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Group-lending with sequential financing, contingent renewal and social capital

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Abstract

This paper focuses on the dynamic aspects of group-lending, in particular sequential financing and contingent renewal. We examine the efficacy of these two schemes in harnessing social capital. We find that, for the appropriate parameter configurations, there is homogenous group-formation so that the lender can ascertain the identity of a group without lending to all its members, thus screening out bad borrowers partially. Moreover, under certain parameter configurations, negative assortative matching occurs as a robust phenomenon.

JEL classification: G2; O1; O2
Keywords: Group-lending; Sequential financing; Contingent renewal; Social capital; Assortative matching

1. Introduction

In this paper, we focus on some of the *dynamic* aspects of micro-lending institutions,[1] in particular those involving group-lending.[2]

Traditionally, the literature has focussed on *joint liability*, where, in case of default by some member, the other members have to make up the deficit. The objective is to analyze

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[1] Relatively recent surveys include Ghatak and Guinnane (1999) and Morduch (1999).

[2] According to Hossein (1998), the Grameen Bank in Bangladesh, as well as ACCION, affiliated ones in Latin America, have a repayment rate in excess of 95%. Christen et al. (1994) and Morduch (1999) all report similar figures.

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the efficacy of joint liability in triggering peer monitoring[3] and homogenous group-formation.[4]

Group-lending schemes, however, also involve many other subtle features. In fact, Aghion and Morduch (2005, p. 119) argue that today joint liability is only one of the elements that differentiate micro-finance from traditional banking. Unfortunately, however, these have attracted relatively little attention in the literature. We focus on two such dynamic schemes, namely *sequential financing and contingent renewal*.

In the Grameen Bank, for example, the groups have five members each. Loans are sequential in the sense that these are initially given to only two of the members (to be repaid over a period of 1 year). If they manage to pay the initial installments, then, after a month or so, another two borrowers receive loans and so on.[5] Despite some recent works (discussed later), sequential financing remains poorly understood.

Contingent renewal of loans refers to the feature that in case of default by a group, no member of this group ever receives a loan in the future. Moreover, in case of repayment, there is repeat lending. Many authors, including Ghatak and Guinnane (1999), Khandker et al. (1995) and Ray (1999), argue that contingent renewal is an important element behind the success of many group-lending schemes.[6]

The relative neglect of dynamic features is surprising given that in reality micro-lending institutions do not always enforce joint liability. Loan officers in Asia and Latin America, for example, say that they see no reason to punish everyone for the actions of a single person (Aghion and Morduch, 2005, p. 113). In fact, in case of default, the original Grameen idea was not that group-members would have to pay for others, but rather that they would be cutoff from future loans. Furthermore, some recent group-lending schemes, e.g. ASA in Bangladesh and even the Grameen, have seen a move away from strict joint liability (Aghion and Morduch, 2005, p. 119).

We focus on the efficacy of these two dynamic schemes in harnessing social capital. Such social capital may take the form of mutual help in times of distress (see Coate and Ravallion, 1993), mutual reliance in productive activities, status in the local community, etc. In case default by one borrower harms the other borrowers, such default may be penalized through a loss of this social capital.[7] Social penalties may also take the form of a reduced level of cooperation, or even admonishment.[8]

We find that our dynamic framework yields some interesting new insights, which cannot be replicated in a static framework. As an example, we can mention our central result that, under certain circumstances, the lending bank can test for the type of a group by lending to just one of the members, thus screening out bad borrowers partially.

Furthermore, even in cases where joint liability is not being imposed, given sequential financing and contingent renewal, actions taken by one member of a group would still affect the

[3] Banerjee et al. (1994), Conning (1996), Ghatak and Guinnane (1999), Stiglitz (1990) and Varian (1990) emphasize the importance of peer monitoring.

[4] Ghatak (1999, 2000) and Tassel (1999) demonstrate that joint liability lending leads to *positive assortative matching* so that borrowers of the same type club together.

[5] See, for example, Morduch (1999). As an example of a group-lending scheme that does not involve sequential financing, consider the BancoSol program in urban Bolivia.

[6] To rephrase, sequential financing refers to group-loans that are staggered within the same round, whereas contingent renewal implies that the selection of the recipient group is history dependent.

[7] In fact, in a study of group-lending in Guatemala, Wydick (1999) finds that, for groups located in rural areas, group pressures play an important role in ensuring loan repayment.

[8] According to Rahman (1999), women are specially sensitive to such admonishments.

others. Given that such interdependence is a key implication of joint liability, the question naturally arises as to whether, in such situations, the joint liability assumption can be interpreted as a convenient shortcut to the descriptively more realistic case of sequential financing with contingent renewal? Our analysis allows us to identify conditions under which such a static approach may or may not generate the correct results, in particular regarding the nature of group-formation.

We build a simple infinite-horizon dynamic model based on social capital, *moral hazard* and *endogenous group-formation*. There are many borrowers, all of whom have access to two projects where the first one has a verifiable income, but no private benefit (non-verifiable), while the second one has a private benefit, but no verifiable income. Thus there is a moral hazard problem.[9] The borrowers are heterogenous, so that some borrowers (denoted the S type) have access to social capital, while the others (denoted the N type) do not. For an S type borrower, social penalty involves the withdrawal of this social capital whenever default by this borrower harms the other group-members. The bank prefers the first project (when it can recoup its initial investment), while at least the N type borrowers prefer the second one. Hence, the bank may be unwilling to lend at all.

There is endogenous group-formation whereby, prior to the actual lending, the borrowers form groups of size two among themselves.[10] The key issue is whether there will be positive assortative matching or negative, i.e. whether group-formation will be homogenous or not.

We then briefly discuss our main results.

Consider the case where sequential financing is used in conjunction with contingent renewal. For intermediate values of the discount factor, there is positive assortative matching, so that the bank can ascertain the identity of a group without lending to all its members, thus screening out bad borrowers partially. In fact, the bank can find out the identity of a group quite cheaply, by lending once to just one member of a group. Hence, group-lending is feasible under the appropriate parameter values.

This works as follows. Because of sequential financing and contingent renewal, default by an S type borrower adversely affects her partner, who receives no further loans from the bank. Since any such default attracts the social penalty, S type borrowers invest in their first projects, thus resolving the moral hazard problem partially. Furthermore, since members of SS type groups always repay, given contingent renewal they receive an infinite sequence of loans. Given that the discount factor is reasonably large, SS type groups are quite attractive, leading to positive assortative matching.

Interestingly, if the discount factor is small enough, then there is negative assortative matching. This happens because, with the discount factor being small, SS type groups are not very attractive. However, this does not necessarily imply that group-lending will be infeasible.

Thus, depending on parameter values, there may be either positive or negative assortative matching. Both Ghatak (1999, 2000) and Tassel (1999), however, find that under their (mainly static) setups there is necessarily positive assortative matching. Hence, our analysis identifies conditions under which the traditional Ghatak (1999, 2000) and Tassel (1999) type results may or may not go through in a dynamic framework.

We then argue that sequential financing is critical since, in its absence, the borrowers may collude among themselves. Let us consider a scenario where the selection of the recipient group

[9] In case of the Grameen Bank, Todd (1996) argues that loan applicants often misrepresent the objectives of their loans.

