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PEER GROUP FORMATION IN AN ADVERSE SELECTION MODEL*

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This paper develops an adverse selection model where peer group systems are shown to trigger lower interest rates and remove credit rationing in the case where borrowers are uninformed about their potential partners and *ex post* state verification (or auditing) by banks is costly. Peer group formation reduces interest rates due to a 'collateral effect', namely, cross subsidisation amongst borrowers acts as collateral behind a loan. By uncovering such a collateral effect, this paper shows that peer group systems can be viewed as an effective risk pooling mechanism, and thus enhance efficiency, not just in the full information set up.

A well-known family of adverse selection models in the Stiglitz and Weiss (1981) tradition demonstrates that when banks are imperfectly informed about the riskiness of borrowers' projects and therefore cannot discriminate against risky borrowers, interest rates become inefficiently high, and worthy borrowers are driven out of the credit market. The extent of this problem is substantially magnified when borrowers do not have adequate collateral to secure a loan. Typically, adverse selection combined with lack of collateral leads to prohibitively high interest rates. Poorly endowed individuals (e.g. students, immigrants, the unemployed, and a vast majority of poor individuals in developing countries) often face such high rates, and therefore cannot take advantage of profitable investment opportunities.

A peer group formation system represents a possible solution to the above problem. Under this system a bank lends to borrowers without collateral on condition that the borrowers organise themselves into groups, and that participant borrowers within each group accept to take 'joint responsibility' for a loan. Thus, in addition to repaying their own share of the loan, each group member must accept to repay the obligations of their defaulting peers, otherwise the entire group is denied access to future refinancing. Systems of this kind have been very successful in practice: they have generated lower interest rates for the rural poor in, for example, Bangladesh, the Philippines, Bolivia, and the State of Arkansas in the United States. Moreover, group lending has also been successfully implemented in large urban areas such in the cities of Dhaka and Chicago.[1]

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[1] A leading peer grouping institution, namely, the Grameen Bank of Bangladesh, lends both to rural and urban borrowers at a 20% interest rate per annum. This should be contrasted with the yearly interest rates charged by the moneylenders in Bangladesh which often exceeds 100%. (See, Fuglesang-Chandler (1994), pp 30). Similar stories can be told about Bolivia, Kenya, India, Indonesia, Lesotho, Nepal, Nigeria, the Philippines, Tanzania, and China, where Grameen-style banking practices have been successfully replicated. (See, the Grameen Dialogue, March 1996).

This paper develops an adverse selection model where peer group systems are shown to trigger lower interest rates and remove credit rationing in the case where borrowers are uninformed about their potential partners and *ex post* state verification (or auditing) by banks is costly. Peer group formation reduces interest rates due to a 'collateral effect', namely, cross subsidisation amongst borrowers acts as a collateral behind a loan. By uncovering such a collateral effect, this paper shows that peer group systems can be viewed as an effective risk pooling mechanism, and thus enhance efficiency, not just in the full information set up – as in the case of village economies where informed individuals self select themselves – but also in the case of urban economies where migration flows and labour turnover are high and, thus, information about the type of potential partners is scarce.

Although our main focus in this paper is on the case where borrowers are uninformed about each others' types – whether 'safe' or 'risky' – the polar case in which borrowers' types are public information, is analysed very briefly in the Appendix.[2]

One natural interpretation of the kind of economy we consider is that of a 'urban' economy with heterogeneous, anonymous, and relatively mobile borrowers, where labour search costs are high.[3] This paper shows that, in such an economy and under a peer group system, random matching can be incentive compatible for all types of borrowers, even though group lending implies that safe borrowers will cross subsidise their risky peers with positive probability. The reason for this is that when the upper tail of the revenue distribution for risky borrowers is higher than the upper tail of the revenue distribution for safe borrowers, group lending reduces the extent to which risky borrowers can take advantage – via the equilibrium interest rate – of the safe borrowers' participation to the credit market. Relative to standard individual loan contracts, peer group systems under imperfect information may thus result in lower interest rates, and thereby encourage – or allow – the participation of safe borrowers in the credit market.[4]

Our analysis differs from the extensive literature on peer monitoring (e.g. Stiglitz (1990), Varian (1990), Banerjee *et al.* (1994), Besley and Coate (1995), and Armendáriz de Aghion (1999)) which focuses exclusively on *ex post* monitoring and loan enforcement. This literature emphasises the relative advantage of borrowers vis-à-vis banks both in monitoring their peers – due to geographical proximity and trade links – and, in enforcing loan contracts –

[2] We refer the reader to Ghatak (2000) for his parallel work on peer group formation under perfect information.

