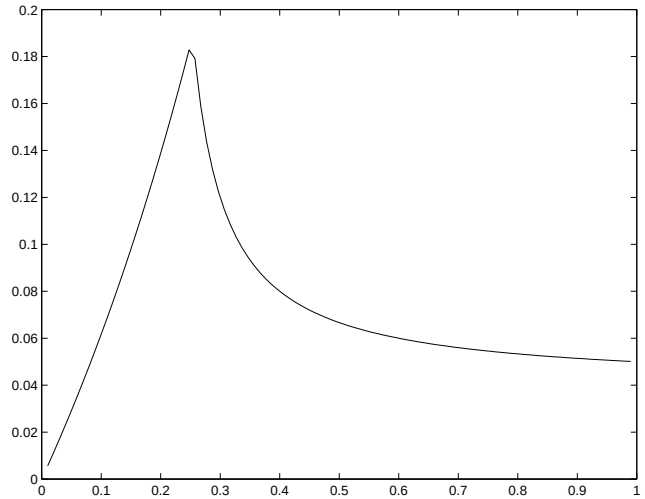
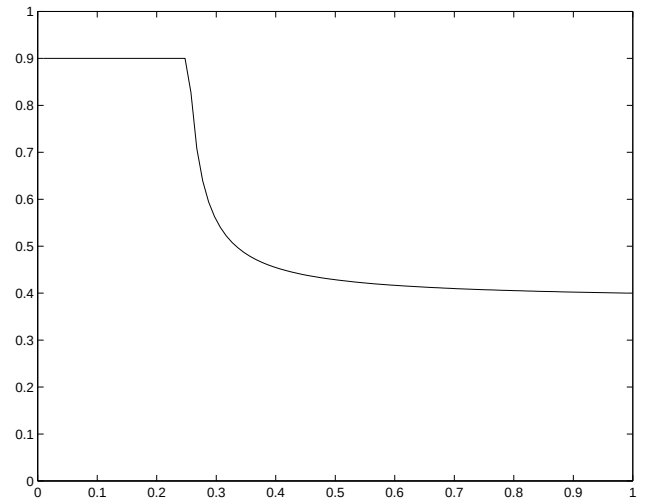


Figure 5: Loan size as a function of θ. Adverse selection is increasing in θ.



4.3 Loan market competition

Thus far we have treated the adverse selection problem under the assumption that there is a single benevolent lender who is concerned only with achieving a high enough level of repayment to cover his per-borrower operating costs α. The analysis would be similar if the lender were instead a monopolist, though the final borrower welfare levels would clearly be different. But what if there were competition between lenders?

If there are two Bertrand competing lenders then no loan above $c - \alpha$ will be made. The argument is as follows. On the one hand, there can be no separating equilibrium with both borrower types taking a loan: For in any such equilibrium, the loan to 0-types would need to be larger, but then the other lender could attract all the 1-types by raising the type-1 loan size. Moreover, there can be no pooling equilibrium with loan size above $c - \alpha$. The argument is as follows. In any pooling equilibrium the lender must be making zero profits, after costs α. Moreover, a loan greater than $c - \alpha$ can only be profitable when made to 1-types. So the loans to 1-types must be strictly profitable, and the loans to 0-types must be strictly unprofitable. But then a lender could always deviate by offering a slightly smaller loan with better terms to the 1-types, attracting all the 1-types by doing so, but none of the 0-types since they prefer their existing loss-making loans.

Thus when the lending problem is characterized by adverse selection in collateral values, the conventional wisdom that MFIs should be encouraged to compete for borrowers does not apply. Competition will only serve to reduce lending activity.[21] In fact, if

$$\frac{\rho - 1}{\rho} c < \alpha \leq \frac{\rho - 1}{\rho} c + \frac{\rho(1 - \theta) - 1}{\rho} d$$

competition will result in lending activity being completely eliminated. This model is consistent with anecdotal evidence of difficulties facing lenders in the two most competitive microfinance markets, Bangladesh and Bolivia (Pearl 2001 and Rhyne 2000).