[10] Ghatak (2000) provides evidence to suggest that endogenous group-formation is a key component behind the success of many group-lending schemes.

is history dependent, but in any round all members of the recipient group receive the loans simultaneously. If the borrowers coordinate on their second projects, then, since the borrowers are not going to get future loans anyway, such default does not attract the social penalty. Consequently, collusion occurs unless the discount factor is large (when a trigger-strategy kind of argument goes through).

Such coordination is captured through our use of *renegotiation-proofness*, which thus plays a critical part in the argument. As is well known, the notion of renegotiation-proofness allows for communication among the agents. Given that the paper focuses on lending to communities with close interactions, it seems natural to allow for such coordination.

We finally argue that, if the social penalty is only triggered when S type borrowers are affected, then, while sequential financing by itself may be feasible, a combination of sequential financing and contingent renewal may not be. In the latter case, there is negative assortative matching whenever the discount factor is small. Given the social penalty function, S type borrowers default whenever they have an N type partner. Hence, the result.

We then relate our paper to the literature. In a strategic repayment game with social capital, Besley and Coate (1995) demonstrate that joint liability may harness social collateral, thus partially mitigating the negative effects of group-lending. On the other hand, in a framework where the borrowers differ in their unobserved sanctioning capacities, Bond and Rai (2004) examine the efficiency of joint liability group-loans vis-a-vis co-signed loans. While the presence of social capital is central to our analysis as well, note that the central problem examined in this paper is one of moral hazard, rather than limited enforcement. Moreover, unlike both the above papers, we allow for endogenous group-formation.

As in Ghatak (1999, 2000) and Tassel (1999), we also allow for endogenous group-formation. In our model, however, the heterogeneity arises not because one group of borrowers is safer, or more able, but because one group has more social capital compared to the other. Furthermore, we show that, for some parameter values, there may be negative assortative matching.

We then consider the literature on sequential financing. Ray (1999) provides an explanation of sequential financing based on coordination failures in case of voluntary default. In a model with moral hazard, Roy Chowdhury (2005) argues that sequential financing enhances the incentive for peer monitoring and may, even in the absence of joint liability, solve the moral hazard problem. Aniket (2004) shows that, by temporally separating the decision on peer-monitoring and investment, sequential financing makes collusion impossible. In contrast to Aniket (2004) and Roy Chowdhury (2005), however, we allow for endogenous group-formation, an issue not dealt with in Aniket (2004) and Roy Chowdhury (2005). Furthermore, in contrast to most of the literature, we use an explicitly dynamic framework where sequential financing and contingent renewal are used in conjunction.

The rest of the paper is organized as follows. In Section 2, we describe the economic environment. In Section 3, we analyze sequential financing without contingent renewal. The interaction between sequential financing and contingent renewal is analyzed in Section 4. In Section 5, we briefly examine an alternative form of the social penalty. Section 6 discusses some modelling assumptions, while Section 7 concludes. Some of the technical material can be found in Appendix A.

2. The economic environment

The market consists of many borrowers, such that their mass is normalized to one and none of the borrowers is an atom. Borrower i can invest in one of two projects, P_i^1 or P_i^2. For every i, P_i^1

has a verifiable income of H and no non-verifiable income, whereas P_i^2 has no verifiable income and a non-verifiable income of b, where $0<b<H$. The sets of projects are different for different borrowers. While the borrowers know the identity of their own projects, they do not know the identity of the other borrowers' projects. In every period, the borrowers consume all their income in that period.

All projects require an initial investment of 1 dollar. Since none of the borrowers have any funds, they have to borrow the required 1 dollar from a bank. The bank also does not know the identity of the projects, so that there is a moral hazard problem. The loan can be taken either individually or as a group. For every dollar loaned, the amount to be repaid is r (≥ 1), where r is exogenously given.[11]

Thus there are significant rigidities in the rate of interest. This is likely to be the case whenever it is exogenously fixed by the government, perhaps on political grounds. This is especially plausible if the lending bank is government controlled. Even if, say, the bank is run by an NGO, the government may have some control over its activities, specially if the NGO is funded (at least partially) by the government.

For the project to be profitable for the borrowers, it must be that $H>r$. For simplicity, we assume that $H\leq 2r$, so that $r<H\leq 2r$.

A fraction $0\leq\theta\leq 1$ of the borrowers have a social capital of s (>0), whereas the other borrowers have no social capital. The borrowers with social capital are denoted by S, whereas the other borrowers are denoted by N. The social penalty involves a loss of this social capital. An S type borrower taking a group-loan is assumed to lose her social capital if she defaults and, moreover, this default affects the other group-member.[12] Thus, the social penalty is *anonymous* in the sense that it is imposed irrespective of whether the default affects an S type or an N type borrower.[13] The borrowers all know one another's types, but the bank does not.

We assume that the magnitude of the moral hazard problem, quantified by b, is not too small.

Assumption 1. $H-r<b$.

Suppose that a borrower has taken a loan of 1 dollar. If the borrower is of type N, then, given Assumption 1, she will prefer to invest in her second project. Further, we assume that the social capital s is not too small.

Assumption 2. $H-r>b-s$.

Suppose some borrower of type S has taken a loan and that she will lose her social capital in case of default. In case she invests in her second project, she obtains a non-verifiable income of b, but loses her social capital, so that her net payoff is $b-s$. Given Assumption 2, the borrower will prefer to invest in her first project.

3. Sequential financing

In this section, we examine the effect of sequential financing on group-lending. For the moment, we abstract from contingent renewal, which will be introduced in the next section. This

[11] We follow Besley and Coate (1995) in assuming that the rate of interest is exogenous. However, some authors, e.g. Ghatak (1999, 2000), Tassel (1999), etc., do take the rate of interest to be endogenous.

[12] Note that the social penalty is imposed only in case it affects the other borrower. Thus. it satisfies Assumption 1(i) in Besley and Coate (1995).

[13] In Section 5, we consider an alternative form of the social penalty function.

section, as well as Section 4.1, provide useful benchmarks for the later analysis. Of course, given the diverse lending schemes adopted by micro-finance institutions, these are of interest in themselves.

Time is discrete so that $t=0, 1, 2, \ldots$. Let $0<\delta<1$ denote the common discount factor of all the agents, the borrowers, as well as the bank.

3.1. Group-lending without sequential financing

In this subsection, we examine a group-lending game without sequential financing. We consider the following infinite horizon game.

Period 0. There is endogenous group-formation whereby the borrowers organize themselves into groups of two. Depending on the type of borrowers comprising the groups, these can be of three types, SS, NN and SN. We assume that the group-formation process follows the *optimal sorting principle*,[14] in the sense that borrowers from different groups cannot form a new group without making some member of the new group worse off.[15]

For every $t\geq 1$, there is a two-stage game.