[3] We associate the 'no information' case to the urban-like scenario where individuals migrate frequently and thus have little information about their neighbours relative to the rural (village-like) economies.

[4] See the Appendix for the polar case in which borrowers are perfectly informed about each others' types. In such a perfect information case group lending is also shown to reduce the equilibrium interest rate, and to encourage the participation of safe borrowers in the credit market, but for quite different reasons. Namely, by inducing assortative matching, group lending under perfect information insulates the safe borrowers from the negative market externalities that would otherwise be imposed upon them by risky borrowers.

due to the borrowers' superior capacity to impose social sanctions. Thus, by inducing peer monitoring among borrowers, group lending can reduce interest rates and thereby mitigate the credit rationing problem.

This *ex post* approach, however, disregards the *ex ante* process of peer group formation, and, in particular, it fails to pin down the different characteristics of participant borrowers – and the corresponding information structures – which are likely to facilitate the success of peer group systems.

The present paper also departs from Armendáriz de Aghion and Gollier (1996) and Ghatak (2000) which focus on the public information case. Borrowers in this context are assumed to be perfectly informed about each others' types, and, therefore, end up matching in an assortative manner (e.g., safe with safe, risky with risky). A main implication of our analysis in this paper is that assortative matching is not necessary in order for peer group lending to be welfare improving.[5] As it turns out, as one moves away from the case of village economies by allowing for imperfect information amongst potential borrowers, assortative matching no longer obtains in equilibrium, and yet peer group lending can improve efficiency.

The reminder of the paper is structured as follows. Section 1 outlines the basic model, analyses the outcome of a standard bank-borrower contract, and pins down various credit market inefficiencies. Section 2 analyses the outcome of a peer group system under the assumption that borrowers are uninformed about each other's types. Section 3 concludes our analysis by spelling out some avenues for future research. Finally, the Appendix examines – using the same framework – the polar case where borrowers have full information about their potential partners.

1. The Basic Model and The Set of Equilibria Without Peer Groups

Consider a population of risk neutral individuals who can invest in a one period project. Investing requires one monetary unit – at the beginning of the period – which individuals do not have. They can, however, finance this investment by borrowing from a bank. The population of potential borrowers is not homogeneous: would be borrowers can either be 'safe' or 'risky', respectively, denoted by S and R. An S-borrower invests one unit of capital and obtains a cash flow h with certainty at the end of the period. An R-borrower invests one unit of capital and obtains H with probability p, and zero with probability $1 - p$. Throughout our analysis we shall assume the same expected returns for R and S-borrowers. That is: $pH = h$.[6]

The bank is competitive and risk-neutral. It incurs a cost of raising funds equal to $r \geqslant 1$, where r is one plus the interest rate at which it borrows. We assume that $h > r$ so that investment by either type of borrower is efficient.

[5] Laffont and N'Guessan (1999) obtain a similar conclusion in a model with costless auditing but where return realisations are correlated across borrowers, and where borrowers can collude in order to conceal information from the bank.

[6] In a previous version we have dealt with the more general case where $pH \neq h$.

There is asymmetric information *ex ante* in that the bank cannot distinguish between the S- and the R-borrowers. However, the bank can *ex post* observe the revenue realisation of a borrower by paying a verification cost c. As shown by Gale and Hellwig (1985), for c sufficiently large, the optimal contract is a debt contract which specifies a fixed repayment r_b to the bank, and such that the bank pays a verification cost c whenever the borrower defaults on its repayment obligation. Let π be the proportion of S-borrowers, and $1-\pi$ the proportion of R-borrowers.