5 Debtor Runs

One feature of credit denial is that the threat of seizure depends on whether other borrowers repay. So if a borrower anticipates that others will default, then he has no incentive to repay, since he will be denied credit *even if he does repay*. MFIs are naturally prone to these kinds of credit collapses. For example, in an international MFI in Ecuador called Childreach, "the number of residents defaulting on loans multiplied as the word spread that few people were paying, that what had been repaid was being pilfered by community leaders in at least a quarter of the communities, and that Childreach was taking little action" (see Goering and Marx, 1998). Since the viability of the microcredit operation had been called to question, borrowers clearly believed that they would be denied credit even if they repaid. In contrast, the threat of seizing physical collateral is independent of whether other borrowers repay.

[21] Competition could also make the successful imposition of exclusion from credit markets more difficult, an argument that has been made by Hoff and Stiglitz (1997) and others.

Suppose there are two identical borrowers, each with collateral $C = c + d$. We will restrict our attention to symmetric contracts. The lender will offer a contract (x, R, γ, δ) where x is the loan size, R is the face value of debt, $\gamma(t)$ is the proportion of collateral c that will be seized if the borrower makes a payment t, and $\delta(t)$ is the proportion of credit denial sanctions d that will be invoked upon payment t.

Suppose, just as in Section 2, the lender offers the following contract

$$\begin{aligned} x &= c + d - \alpha \\ R &= c + d \\ \gamma(t) &= 0 \text{ if } t = R \text{ and } 1 \text{ o/w} \\ \delta(t) &= 0 \text{ if } t = R \text{ and } 1 \text{ o/w} \end{aligned}$$

Without loss, we can restrict attention to the borrowers choosing between repayments R and c (a borrower will always be prepared to repay c to avoid seizure of his physical collateral). If both borrowers repay the lender is left with non-negative resources, since by construction $2R = 2(x + \alpha)$. On the other hand, if only one borrower repays R while the other repays c then the lender has negative resources since $R + c < 2(x + \alpha)$. In this case the lender is effectively bankrupt, and both borrowers are denied future credit independent of whether or not they repaid R. The payoffs to the two borrowers are summarized in the following payoff matrix:

	R	c
R	$\rho x - R, \rho x - R$	$\rho x - R - d, \rho x - c - d$
c	$\rho x - c - d, \rho x - R - d$	$\rho x - c - d, \rho x - c - d$

In addition to the equilibrium in which both borrowers repay the full amount R, there is now a second equilibrium in which both borrowers repay only c. We term this non-repayment equilibrium a "debtor run". To reiterate, the debtor run equilibrium is a consequence of the fact that a bankrupt lender is forced to impose credit denial even on borrowers who repay.

If the MFI wants to eliminate the debtor run equilibrium altogether, it basically has two options. First, it can simply avoid using credit denial as a threat. The resultant loan size is $c - \alpha$ if $\alpha \leq \frac{\rho - 1}{\rho} c$, while otherwise no loan is made. Second, it can seek to ensure that repayment by a single borrower is enough to ensure its survival. That is, it can employ a loan contract for which

$$R + c \geq 2(x + \alpha)$$

i.e. a single repayment of R, together with the payment c that it will always be able to recover from a borrower, cover the cost of lending to both borrowers. Since we still need $R \leq c + d$ (for the borrower's IC) this implies that

$$x \leq c + \frac{d}{2} - \alpha$$

The borrower's IR condition $\rho x - R \geq 0$ must also hold. Thus if the MFI seeks to make use of

the threat of credit denial and sets $x > c - \alpha$ we have

$$\begin{aligned}
\rho x - R &\leq \rho x - (2(x+\alpha) - c) \\
&\leq (\rho - 1)x - x - 2\alpha + c \\
&< (\rho - 1)\left(c + \frac{d}{2} - \alpha\right) - (c - \alpha) - 2\alpha + c \\
&= (\rho - 1)\left(c + \frac{d}{2}\right) - \rho\alpha
\end{aligned}$$

So a necessary condition for the MFI to at least partially make use of credit denial, and yet avoid the debtor run equilibrium, is that

$$\alpha < \frac{\rho - 1}{\rho}\left(c + \frac{d}{2}\right)$$

If there were $N > 2$ borrowers, then it becomes even more difficult to avoid debtor runs. The MFI must make a drastic reduction to the loan size to ensure that he will break even if only one borrower repays. It now needs

$$R + (N - 1)c \geq N(x + \alpha)$$

The same logic as before generates a necessary condition to avoid debtor runs of

$$\alpha < \frac{\rho - 1}{\rho}\left(c + \frac{d}{N}\right)$$

These debtor runs are different from coordination failures with group lending that Besley and Coate (1995) analyze. There the joint liability creates an interdependence between repayment behavior of individual borrowers, here even with individual loans there is an interdependence. So it is not the form of the lending contract that makes microfinance fragile, but instead it is the nature of the collateral substitute.[22]