Stage 1. The bank randomly selects one of the groups as the recipient and lends it two dollars, which are divided equally among the two members of the selected group. Note that the lending policy of the bank does not involve contingent renewal.[16]

Stage 2. Both the borrowers then simultaneously invest 1 dollar into one of their two projects. If the i-th borrower invests in P_i^1, she has a payoff of $H-r$; otherwise, she has a payoff of b. Note that, given the lending policy, default by a borrower does not affect the expected income of the other borrower and hence does not attract the social penalty even if she is of type S. The bank has a payoff of $2(r-1)$ in case both the borrowers invest in their first projects, $r-2$ in case only one of the borrowers invests in her first project and the other borrower invests in her second project, and a payoff of -2 in case both the borrowers invest in their second projects.

We need some more definitions before we can proceed further.

Definition. There is *positive assortative matching* if there are $\frac{\theta}{2}$ groups of type SS and $\frac{1-\theta}{2}$ groups of type NN.

Definition. There is *negative assortative matching* if there are $\min\{\theta, 1-\theta\}$ groups of type SN, $\max\left\{\frac{1-2\theta}{2}, 0\right\}$ groups of type NN and $\max\left\{\frac{2\theta-1}{2}, 0\right\}$ groups of type SS.

We then describe our solution concept. We first solve for the *renegotiation-proof equilibria* of the period 1 game (a formal definition of renegotiation-proofness has been provided in Appendix A). Next, the period 0 game is solved using the optimal sorting principle. This solution concept will be used throughout the paper.

The notion of renegotiation-proofness used here draws on Bernheim and Ray (1989).[17] Following their idea, we look for equilibria that are consistent over subgames that are identical as far as the continuation games are concerned. Note that, in the context of our paper, such subgames can be identified with the identity of the borrowing group selected by the bank.

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[14] In this context, the optimal sorting principle was first used by Ghatak (1999, 2000). Ghatak (1999), in turn, traces this idea to Becker (1993).

[15] It is clear that the optimal sorting principle is closely related to the core, as well as the idea of stability.

[16] Given that we are interested in examining the implications of various lending policies, we model the bank as a non-strategic agent following some fixed lending policy. Of course, this also simplifies the analysis, as well as the exposition.

[17] In the presence of contingent renewal, note that the set of players still eligible for loan (i.e. the state of the game) is a function of history. In this respect, the present framework differs from that in Bernheim and Ray (1989).

Clearly, the notion of renegotiation-proofness (as well as the optimal sorting principle to be introduced later on) allows for coordination among the agents. In the context of lending to rural communities with close interactions, allowing for such coordination may not be too unreasonable though.

Given the lending policy of the bank, once a group receives a loan, this group has zero probability of receiving a loan in the future. Hence, the members of this group are going to behave as if they are playing a one shot game. Thus, it is sufficient to examine a one-period version of the game.

Let v_{ij} denote the expected equilibrium payoff of a type i borrower at some period $t \geq 1$ if she forms a group with a type j borrower and the group receives the bank loan at this period.

Assuming that side payments are possible, there will be positive assortative matching if and only if the maximum, a type N borrower is willing to pay to a type S borrower, is strictly less than the minimum a type S borrower will need as compensation for having a type N partner, i.e.

$$v_{\mathrm{SS}} - v_{\mathrm{SN}} > v_{\mathrm{NS}} - v_{\mathrm{NN}}. \tag{1}$$

Clearly, there will be negative assortative matching whenever $v_{\mathrm{SS}} + v_{\mathrm{NN}} < v_{\mathrm{SN}} + v_{\mathrm{NS}}$. In the case $v_{\mathrm{SS}} + v_{\mathrm{NN}} = v_{\mathrm{SN}} + v_{\mathrm{NS}}$, there is no strong justification for either positive or negative assortative matching. In general, we can expect that there will be x groups of type SN, where $x \leq \min\{\theta,\ 1-\theta\}$, and the remaining borrowers will form groups with their own types. However, for ease of exposition, we assume that in this case there will be negative assortative matching, i.e. $x = \min\{\theta,\ 1-\theta\}$.[18]

We then turn to the solution of this game. Consider some period $t \geq 1$.

Stage 3. For any borrower, her payoff from investing in her first project is $H - r$, whereas her payoff from investing in her second project is b. Given Assumption 1, both the borrowers will invest in their second projects irrespective of their type. Thus

$$v_{\mathrm{SS}} = v_{\mathrm{SN}} = v_{\mathrm{NN}} = v_{\mathrm{NS}} = b. \tag{2}$$

Stage 2. Since the borrowers always invest in their second project, the bank's expected payoff at any period from making a loan is -2.

Stage 1. Given Eq. (2), the tie-breaking rule implies that there will be negative assortative matching. Of course, the expected payoff of the bank is independent of the nature of the matching.

Summarizing the above discussion, we obtain our first proposition.

Proposition 1. *Group-lending without sequential financing is not feasible*.

In this case, default by a borrower does not affect her partner's payoff and hence, even for an S type, does not attract the social penalty. Thus, given the parameter restrictions, the borrowers always invest in their second projects, so that lending is not feasible.

Remark 1. It is clear that our analysis goes through even if $H > 2r$.

[18] Fortunately, it turns out that, whenever the borrowers are indifferent between positive and negative assortative matching, the expected payoff of the bank is independent of the nature of the matching. Hence, our basic results would still go through if we adopt a different tie-breaking rule.

3.2. Group-lending with sequential financing

In this subsection, we examine a group-lending scheme with sequential financing, but no contingent renewal. Thus, in every round, the members of the selected group receives loans in a staggered manner, but the selection of the recipient group is independent of history. We consider the following game.

Period 0. There is endogenous group-formation whereby the borrowers organize themselves into groups of two.

For every $t \geq 1$, there is a three-stage game.

Stage 1. The bank randomly selects a group and lends the selected group 1 dollar. Thus, as in the previous subsection, there is no contingent renewal.

Stage 2. One of the borrowers is randomly selected (with probability half) by the group as the recipient of the 1 dollar lent by the bank. (One can alternatively assume that this selection is done by the bank.) This borrower, say B_i, then decides whether to invest the 1 dollar in P_i^1 or P_i^2. If B_i invests in P_i^2, then B_i defaults, there is no further loan by the bank and the game goes to the next period. Note that, in case of default by B_i, B_j does not obtain the loan at all. Hence, depending on its type, B_i obtains either b or $b-s$. If B_i invests in P_i^1, then there is a verifiable return of H, out of which the bank is repaid r and B_i obtains $H-r$. We assume that $H-r<1$, so that this amount is not sufficient to finance the investment in the next stage.[19] Since we are interested in analyzing the implications of sequential financing, this assumption is a natural one to make.

Stage 3. This stage arises only if B_i had invested in P_i^1 in stage 2. The bank lends a further 1 dollar to the group, which is allocated to the other borrower, B_j, who decides whether to invest it in P_j^1 or P_j^2. Note that, in this case, default by B_j does not affect the payoff of B_i, the group-member who had received the loan earlier. Hence, if this amount is invested in P_j^2, then B_j obtains b and the bank obtains nothing. If its invested in P_j^1, then B_j obtains $H-r$ and the bank obtains r.[20]

As in the previous subsection, for $t \geq 1$, it is sufficient to restrict attention to one-shot games.

Let v_{ij} denote the expected equilibrium payoff of a type i borrower at some period $t \geq 1$, in case she forms a group with a type j borrower and this group obtains the loan at this period.

We next turn to solving this game. Consider $t \geq 1$.

Stage 3. Both types of borrowers would invest in their second projects.

Stage 2. Given that borrowers of both types default in stage 3, in stage 2, S type borrowers will invest in their first projects (Assumption 2) and N type borrowers will invest in their second projects (Assumption 1). Hence

$$\hat{v}_{\text{SS}} = \frac{H-r+b}{2}, \hat{v}_{\text{SN}} = \frac{H-r}{2}, \hat{v}_{\text{NN}} = \frac{b}{2} \text{ and } \hat{v}_{\text{NS}} = b. \tag{3}$$

Stage 1. It is easy to see that, irrespective of the nature of the matching process, the expected per period payoff of the bank is

$$\theta r - 1 - \theta. \tag{4}$$

This follows because the investment decision of a borrower does not depend on the nature of the group, but only on whether the borrower is the first recipient of the loan or not.

[19] Since $r \geq 1$, the condition that $H-r<1$ implies that $H<2r$. Thus, the assumption that $H<2r$ plays a role here as well.

[20] Alternatively, we can assume that the second borrower obtains the loan in the next period. Our analysis, not reported here, shows that this does not affect the results qualitatively. Moreover, the formulation adopted in the text is not too unrealistic. Under the Grameen Bank, for example, loans are meant to be repaid in weekly installments, with the loans to the later borrowers being released once the first few installments are made.

Period 0. Given Eq. (3), it is easy to see that group-formation would lead to negative assortative matching. Of course, the expected payoff of the bank is independent of the exact nature of the matching.

Summarizing the above discussion, we obtain our next proposition.

Proposition 2. *Sequential financing is feasible if and only if $\theta r - 1 - \theta \geq 0$.*[21]

Under sequential financing, default by the first recipient of the group-loan adversely affects her partner (who does not obtain any loan). Hence, for type S borrowers, the social capital is brought into play, so that they invest in their first projects. Thus, the moral hazard problem is resolved partially and group-lending may be feasible. Further, note that group-lending may be feasible even if there is negative assortative matching.

Remark 2. Consider the case where, in case the loan goes to a group of type SN, the S type borrower is the first recipient with probability α, $0 \leq \alpha \leq 1$. In this case, it is easy to see that

$$\hat{v}_{\mathrm{SS}} = \frac{H - r + b}{2}, \ \hat{v}_{\mathrm{SN}}(\alpha) = \alpha(H - r), \ \hat{v}_{\mathrm{NN}} = \frac{b}{2} \text{ and } \hat{v}_{\mathrm{NS}}(\alpha) = b. \tag{5}$$

Moreover, there is negative assortative matching if and only if $\alpha \geq 1/2$. Thus, somewhat surprisingly, positive assortative matching is more likely when the 'bargaining power' of the S type agents is low, in the sense that α is small.

4. Contingent renewal and sequential financing

In this section, we analyze the interaction of sequential financing with contingent renewal schemes, namely repeat lending and withholding of future loans from all group-members in case of default.[22]

4.1. Contingent renewal without sequential financing

We then consider a game where the selection of the recipient group is history dependent, but in any round, all members of the recipient group receive loans simultaneously:

In period 0, the borrowers endogenously form groups of size two. For every $t \geq 1$, there is a two-stage game with the following sequence of actions.

Stage 1. At $t=1$, the bank lends some randomly selected group 2 dollars. Next consider $t>1$. In case the recipient group at $t-1$ had repaid its loans, at t the bank makes a repeat loan to this group. In case the recipient group had defaulted at $t-1$, no member of this group ever obtains a loan, either at t or in the future. In that case, the bank lends 2 dollars to some randomly selected group (among those who had not defaulted earlier). Thus, there is contingent renewal.

Stage 2. The borrowers simultaneously make their project choice.

Let V_{ij} denote the expected equilibrium payoff of a type i borrower in period $t \geq 1$, in case she forms a group with a type j borrower and this group obtains the loan in period t.

We next turn to solving this game. The proofs of Proposition 3 below, as well as Proposition 5 later on, can be found in Appendix A.

[21] Note, for example, that $\theta r - 1 - \theta \geq 0$ if $H=4$, $r=3.1$, $b=3.5$, $s=2.9$ and $\theta=0.5$.

[22] We are grateful to an anonymous referee for suggesting that we allow for multiple loans.

Proposition 3.

(i) *If* $\delta \geq \frac{b-H+r}{b}$*, then the unique renegotiation-proof equilibrium involves borrowers of both types investing in their first projects at every period they obtain the loan.*
(ii) *If* $\delta < \frac{b-H+r}{b}$*, then the unique renegotiation-proof equilibrium involves all the borrowers investing in their second projects at every period they obtain the loan.*

Proposition 3 is quite intuitive. Consider $\delta \geq \frac{H-r+b}{b}$. It is clear that, even under individual lending, contingent renewal would lead a borrower to invest in her first project whenever she obtains the loan. The same result goes through under group-lending also, since, for an S type borrower, the incentive to invest in her first project is higher (because of social capital), whereas for an N type borrower the incentives are the same.

Next consider $\delta < \frac{b-H+r}{b}$. Under individual lending with contingent renewal, any borrower would invest in her second project whenever she gets the loan. Next let us consider group-lending. Why does not the presence of social capital upset this result? Suppose the loan goes to the group B_iB_j, where B_j is of type S. Let the borrowers coordinate on the outcome where both invest in their second projects. Given that B_i is investing in her second project, she will not obtain any more loans in the future anyway. Hence, her payoff is not adversely affected even if B_j defaults, so that such default does not attract the social penalty. Further, given that $\delta < \frac{b-H+r}{b}$, this strategy payoff dominates any other subgame perfect equilibria. Consequently, the borrowers coordinate on this outcome. Formally, this coordination is captured by our use of the notion of renegotiation-proofness.

Given Proposition 3, it is easy to see that

$$V_{SS} = V_{SN} = V_{NN} = V_{NS} = \frac{H-r}{1-\delta}, \text{ if } \delta \geq \frac{b-H+r}{b}, \tag{6}$$

$$V_{SS} = V_{SN} = V_{NN} = V_{NS} = b, \text{ otherwise.} \tag{7}$$

In case $\delta \geq \frac{b-H+r}{b}$, the borrowers always invest in their first projects and the bank has a per period payoff of $2(r-1)>0$. If, however, $\delta < \frac{b-H+r}{b}$, then the borrowers always invest in their second projects, so that the bank makes a loss.

We can now write down our next proposition.

Proposition 4. *Group-lending with contingent renewal, but without sequential financing is feasible if and only if* $\delta \geq \frac{b-H+r}{b}$.[23]

Thus, for $\delta \geq \frac{b-H+r}{b}$, the first best outcome is implemented.[24] The argument clearly relies on the trigger strategy like aspect of contingent renewal. For $\delta < \frac{b-H+r}{b}$, however, all the borrowers invest in their second projects, so that contingent renewal fails to resolve the moral hazard problem.

[23] Consider the earlier example where $H=4$, $r=3.1$, $b=3.5$, $s=2.9$ and $\theta=0.5$. Contingent renewal by itself is feasible if and only if $\delta \geq \frac{26}{35}$.