This provides an explanation for why successful MFIs must have the appearance of sustainability, at least to their borrowers. The threat of credit denial is clearly only a threat if the MFI is actually going to remain in business. For example, the prospect that donors may suddenly cut funding to microfinance and move to the next development fad would severely undermine existing MFIs. Moreover, the prospect of future competition may undercut the credit denial threat, suggesting that MFIs with some monopoly power are likely to be more successful.

Finally, and closely related, the risk of debtor runs may partially account for why MFIs stress their high repayment rates. Some argue that microfinance should provide more insurance against aggregate shocks (such as floods), and so occasional drops in repayment rates should not be any cause for concern (Yaron and Townsend 2001) . But MFIs are typically reluctant to see themselves in such a role. One possibility is that a rise in default rates might lead to a run as other borrowers realize that they will be denied future access to credit whether or not they repay.

[22] Our explanation for microfinance fragility is also distinct from Banerjee (2002) who argues that MFIs may just be running Ponzi schemes.

6 Evidence

In this section we will discuss some *suggestive* evidence that is consistent with our theoretical predictions. The data we use comes from a large survey of MFIs in Asia, Africa and Latin America by the International Food Policy Research Institute (IFPRI) in 1999 (Lapenu 2000). This survey is remarkable for being so extensive (it covers 785 institutions in a total of 85 countries). Institutions with average loan sizes of under \$1000 were defined as MFIs. Asian countries with per capita GDP exceeding \$5000 were excluded from the sample. Only MFIs with some international links in terms of funding, technical assistance or information dissemination were sampled. The data are self-reported.

For our purposes, the most useful variables covered by this survey are the average loan size, the lending methodology used, and degree to which the funds loaned come from deposit taking. Approximately 40% of the MFIs in the sample report both average loan size and lending methodology, while approximately 30% report the deposit/loan ratio in addition to these last two variables. The average loan size among those MFIs who also report their lending methodology is \$300 (standard deviation of \$408). MFIs report their lending methodology as one of "group", "village banking", "linkage", "mutual" and "individual". Of these, only the first two responses clearly identify an MFI as following lending strategies largely free of physical collateral.[23] We define a dummy variable, Substitute, that takes a value of 1 when an MFI reports its lending method to be either "group" or "village banking", and 0 otherwise. This will be our measure of whether an MFI has replaced physical collateral with collateral substitutes.[24] Finally, we measure an MFI's source of funds by constructing an Intermediation Ratio measure (IR), defined as the ratio of total voluntary savings outstanding to the total loan portfolio. The average IR in the sample is 1.5.

Unfortunately there is no direct measure of collateral use, and so we will be forced to rely entirely on our dummy variable Substitute to proxy for the *type* of collateral used. The survey also includes information on the total number of staff, borrowers and depositors, and on whether the MFI is predominantly urban or rural.[25]

Model	Loan size	Collateral condition	
Benchmark	$C - \alpha$	if $C \geq \frac{\rho}{\rho-1}\alpha$	(Proposition 1)
Delegation (I)	$c + \mu s - \alpha$	if $c + \mu s \geq \frac{\rho}{\rho-1}\alpha$	(Proposition 2)
Delegation (II)	$c + \min\{s, k\} - \alpha$	if $c + \min\{s, k\} \geq \frac{\rho}{\rho-1}\alpha$	(Proposition 4)
Adverse selection	$\begin{cases} c + d - \alpha & \text{if } c + \frac{\rho(1-\theta)-1}{\rho-1}d \geq \frac{\rho}{\rho-1}\alpha \\ \frac{\rho(\theta c-\alpha)}{1-\rho(1-\theta)} & \text{if } c \geq \frac{\rho}{\rho-1}\alpha \end{cases}$		(Proposition 5)

Table 2: Summary of main results: Loan size is zero if collateral condition not met

[23] Village banking is a version of group lending with larger groups and an emphasis on savings collection (Morduch 1999a).

[24] To the extent that we have wrongly classified some of the other MFIs as not making use of collateral substitutes, this will affect our regressions like any other form of measurement error by biasing our results towards zero.