[24] This result is in contrast to Bulow and Rogoff (1989) who argue that lending cannot be sustained using a purely reputational argument. Note, however, that in our framework the borrowers consume all their current income. Hence, in contrast to Bulow and Rogoff (1989), they cannot use their income to finance future projects and are dependent on the bank in every period. We are indebted to a referee for this point.

Further, as argued earlier, under individual lending with contingent renewal, analogues of Propositions 3 and 4 go through. Thus, the presence of social capital does not affect the performance of contingent renewal schemes.

4.2. Contingent renewal with sequential financing

We consider the following game.

In period 0, the borrowers endogenously form groups of size two.

For every $t \geq 1$, there is a three-stage game with the following sequence of actions.

Stage 1. At $t=1$, the bank lends some randomly selected group 1 dollars. Consider $t>1$. In case the recipient group at $t-1$ had repaid its loans, the bank gives the group 1 dollar in this period. In case the recipient group at $t-1$ had defaulted, no member of this group ever obtains a loan in this period or in the future. Moreover, the bank lends 1 dollar to some randomly selected group (among those who had not defaulted earlier).

Stage 2. One of the borrowers is randomly selected (with probability half) as the recipient of the 1 dollar lent by the bank. This borrower, say B_i, then decides whether to invest the 1 dollar in P_i^1 or P_i^2. If B_i invests in P_i^2, then, depending on her type, B_i obtains either b or $b-s$, and the bank obtains nothing. In that case, there is no further loan in this period and the game moves to the next period. If B_i invests in P_i^1, then the bank is repaid r, B_i obtains $H-r$ and the game goes to the next stage.

Stage 3. The bank lends a further 1 dollar to the group, which is allocated to the other borrower, B_j, who decides whether to invest it in P_j^1 or P_j^2. If she invests in P_i^2, then, depending on her type, B_j obtains either b, or $b-s$, and the bank obtains nothing. If she invests in P_j^1, then the bank is repaid r and B_j obtains $H-r$.

Let $\hat{V}_{ij}$ denote the expected equilibrium payoff of a type i borrower in period $t \geq 1$, in case it forms a group with a type j borrower and this group obtains the loan in period t.

We begin by solving for the set of renegotiation-proof equilibria in stage 2 of period 1.

Proposition 5.

(i) *If $\delta \geq \frac{b-H+r}{b}$, then the unique renegotiation-proof equilibrium involves borrowers of both types investing in their first projects at every stage when they obtain the loan.*

(ii) *If $\delta < \frac{b-H+r}{b}$, then the unique renegotiation-proof equilibrium involves the S type borrowers investing in their first projects, and the N type borrower investing in their second projects at every stage when they obtain the loan.*

Let us compare Proposition 5 with Proposition 3. Critically, in this case, the S type borrowers invest in their first projects even if $\delta < \frac{b-H+r}{b}$. Thus, for the S types, the incentive to invest in their first projects is greater compared to the case where there is contingent renewal, but no sequential financing. This is because in this case default by an S type borrower adversely affects her partner (which it does not under contingent renewal alone if her partner is also defaulting). In case the S type borrower is the first recipient, her partner receives no loan in this period, as well as in the future.

Whereas if she is the second recipient, her partner obtains no loan in the future. Hence, any default by an S type borrower attracts the social penalty. Similarly, comparing Proposition 5 with Proposition 2, we find that, in case there is sequential financing alone, an S type invests in her first project if she is the first recipient, but not otherwise. Thus, the incentive to invest in the first projects is higher in case both the schemes are used in conjunction.

Propositions 3 and 5 together provide an answer to Aghion and Morduch (2005, p. 86) who ask, "Might groups collude against the microlender by collectively deciding not to repay? If the group of borrowers is not willing to impose social sanctions against itself, can the group nonetheless provide advantages?" Our analysis shows that such collusion is possible in case the discount factor is not too large and the lending scheme involves contingent renewal alone. However, in case the scheme also involves sequential financing, for intermediate values of the discount factor, such collusion is not possible and the group still has some advantages. Note that this is reminiscent of Aniket (2004) who argues that sequential financing plays a role in preventing collusion.

Given Proposition 5, we have that

$$\hat{V}_{\mathrm{SS}} = \hat{V}_{\mathrm{SN}} = \hat{V}_{\mathrm{NN}} = \hat{V}_{\mathrm{NS}} = \frac{H-r}{1-\delta}, \text{ if } \delta \geq \frac{b-H+r}{b}, \tag{8}$$

$$\hat{V}_{\mathrm{SS}} = \frac{H-r}{1-\delta}, \; \hat{V}_{\mathrm{SN}} = \frac{H-r}{2}, \; \hat{V}_{\mathrm{NN}} = \frac{b}{2}, \; \hat{V}_{\mathrm{NS}} = b, \text{ otherwise.} \tag{9}$$

Next, from Eqs. (8) and (9), there is going to be positive assortative matching if and only if $\frac{b-H+r}{b+H-r} < \delta < \frac{b-H+r}{b}$.

We then solve for the payoff of the bank. In case $\delta \geq \frac{b-H+r}{b}$, the borrowers always invest in their first projects and the bank has a per period payoff of $2(r-1) > 0$. From the tie-breaking rule, there will be negative assortative matching, though, of course, the nature of matching does not affect the expected payoff of the bank.

If $\frac{b-H+r}{b+H-r} < \delta < \frac{b-H+r}{b}$, then there will be positive assortative matching and the expected payoff of the bank is

$$\frac{2\theta(r-1) - (1-\delta)(1-\theta)}{(1-\delta)[1-\delta(1-\theta)]}. \tag{10}$$

Finally, if $\delta \leq \frac{b-H+r}{b+H-r}$, then there is negative assortative matching. Thus, the expected payoff of the bank is

$$\frac{2(2\theta-1)(r-1) + (1-\delta)(1-\theta)(r-3)}{(1-\delta)[1-2\delta(1-\theta)]}, \; \forall \theta \geq \frac{1}{2}, \tag{11}$$

$$\frac{\theta r - \theta - 1}{1-\delta}, \text{ otherwise.} \tag{12}$$

We can now write down our next proposition.

Proposition 6.

(i) *There is positive assortative matching if and only if* $\frac{b-H+r}{b+H-r} < \delta < \frac{b-H+r}{b}$.

(ii) *If* $\delta \geq \frac{H-r+b}{b}$, *then group-lending with both sequential financing and contingent renewal is feasible. For* $\delta < \frac{b-H+r}{b}$, *group-lending is feasible if and only if*

(a) $\frac{b-H+r}{b+H-r} < \delta < \frac{b-H+r}{b}$ *and* $2\theta(r-1) - (1-\delta)(1-\theta) \geq 0$, *or*

(b) $\delta < \frac{b-H+r}{b+H-r}$, $\theta \geq 1/2$ *and* $2(2\theta-1)(r-1) + (1-\delta)(1-\theta)(r-3) \geq 0$, *or*

(c) $\delta < \frac{b-H+r}{b+H-r}$, $\theta < 1/2$ *and* $\theta r - \theta - 1 \geq 0$.[25]

[25] Consider the example where $H=4$, $r=3.1$, $b=3.5$, $s=2.9$. For $\delta \geq \frac{26}{35} = \frac{b-H+r}{b}$, all borrowers invest in their first projects and group-lending is feasible. Next consider $\delta < \frac{26}{35}$. In footnote 28, we argue that a sufficient condition for group-lending to be feasible is that $\theta r - \theta - 1 \geq 0$, i.e. $\theta \geq 0.476$.

Proposition 6(i) is the central result of this paper. The intuition is as follows. For $\delta < \frac{b-H+r}{b}$, the lending policy ensures that S type borrowers invest in their first projects, whereas N type borrowers invest in their second projects. If, in addition, $\frac{b-H+r}{b+H-r} < \delta$, then contingent renewal ensures that SS type groups are very profitable, leading to positive assortative matching. Thus, in case an NN type group obtains the loan, the first recipient will default and the other N type borrower will not get a loan at all. Thus, sequential financing acts as a partial screening mechanism whereby the identity of the good and bad groups can be ascertained relatively cheaply.[26] This ensures that group-lending is feasible under the appropriate parameter values.[25]

Note that, in the presence of sequential financing, contingent renewal has a dual role. Not only does it promote positive assortative matching, it also increases the incentive to invest in the first projects. This is interesting since, for $\delta < \frac{b-H+r}{b}$, contingent renewal by itself fails to solve the moral hazard problem.

We then observe that, for $\delta \leq \frac{b-H+r}{b+H-r}$, given that the discount factor is small, SS type groups are not very attractive, so that the outcome involves negative assortative matching. Further, given that, in this case the partial screening effect does not operate, the expected payoff of the bank is lower compared to what it would have been under positive assortative matching. This, however, does not necessarily imply that group-lending will be infeasible.[25]

Given that Ghatak (1999, 2000) and Tassel (1999) demonstrate that joint liability lending leads to positive assortative matching, the possibility of negative assortative matching is of some interest. Another paper that demonstrates the possibility of negative assortative matching is Chatterjee and Sarangi (2004). They use a model with costly group-formation, where these costs are contingent on the nature of group-formation.

Given the above discussion, what should be the optimal lending policy in case $\delta \leq \frac{b-H+r}{b+H-r}$? From Proposition 4, contingent renewal lending by itself is not feasible. Next let us consider sequential financing by itself. For $\theta < 1/2$, the bank's payoff in this case is the same as that when sequential financing and contingent renewal are used together (see Eq. (12)). For $\theta \geq 1/2$, however, a combination of sequential financing and contingent renewal payoff dominates sequential financing by itself (i.e. the payoff in (11) exceeds that in (12)). This is because, for $\theta \geq 1/2$, there will be some SS type groups even under negative assortative matching. Since the S type borrowers have a greater incentive to invest whenever sequential financing and contingent renewal are used in conjunction, the result follows.

5. A non-anonymous social penalty function

Recall that so far the social penalty has been taken to be anonymous. A natural alternative may be to assume that it is imposed whenever default by an S type borrower harms other *S type borrowers*, but not otherwise. We call such a social penalty function *non-anonymous*. We next re-examine our results under this alternative social penalty function.

[26] In reality, groups have more than two members. Hence, in case sequential financing with contingent renewal leads to positive assortative matching, the partial screening effect will assume a greater significance. Further, given that all borrowers are infinitesimally small, the partial screening effect does not improve the pool of borrowers. However, in case there are a finite number of borrowers, this effect would also come into play.

5.1. Sequential financing

Consider a game that is the same as that in Section 3.2, with the difference that we now use the alternative social penalty function. It is easy to see that the analysis in Section 3.2 goes through for SS or NN type groups. However, given that the social penalty is non-anonymous, an S type borrower would behave like an N type, if her partner is an N type. Hence

$$\hat{v}_{\mathrm{SS}}=\frac{H-r+b}{2},\ \hat{v}_{\mathrm{SN}}=\frac{b}{2},\ \hat{v}_{\mathrm{NN}}=\frac{b}{2}\ \text{and}\ \hat{v}_{\mathrm{NS}}=\frac{b}{2}. \tag{13}$$

Thus, there is positive assortative matching. The expected per period payoff of the bank, however, is the same as that under the anonymous social penalty function, i.e. $\theta r-\theta-1$. In contrast to Section 3.2 though, in this case group-lending would not have been feasible without positive assortative matching.

5.2. Contingent lending

Consider a game that is the same as that in Section 4.1, with the difference that the social penalty function is non-anonymous. Recall that, for Propositions 3 and 4, the argument does not depend on the presence, and thus on the nature, of the social penalty. Thus, they go through in this case also.

5.3. Sequential financing with contingent lending

Consider a game that is the same as that in Section 4.2, with the difference that we now use the alternative social penalty function. Clearly, for $\delta\geq\frac{b-H+r}{b}$, the argument is not affected. For $\delta<\frac{b-H+r}{b}$ also, the analysis in Section 4.1 goes through whenever the borrowers are members of SS or NN type groups. However, given the social penalty function, an S type borrower would behave as an N type if she has an N type partner. Thus

$$\hat{V}_{\mathrm{SS}}=\frac{H-r}{1-\delta},\ \hat{V}_{\mathrm{SN}}=\frac{b}{2},\ \hat{V}_{\mathrm{NN}}=\frac{b}{2}\ \text{and}\ \hat{V}_{\mathrm{NS}}=\frac{b}{2}. \tag{14}$$

Hence, there is positive assortative matching if and only if $\frac{b-H+r}{b}>\delta>\frac{b-2H+2r}{b}$, with the expected payoff of the bank being given by (10). We can now write down our final proposition.

Proposition 7. *Suppose that $\delta\leq\frac{b-2H+2r}{b}$ and the social penalty function is non-anonymous. In case there is both sequential financing and contingent lending, the outcome involves negative assortative matching and, for $\theta\leq 1/2$, group-lending is not feasible. Whereas, if there is sequential financing alone, then there is positive assortative matching and, moreover, group-lending is feasible whenever $\theta r-\theta-1\geq 0$.*[27]

Proposition 7 demonstrates that putting different incentive schemes together, without giving due attention to how these might interact, may be counter-productive.[28]

[27] Consider an example where $H=4$, $r=3.1$, $b=2$, $s=1.2$, $\theta=0.5$ and $\delta=0.3$.

[28] Suppose social capital is anonymous. From Eqs., (4), (10) (11) (12), it then follows that, whenever group-lending is feasible under sequential financing alone (i.e. $\theta r-\theta-1\geq 0$), it is also feasible under a combination of social capital and contingent lending. Thus, an analogue of Proposition 7 cannot hold if social capital is anonymous.