[25] There is also information that we do not make use of on the names of MFI and its donors, and on the reported repayment rate, and on the year the MFI in question was established.

Table 2 summarizes our main results concerning loan size. These results lead to the following predictions (all holding the borrower constant):

(A) A decrease in the level of either collateral or one of its substitutes leads to a decrease in the loan size.

(B) A replacement of physical collateral, c by an equal value of a collateral alternative (social sanctions, s, or credit denial, d) will generally lead to a decrease in the loan size.

(C) Assume that a switch from subsidized lending to deposit taking leads to a lower subsidy per borrower.[26] Then α is effectively higher after such a switch, and the loan size is smaller.

(D) Under the same assumption as in prediction (C), a switch from subsidized lending to deposit taking will *disproportionately* affect MFIs that rely on collateral substitutes, as follows. The introduction of depositors creates a new delegation problem between the depositors and the MFI, akin to that analyzed in Section 3. This delegation problem does not affect loans based on physical collateral, which depositors can always directly seize. But it will affect loans based on social sanctions and/or credit denial, which depositors cannot directly impose.

To examine these predictions, we regress loan size on our proxy for the use of collateral substitutes (the dummy variable Substitute), and on our proxy for an MFI's source of funds, the Intermediation Ratio (IR). We stress that these regressions are not intended as a formal test of our model. In particular, we have no effective instrument to control for possible endogeneity problems in the lending methodology and in the pool of borrowers served by each MFI. But with these (considerable) caveats, we believe our regressions point to an interesting set of correlations that our models of collateral substitutes can help explain.

Table 3 displays our regression results. Columns 1 through 10 report different specifications with and without country fixed effects. Columns $3-10$ include controls for whether the MFI is primarily rural (73 percent of the MFIs in the sample are), and for the borrower-staff ratio (which is 122 on average). Note that many MFIs do not report the borrower-staff ratio, so using this last control variable leads to a much smaller sample size. Columns $7-10$ also include the Intermediation Ratio measure (IR) of an MFI's source of funds, along with the interaction with the use of collateral substitutes, IR*Substitute.

Our main findings are:

1. MFIs that rely more on collateral substitutes have a significantly lower loan size. In particular, the shift to group or village banking is associated with a substantial reduction in the average loan size of about \$200 to \$300 at the mean. This is consistent with prediction (B) above. To the extent to which MFIs relying on collateral substitutes are lending to borrowers who have less total collateral (physical collateral plus collateral substitutes) this is also evidence in favor of prediction (A).

2. MFIs that take in larger amounts of savings (and so, most likely, have fewer subsidies) make smaller loans. That is, the IR coefficient is negative and significant. This is

[26] This will be true unless either (a) donors heavily reward an MFI for taking in more deposits, or (b) an MFI has the ability to raise deposit funds very cheaply, while simultaneously paying very low interest rates on the deposits collected.

consistent with prediction (C).

3. MFIs that use collateral substitutes are more affected by a shift to using savings deposits as a source of funds than are MFIs that do not use collateral substitutes. That is, the interaction term IR*Substitute is negative and significant. This is consistent with prediction (D).

In columns $11 - 15$ we repeat the basic regressions using the ratio of average loan size to GNP per capita as a dependent variable. The mean of the dependent variable is 0.66 (standard deviation of 1.02). The findings are basically unchanged. The proxy for collateral substitutes still has a significantly large negative association with loan size. The coefficients on the source of funds measure, IR, and on the interaction term IR*Substitute are still negative and significant in regression 14. (However, when we add more controls in Regression 15, the sample size is reduced and we lose significance.)

Finally, we note that the theory predicts that only MFIs that have a sufficiently low α (i.e. high level of subsidies) will be able to lend using collateral substitutes. Though the IFPRI data set does not ask MFIs about their self sufficiency, we know from other surveys that MFIs that use group or village bank lending methodologies have lower self-sufficiency ratios than those that lend using individual loans (Morduch 1999a). This too is consistent with the theory.