While the result may appear paradoxical, the intuition is simple. In case there is both sequential financing and contingent lending, the combination is sufficient to ensure that, in an SS type group, both the borrowers invest in their first projects, leading to a payoff of $\frac{H-r}{1-\delta}$ for both. Whereas, if there is sequential financing alone, then, in an SS group, a borrower invests in her first project if she is the first recipient, but not otherwise (since in this case there is less of an incentive to invest in her first project). This implies that the payoff of both the borrowers is $\frac{H-r+b}{2}$. Clearly, for δ small, $\frac{H-r}{1-\delta}<\frac{H-r+b}{2}$. Hence, there is negative assortative matching in case there is both sequential financing and contingent renewal, and positive assortative matching in case there is sequential financing alone. Further, when both the schemes are used in conjunction, S type borrowers invest in their second projects whenever they have N type partners (since the social capital is non-anonymous). Hence, for $\theta \leq 1/2$, lending is not feasible. Whereas if there is sequential financing alone, then positive assortative matching implies that lending is feasible whenever $\theta r-\theta-1\geq 0$.

Finally, along with the earlier result that contingent renewal fails to harness the social capital, Proposition 7 suggests that schemes involving contingent renewal needs to be used with care, especially if the discount factor is small.

6. Discussion

In this section, we discuss the robustness of our analysis with respect to some of the modelling assumptions.

We first briefly examine the possible implications if the rate of interest, instead of being exogenous, is endogenously determined by the bank. In particular, would such flexibility allow the bank to improve the pool of potential borrowers, either by screening out 'bad' borrowers (as in Ghatak, 2000; Tassel, 1999), or by inducing more 'good' borrowers to join the pool of potential applicants (as in Ghatak, 1999)?

For simplicity, we focus on the case where $b>H-r>b-s$ and $H>r$. This may be justified as follows. If $b\leq H-r$, then the rate of interest may be too low for the bank to break even. Whereas if $b-s\geq H-r$, then borrowers of both types will default. Finally, if $H\leq r$, then not only do N type borrowers default, S type borrowers either default, or are not willing to take the loan at all.

We first observe that, since $H-r>0$, all borrowers find it profitable to borrow. Thus, all 'good' borrowers are already in the pool of potential applicants and, hence, unlike in Ghatak (1999), it is not possible to improve the pool any further by attracting more 'good' borrowers. We then examine if it is possible to screen out 'bad' (i.e. N type) borrowers. Under any equilibrium where there is positive assortative matching and the N type borrowers invest in their second project, their payoffs are independent of the rate of interest. Whereas if the equilibrium involves the N type borrowers investing in their first projects, screening them out is not required. Thus, in contrast to Ghatak (2000) and Tassel (1999), the rate of interest and the extent of joint liability cannot be used to screen out 'bad' borrowers.

We next examine the group-formation process in somewhat greater detail.[29] Recall that the optimal sorting principle presumes that side-payments are feasible. Following Ghatak (2000), we can appeal to non-pecuniary forms of transfers, e.g. providing free labor services and the use of agricultural implements, to justify side-payments.[30] Moreover, contracts involving side-

[29] We are extremely grateful to an anonymous referee for comments that encouraged us to think through this discussion.

[30] Given that, in our model, the return from the second project is non-verifiable, Ghatak's (2000) other justification that borrowers can promise to pay their partners out of the returns from the project is not applicable to our case.

payments have to be enforceable. For S type borrowers, we can appeal to the social penalty s itself, to ensure enforceability.[31] Under negative assortative matching though, formation of SN type groups would require type N members to commit to side-payments to S type borrowers. In this case, of course, we cannot appeal to the social penalty s to ensure enforceability.

In order to deal with this question, let us extend the model so that the N type agents also has some social capital, say s' . In case an N type borrower defaults, either to the bank or on side-payments, and it harms the other borrowers, the defaulter loses this social capital. In the spirit of our model, we assume that $s' < s$. Moreover, s' must satisfy $s' < b-H+r$; otherwise, an analogue of Assumption 2 will hold for the N type borrowers.

To begin with, let us examine the possibility of negative assortative matching for the case where there is sequential financing, but no contingent renewal. For SN type groups, suppose the side-payment contract states that, irrespective of whoever is the first recipient of the loan, the S type borrower has a net payoff of $\beta\hat{v}_{\mathrm{SS}}$, where β (≥ 1) is determined by the relative bargaining power of the two types.[32] Thus, the N type member commits to paying her S type partner $\beta\hat{v}_{\mathrm{SS}}$, in case she, i.e. the N type member, obtains the loan and $\beta v_{\mathrm{SS}}-(H-r)$, otherwise. Thus, for any $s' \geq \frac{\beta(H-r+b)}{2}$, the side-payment contract will be honored and there will be negative assortative matching (in footnote 21, for example, for $\beta=1.1$, $s' = 2.5$ would do).

We next consider the possibility of negative assortative matching for the case where there is both sequential financing and contingent lending. Note that, for an analogue of Proposition 5(ii) to go through, s' must satisfy $s' < b - \frac{H-r}{1-\delta}$, i.e. $\delta < \frac{b-s' -H+r}{b-s'}$. For SN type groups, suppose the side-payment contract states that, irrespective of whoever is the first recipient of the loan, the S type borrower has a net payoff of $\beta\hat{V}_{\mathrm{SS}}$. Thus, the N type member commits to paying her S type partner $\beta\hat{V}_{\mathrm{SS}}$, in case she, i.e. the N type member, obtains the loan and $\beta\hat{V}_{\mathrm{SS}}-(H-r)$, otherwise. These commitments are enforceable provided $s' \geq \beta\hat{V}_{SS} = \frac{\beta(H-r)}{1-\delta}$, i.e. $\delta \leq \frac{s' -\beta(H-r)}{s'}$. Summarizing the above discussion, we obtain the following analogue of Propositions 5 and 6.

For $\delta \geq \frac{b-s' -H+r}{b-s'}$, borrowers of both types invest in their first projects. Otherwise, the S type borrowers invest in their first projects and the N type borrowers invest in their second projects. Further, for $\min\left\{\frac{s'-\beta(H-r)}{s'}, \ \frac{b-H+r}{b+H-r}\right\} < \delta < \frac{b-s'-H+r}{b-s'}$, there is positive assortative matching, whereas for $\delta \leq \min\left\{\frac{s'-\beta(H-r)}{s'}, \ \frac{b-H+r}{b+H-r}, \ \frac{b-s'-H+r}{b-s'}\right\}$, there is negative assortative matching.

Thus, as long as s' is not too small, i.e. $s' > \beta(H-r)$, there will be negative assortative marching whenever δ is sufficiently small.[33] Even for $s' > \beta(H-r)$, however, (it is easy to check that) negative assortative matching occurs for a smaller parameter range than that in Proposition 6.

Thus, to summarize, we find that our results regarding the possibility of negative assortative matching go through qualitatively as long as s' is not too small.

Finally, we consider the linkage between social capital and social penalty. While Floro and Yotopolous (1991) emphasize the importance of social capital, Besley and Coate (1995) put more emphasis on social penalties.[34] Under our framework, however, the two are

[31] Thus, the social penalty is invoked twice, first to ensure proper project selection and second for ensuring that side payments are honored. In equilibrium, of course, the social penalty is never imposed and thus the threat can be used to enforce the side-contract.

[32] One can think of other kind of side-contracts. For example, the side-payment may take place before the loan allocation is decided, so that the S type borrower has an ex ante net payoff of βv_{SS}. This, however, does not affect our analysis qualitatively.

[33] In footnote 25, for example, for $\beta=1.1$ and $s' = 2.5$, there is negative assortative matching for all $\delta \leq 0.1$.

[34] In fact, Wydick (1999) finds that, while group-pressure is important in ensuring borrowing group performance, at least in the rural context, social ties per se are not.

complementary, rather than competitive. While the mere presence of social capital does not affect repayment rates, the presence of social capital is a necessary condition for the imposition of social penalties.

7. Conclusion

Given the widespread adoption of group-lending schemes, we need a clear understanding of the various aspects of such schemes. In this paper, we focus on some dynamic aspects of such schemes that have been relatively neglected in the literature, namely sequential financing and contingent renewal.

We show that, under the appropriate parameter configurations, there is positive assortative matching, so that the bank can test whether a group is good or bad relatively cheaply, i.e. without lending to all its members, thus leading to a partial screening out of bad borrowers. Hence, given the appropriate parameter configurations, group-lending would be feasible. Moreover, in contrast to most of the literature, there may be negative assortative matching if the discount factor is sufficiently small.

The analysis also suggests that schemes involving contingent renewal needs to be used with care. First, contingent renewal by itself may lead to collusion, thus failing to harness the social capital. Hence, it can resolve the moral hazard problem if and only if the discount factor is relatively large. Further, in case the social penalty is non-anonymous and the discount factor is relatively small, sequential financing by itself may be feasible, whereas a combination of sequential financing and contingent renewal may not be.

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Appendix A. Formal definition of renegotiation-proof equilibria

Let $x=B_iB_j$ denote all subgames starting at any node where the group consisting of the borrowers B_i and B_j has been selected by the bank as the recipient of the loan.

Let $G_x=\{g\in R^2|g$ is the present discounted payoff vector of the two borrowers in x, associated with some subgame perfect equilibrium$\}$.

Definition. Consider $R\subseteq G_x$. R is *internally consistent* with respect to some subgame x if it is non-empty and

(i) $r\in R$ implies that there is a subgame perfect equilibrium yielding the payoff vector r in x and, moreover, for this equilibrium and for every history leading to x, the continuation payoff vectors belong to R; and
(ii) for no r, $r'\in R$ it is the case that $r\gg r'$.

Definition. Let R, $R'\subseteq G_x$ both be internally consistent with respect to x. Then, R *directly dominates* R' with respect to x, i.e. $R\ d_x\ R'$, if there exist $r\in R$ and $r'\in R'$ such that $r\gg r'$. We say $\hat{R}$ *dominates* $\tilde{R}$ with respect to x, i.e. $\hat{R}\ d_x^*\ \tilde{R}$, if there exist $R_1,\cdot\ldots, R_n$ ($R_i\subseteq G_x$), all of them internally consistent with respect to x, such that $\hat{R}\ d_x\ R_1,\ \ldots,\ R_n\ d_x\ \tilde{R}$.

Definition. Consider $R \subseteq G_x$. Then R is *externally consistent* with respect to x if it is non-empty and for every other $R' \subseteq G_x$ that is internally consistent with respect to x, if $R' \ d_x^* \ R$, then $R \ d_x^* \ R'$.

Definition. $R \subseteq G_x$ is *consistent* with respect to x if it is both internally and externally consistent with respect to x.

We are now in a position to define renegotiation-proofness.

Definition. A strategy profile is *renegotiation-proof* (or *consistent*) if, $\forall x$, it supports some element of some R_x, where $R_x \subseteq G_x$ is consistent with respect to x. □

Proof of Proposition 3. Consider some subgame B_iB_j. Note that, in any subgame perfect equilibrium, if, in period N, B_i invests in her second project, then so must borrower B_j (Assumption 1). Thus, any subgame perfect equilibrium must involve both the borrowers investing in their first projects for T periods and both deviating in the next period. Thus, in any subgame perfect equilibrium of B_iB_j, the present discounted value of the borrowers payoff must be

$$\frac{(1-\delta^T)(H-r)}{1-\delta} + \delta^T b. \tag{15}$$

(i) Consider the case where $\delta \geq \frac{b-H+r}{b}$. Given the parameter configuration, the strategy where all the borrowers invest in their first projects whenever they obtain the loan constitutes a subgame perfect Nash equilibrium. We then argue that, in fact, the above strategy constitutes the unique renegotiation-proof equilibrium of this game. Note that, at the subgame B_iB_j, all continuation present discounted payoff vectors from this strategy yield $\left(\frac{H-r}{1-\delta},\ \frac{H-r}{1-\delta}\right)$. Thus, the set $A = \left\{\left(\frac{H-r}{1-\delta},\ \frac{H-r}{1-\delta}\right)\right\}$ is internally consistent. Moreover, since $\forall t < \infty$,

$$\frac{H-r}{1-\delta} > \frac{(1-\delta^t)(H-r)}{1-\delta} + \delta^t b, \tag{16}$$

the set A is externally consistent.

We finally argue that there cannot be any other renegotiation-proof equilibrium. From Eq. (16), any other internally consistent set, say A', cannot contain $\left(\frac{H-r}{1-\delta},\ \frac{H-r}{1-\delta}\right)$. Hence, A directly dominates A', whereas A' cannot directly dominate A.

(ii) We then consider the case where $\delta < \frac{b}{b-H+r}$. Given the parameter values, the strategy where all the borrowers invest in their second projects whenever they obtain the loan do constitute a subgame perfect equilibrium. Note that, given B_j is also defaulting, default by B_i does not affect B_j's payoff and hence does not attract the social penalty. Thus, the payoff of both the borrowers is b, irrespective of their types.

We then argue that the above strategy constitutes the unique renegotiation-proof equilibrium of this game. Since, at B_iB_j, all continuation present discounted payoff vector from the above strategy yield (b, b) itself, the set $B = \{(b, b)\}$ is internally consistent. Moreover, since $\forall t < \infty$,

$$b > \frac{(1-\delta^t)(H-r)}{1-\delta} + \delta^t b, \tag{17}$$

the set B is also externally consistent.

We finally argue that there cannot be any other renegotiation-proof equilibrium. From Eq. (17), any internally consistent set different from B, say B', cannot contain (b, b). However, in that case, B directly dominates B', whereas B' cannot dominate B. □

Proof of Proposition 5.

(i) Consider the case where $\delta \geq \frac{b-H+r}{b}$ band some subgame B_iB_j. Given the parameter values, the strategy where all the borrowers invest in their first projects whenever they obtain the loan does constitute a subgame perfect equilibrium. Mimicking the argument in Proposition 3(i), we can argue that the set $A = \left\{\left(\frac{H-r}{1-\delta},\ \frac{H-r}{1-\delta}\right)\right\}$ is both internally and externally consistent for B_iB_j, and, moreover, the above strategy constitutes the unique renegotiation-proof equilibrium.

(ii) We next consider the case where $\delta < \frac{b-H+r}{b}$. For any borrower of type S, at every stage where it obtains the loan, its payoff from investing in her first project is at least $H-r$, whereas her payoff from investing in her second project is $b-s$. Given Assumption 2, it is optimal for the S type borrowers to invest in their first project at every stage they get to invest. Hence, given the parameter values, it is optimal for the N type borrowers to always invest in their second projects. □

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