7 Conclusion

The vast majority of the existing literature on microfinance and group lending has taken the key difficulty facing lenders to be that of a lack of information. That is, lenders are unsure whether a borrower's project returns are high enough and safe enough to justify making a loan, and are unsure as to whether the borrower exerts sufficient effort in carrying out the project. Under this view, the main achievement of microfinance has been to find ways (with group lending a prime example) of inducing borrowers to reveal their information. In this paper we have emphasized a second and complementary difficulty: Even if a borrower has sufficient funds, a lender may simply have a hard time enforcing the repayment clause of the loan contract. In many environments this enforcement problem is solved by the use of physical collateral. The achievement of successful MFIs under this view is thus to successfully use social sanctions and credit denial as *collateral substitutes*.

In line with our conjecture that collateral substitutes lie at the heart of the microfinance success story, in this paper we have studied what we regard as the two main forms of collateral substitutes in some detail.

With regard to social sanctions, our model suggests that at least under some circumstances social sanctions can be effective even outside the usual joint liability setting. On the other hand, social sanctions become less effective as the individual imposing the sanctions is endowed with greater commitment ability. We argue this observation can account for why microfinance appears to make so little use of individuals such as village leaders and money lenders who might be thought to have the most commitment ability.

Credit denial is a threat that can be unilaterally invoked by an MFI, thus avoiding the delegation problem inherent in the use of social sanctions as a collateral substitute. However, it is subject to a serious adverse selection problem: the lender does not actually know how much the borrower values future access to credit. Moreover, this adverse selection problem is liable to be more severe for credit denial than for conventional physical collateral, for the simple reason that access to credit is not a traded good and so does not possess a market price. We show that high loan repayment rates are fully consistent with a severe adverse selection problem. It follows that some care should be taken in the interpretation of the much-publicized repayment rates of MFIs. Moreover, employing credit denial as a collateral substitute leaves the MFI subject to what we have termed a "debtor run", closely related to the more well-known deposit run. The focus on repayment rates, often a source of some puzzlement for economists, may be due to a desire to avoid these undesirable equilibria.

We find some empirical confirmation for our view that the enforcement problem lies at the heart of credit provision. Loan sizes are smaller when collateral appears scarcer. Intermediation appears to disproportionately affect the use of social sanctions as a collateral substitute.

Taking seriously the difficulties inherent in enforcing the repayment clause of a loan contract leads us to question some current policy views that microfinance should be made more competitive and profitable. More competition may actually hurt successful MFIs, in part because of the adverse selection problem discussed in Section 4. The desire to have MFIs achieve financial self-sufficiency, while laudable, may be simply unrealistic. Enforcement problems constrain the loan size to be small, while high per-borrower costs require large loan sizes or subsidies.

Finally, much effort has been devoted to extending the microfinance model to a large number of countries. These efforts have not always been successful. If enforcement is less of a problem in some countries than in others, such failures are not surprising. That is, if enforcement of repayment functions better in the US than in Bangladesh, the pool of borrowers not currently served by the formal financial sector in the US should be expected to possess projects of a much lower quality than the same group in Bangladesh. Put differently, the microfinance innovation of finding collateral substitutes is of much less value in countries where enforcement already functions well.

Dependent Variable: Average Loan Size (in columns 1-10)
Average Loan Size/GNP per capita (in columns 11-15)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Substitute	-199.53	-240.21	-199.19	-234.44	-202.13	-251.9	-219.31	-244.13	-163.74	-156.69	-0.57	-0.56	-0.69	-0.73	-0.64
	(-4.14)***	(-4.17)***	(-4.32)***	(-4.05)***	(-3.39)***	(-3.21)***	(-3.72)***	(-2.84)***	(-2.21)**	(-1.15)	(-4.47)***	(-4.52)***	(-3.36)***	(-4.36)***	(-2.49)**
IR=Savings/Loans							-2.01	-1.87	-6.36	-8.14				-0.01	-0.01
							(-2.98)***	(-1.80)*	(-2.59)**	(-2.94)***				(-3.46)***	(-1.23)
IR*Substitute							-17.91	-15.12	-118.19	-144.21				-0.02	-0.19
							(-2.87)***	(-2.10)**	(-2.29)**	(-1.71)*				(-2.00)**	(-1.28)
Rural			-279.82	-168.06	-415.97	-350.91	-339.57	-250.52	-439.28	-430.63		-0.36	-0.55	-0.44	-0.55
			(-4.11)***	(-1.87)*	(-3.89)***	(-3.46)***	(-3.85)***	(-1.79)*	(-3.67)***	(-2.01)**		(-1.81)*	(-1.64)	(-1.71)*	(-1.44)
Borrower/Staff Ratio					-0.39	-0.38			-0.43	-0.60			-0.001		-0.001
					(-3.71)***	(-2.59)**			(-3.03)***	(-2.87)***			(-3.29)***		(-2.69)***
Country Fixed Effec	no	yes	no	yes	no	yes	no	yes	no	yes	no	no	no	no	no
Observations	320	320	320	320	151	151	226	226	132	132	311	311	150	222	132
R-squared	0.06	0.38	0.12	0.40	0.25	0.39	0.17	0.41	0.28	0.43	0.07	0.09	0.13	0.13	0.13

T-statistics are reported in parentheses.
Standard errors are adjusted for heteroskedasticity.
* Statistically Significant at 10% level
**Statistically Significant at 5% level
*** Statistically Significant at 1% level

Table 3: Determinants of Loan Size

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A Omitted mathematical solutions

A.1 Proof of Proposition 3

Trivially t_I and t_B are bounded above by $c+s$. Below we establish that $t_i - W(t_i) \leq c+k$ for $i = I, B$.

First, suppose to the contrary that $t_I - W(t_I) > c+k$. Consider an offer $\left(\hat{\sigma}, \hat{b}\right)$ of the type

$$\hat{\sigma}(t) = \begin{cases} \tilde{\sigma}(t) & \text{if } t \neq 0 \\ 0 & \text{if } t = 0 \end{cases}$$

By assumption $t_I > c \geq \gamma(0)c - \gamma(t_I) - \tilde{\sigma}(t_I)s$. Thus

$$-\gamma(0)c > -t_I - \gamma(t_I)c - \tilde{\sigma}(t_I) \geq -t - \gamma(t)c - \tilde{\sigma}(t)$$

for all t, where the second inequality is due to the fact that t_L is an equilibrium payment given $\tilde{\sigma}$. So if the offer $\left(\hat{\sigma}, \hat{b}\right)$ is accepted, the borrower will repay $t = 0$ to the lender. The borrower will accept any offer that gives him a higher level of utility from not accepting. Since the utility from not accepting is certainly less that the utility from accepting $(\tilde{\sigma}_I, b_I)$ and repaying t_I, a sufficient condition for acceptance is that

$$-\gamma(0)c - \hat{b} > -t_I - \gamma(t_I)c - \sigma(t_I) - b_I$$

So the insider will strictly gain from such an offer provided

$$W(0) - \kappa(0)k + \hat{b} > W(t_I) - \kappa(t_I)k + b_I$$

It follows that $(\tilde{\sigma}_L, b_L)$ and t_L are only an equilibrium (given the lender is making the offer) if

$$W(0) - \kappa(0)k + (-\gamma(0)c + t_I + \gamma(t_I)c + \sigma(t_I) + b_I) \leq W(t_I) - \kappa(t_I)k + b_I$$

i.e. if

$$t_I - W(t_I) \leq \gamma(0)c + \kappa(0)k - W(0) - \gamma(t_I)c - \sigma(t_I) - \kappa(t_I)k$$

Since the right-hand side must be less than $c+k$ this gives a contradiction, completing the first part of the proof.

For the second part of the proof, suppose that contrary to out initial claim that $t_B - W(t_B) > c+k$. We proceed in a way that closely parallels above. We consider the same class of deviations $\left(\hat{\sigma}, \hat{b}\right)$. As above, if the insider accepts such an offer, the borrower will respond by repaying $t = 0$ to the lender. A sufficient condition that guarantees that the insider accepts the borrower's offer $\left(\hat{\sigma}, \hat{b}\right)$ is that

$$W(0) - \kappa(0)k + \hat{b} > W(t_B) - \kappa(t_B)k + b_B$$

The borrower strictly prefers the offer $\left(\hat{\sigma}, \hat{b}\right)$ to (σ_B, b_B) if

$$-\gamma(0)c - \hat{b} > -t_B - \gamma(t_B)c - \sigma(t_B) - b_B$$

As before, these two inequalities imply that we must have $t_B - W(t_B) \leq c+k$, giving a contradiction and completing the proof. ■

A.2 Proof of Proposition 5

Without loss, we can impose maximal punishments everywhere other than at the repayment levels corresponding to the face values R^0 and R^1. That is, the contract menu $\left\{\left(x^{i*}, R^{i*}, \gamma^{i*}, \delta^{i*}\right) : i = 0, 1\right\}$ solves Problem 3 if and only if $\left\{\left(x^{i*}, R^{i*}, \bar{\gamma}^{i*}, \bar{\delta}^{i*}\right) : i = 0, 1\right\}$ (where $\bar{\gamma}^{i*} = \gamma^{i*}\left(R^{i*}\right)$ and $\bar{\delta}^{i*} = \delta^{i*}\left(R^{i*}\right)$) solves

$$\max_{\substack{x^i \geq 0 \\ \theta x^0 + (1-\theta) x^1 \leq c + d - \alpha \\ \bar{\gamma}^i \in [0,1] \\ \bar{\delta}^i \in [0,1] \\ R^i \in \left[0, \rho x^i\right]}} \theta\left(\rho x^0 - R^0 - \bar{\gamma}^0 c\right) + (1-\theta)\left(\rho x^1 - R^1 - \bar{\gamma}^1 c - \bar{\delta}^1 d\right)$$

subject to

$$\begin{aligned}
\alpha &\leq \theta\left(R^0 - x^0\right) + (1-\theta)\left(R^1 - x^1\right) \\
0 &\leq \rho x^0 - R^0 - \bar{\gamma}^0 c \\
0 &\leq \rho x^1 - R^1 - \bar{\gamma}^1 c - \bar{\delta}^1 d \\
c &\geq R^0 + \bar{\gamma}^0 c \\
c + d &\geq R^1 + \bar{\gamma}^1 c + \bar{\delta}^1 d \\
\rho x^0 - R^0 - \bar{\gamma}^0 c &\geq \rho x^1 - R^1 - \bar{\gamma}^1 c \\
\rho x^0 - R^0 - \bar{\gamma}^0 c &\geq \rho x^1 - c \\
\rho x^1 - R^1 - \bar{\gamma}^1 c - \bar{\delta}^1 d &\geq \rho x^0 - R^0 - \bar{\gamma}^0 c - \bar{\delta}^0 d \\
\rho x^1 - R^1 - \bar{\gamma}^1 c - \bar{\delta}^1 d &\geq \rho x^0 - c - d
\end{aligned}$$

This problem has a solution provided that the constraint set in non-empty. Clearly we can restrict attention to the cases where $\bar{\delta}^1 = 0$ and $\bar{\delta}^0 \equiv 1$ (no credit denial penalty in the type 1 contract when the borrower repays in full, and maximal credit denial penalties on the type 0 contract, since this has no effect on the type 0 agents and may help with the self-selection constraints). Moreover, observe that any solution must feature $\bar{\gamma}^0 = \bar{\gamma}^1 = 0$. For suppose to the contrary that $\bar{\gamma}^i > 0$, some i. Then we can decrease $\bar{\gamma}^i$ by ε/c while increasing R^i by ε while leaving all the constraints satisfied and actually slackening the lender's IR constraint. We could then increase both x^0 and x^1 by ε' sufficiently small to leave the objective strictly higher than when we started and all the constraints still satisfied.

Substituting in these observations gives

$$\max_{\substack{x^i \geq 0 \\ \theta x^0 + (1-\theta) x^1 \leq c + d - \alpha \\ R^i \in \left[0, \rho x^i\right]}} \theta\left(\rho x^0 - R^0\right) + (1-\theta)\left(\rho x^1 - R^1\right)$$

subject to

$$\begin{aligned}
\alpha &\leq \theta\left(R^0 - x^0\right) + (1-\theta)\left(R^1 - x^1\right) && (19)\\
0 &\leq \rho x^0 - R^0 && (20)\\
0 &\leq \rho x^1 - R^1 && (21)\\
c &\geq R^0 && (22)\\
c + d &\geq R^1 && (23)\\
\rho\left(x^0 - x^1\right) &\geq R^0 - R^1 && (24)\\
\rho\left(x^0 - x^1\right) &\geq R^0 - c && (25)\\
\rho\left(x^1 - x^0\right) &\geq R^1 - R^0 - d && (26)\\
\rho\left(x^1 - x^0\right) &\geq R^1 - c - d && (27)
\end{aligned}$$

We will start by establishing that whenever a solution exists, $x^{0*} = x^{1*}$.

First, suppose that $x^{1*} > x^{0*}$. Then constraint (25) implies (22) must be slack, and constraint (23) implies (27) is slack. Note that constraint (26) cannot be slack, for if it were the lender could increase aggregate utility by increasing both x^0 and R^0 by ε. For ε sufficiently small this leaves all the constraint satisfied, since (22) and (27) are slack. On the other hand, if constraint (26) binds then (24) is slack, in which case the lender can increase aggregate utility by increasing both x^0 by ε/ρ and R^0 by ε, while decreasing R^1 by $\varepsilon(\rho-1)\theta/((1-\theta)\rho)$. For ε sufficiently small this leaves type-0 borrowers with the same utility, the lender with the same utility, increases the utility of type-0 borrowers and still satisfies constraints (22)-(27) since (22), (27) and (24) are slack. Thus it cannot hold that $x^{1*} > x^{0*}$.

Next, suppose that $x^{0*} > x^{1*}$. In a way exactly parallel to above, we can again establish a contradiction. Note that the constraint (27) implies (23) must be slack, and constraint (22) implies (25) is slack. Note that constraint (24) cannot be slack, for if it were the lender could increase aggregate utility by increasing both x^1 and R^1 by ε. For ε sufficiently small this leaves all the constraint satisfied, since (23) and (25) are slack. On the other hand, if constraint (24) binds then (26) is slack, in which case the lender can increase aggregate utility by increasing both x^1 by ε/ρ and R^1 by ε, while decreasing R^0 by $\varepsilon(\rho-1)\theta/((1-\theta)\rho)$. For ε sufficiently small this leaves type-1 borrowers with the same utility, the lender with the same utility, increases the utility of type-0 borrowers and still satisfies constraints (22)-(27) since (23), (25) and (26) are slack. Thus it cannot hold that $x^{0*} > x^{1*}$.

Thus we know that any solution must entail $x^{0*} = x^{1*}$, and so can restrict attention to the subproblem in which x^1 is constrained to equal x^0. We write x for this common value. In this case, the constraints (22) and (25), and (23) and (27) coincide. Moreover, the lender break-even constraint (19) certainly binds, since otherwise the lender could simultaneously reduce both R^0 and R^1. Constraints (24) and (21) together imply (20).

Moreover, note that (25) must bind. To see this, suppose to the contrary that it is slack. Constraint (26) then implies that (27) must also be slack. But then aggregate borrower welfare can increased while still satisfying all constraints by increasing each of x, R^0 and R^1 by ε.

¿From (19) and (25) binding we have $R^0 = c$ and $x = \theta c + (1-\theta)R^1 - \alpha$. Constraints (26) and (27) coincide. Conditional on the lender break-even constraint (19) holding with equality,

aggregate borrower welfare is strictly increasing in loan size x, and thus in R^1. The problem thus reduces to maximizing R^1 subject to satisfying constraints (21), (24) and (26), that is

$$\begin{aligned} (1-\rho(1-\theta))\,R^1 &\leq \rho(\theta c-\alpha) && (28)\\ R^1 &\in [c, c+d] && (29) \end{aligned}$$

First, if $\rho(1-\theta) < 1$ then this implies there is no solution if

$$(\rho-1)\,c-\rho\alpha \geq 0 \tag{30}$$

does not hold, that the solution is $R^1 = \rho(\theta c-\alpha)/(1-\rho(1-\theta))$ if (30) holds but

$$(\rho-1)\,c-\rho\alpha+(\rho(1-\theta)-1)\,d \geq 0 \tag{31}$$

does not, and is $R^1 = c+d$ if (31) holds.

Second, if $\rho(1-\theta) > 1$ then if (31) holds $R^1 = c+d$ is the solution, while otherwise there is no solution.

Third, if $\rho(1-\theta) = 1$ then $R^1 = c+d$ is the solution provided $\theta c-\alpha \geq 0$ holds, which in this case is equivalent to either (30) or (31) holding. Otherwise, there is no solution.

Finally, combining the above cases gives: If (31) holds then the solution is

$$R^0 = c, R^1 = c+d, x = c+(1-\theta)\,d-\alpha \tag{32}$$

If (31) does not hold but (30) does, then the solution is

$$R^0 = c, R^1 = \frac{\rho(\theta c-\alpha)}{1-\rho(1-\theta)}, x = \frac{\theta c-\alpha}{1-\rho(1-\theta)} \tag{33}$$

If neither (31) nor (30) holds, then there is not solution. This completes the proof. ■