In what follows we shall first analyse the benchmark case of a standard loan contract without peer groups and shall try to characterise the set of equilibria. Specifically, if only S-borrowers apply for a loan, the bank breaks even at rate $r_b = r$ because S-borrowers always reimburse with probability one. If both S- and R-borrowers apply for a loan, the bank breaks even at rate r_b such that: $\pi r_b + (1-\pi)[pr_b - (1-p)c] = r$. That is: $r_b = [r + (1-\pi)(1-p)c]/[\pi + (1-\pi)p]$. If only R-borrowers apply for a loan, the break even rate is higher: $r_b = [r + (1-p)c]/p$. Whether S-borrowers, both S- and R-borrowers, or just R-borrowers apply will critically depend upon r_b, which the borrowers take as given, as well as the value of the parameters r, h, H and p.

Suppose that the bank anticipates that both types of borrowers will request a loan. The bank will then charge the break-even rate $r_b = [r + (1-\pi)(1-p)c]/[\pi + (1-\pi)p]$. This is consistent with an equilibrium if

$$h - r_b \geqslant 0, \text{ or } h \geqslant \frac{r + (1-\pi)(1-p)c}{\pi + (1-\pi)p} \tag{1}$$

which automatically implies that

$$p(H - r_b) \geqslant 0, \text{ since } H > h. \tag{2}$$

One can immediately see that: (a) an equilibrium with only S-borrowers applying for a loan cannot exist; (b) an equilibrium where only risky borrowers apply for a loan does exist whenever $h \leqslant [r + (1-p)c]/p \leqslant H$, where $[r + (1-p)c]/p = r_b$ is the interest rate consistent with such an equilibrium.

Not surprisingly, under asymmetric information, an equilibrium may not be socially efficient. In particular, notice that it is always socially efficient to extend loans to S-borrowers since $h > r$ by assumption. Still, there are some parameter values for which S-borrowers do not obtain a loan in equilibrium. In particular, this is true for parameter values such that the cash flow of S-borrowers is less than the break-even rate $[r + (1-\pi)(1-p)c]/[\pi + (1-\pi)p]$ at which both S- and R-borrowers request a loan. And the intuition is straightforward: R-borrowers' participation triggers a higher interest rate, which in turn drives S-borrowers out of the credit market.[7]

Various mechanisms could solve the above inefficient shortage of credit

[7] In the more general case where the mean returns on the two kinds of projects can be different there exist parameter values for which there is an excess of credit in equilibrium. To see this, let us first notice that it is efficient to extend loans to R-borrowers if and only if H is larger than r/p. However, there exist equilibria where at least some R-borrowers can obtain a loan at an interest rate which is lower than r/p. Put simply, S-borrowers effectively subsidise inefficient risky projects in this latter case.

which results from a standard adverse selection problem. Output-contingent contracts are one, collateral requirements another. Output contingent contracts could force borrowers into self-selecting their contracts, but such type of contracts may require exceedingly high monitoring costs of project returns by banks, and, thus, may not be feasible. Collateral requirements could also induce self-selection as S-borrowers would be relatively less reluctant to risk their own resources. The assumption we make throughout this paper, however, is that would be borrowers do not have any resources of their own at the beginning of the period. Thus, collateral requirements are ruled out as a feasible mechanism.

The mechanism that this paper focuses on is peer group formation. For simplicity we shall focus on peer groups involving only two potential borrowers. A bank requests that would be borrowers form pairs. Each pair is held jointly responsible for the loan. That is, in addition to repaying her own share of the debt, each individual in the pair repays the share of her defaulting partner, or else both individuals are excluded from future refinancing.

2. Peer Group Formation Under Private Information

Throughout this section we shall assume that a would be borrower knows her own type, but has no *ex ante* information about the other borrowers' types. We also assume that search costs are prohibitively high, so that potential borrowers are forced to pair randomly. Moreover, since prior to the realisation of projects' returns borrowers do not have any resources of their own, *ex ante* side monetary transfers are ruled out. Finally, based on the above discussion we also assume away *ex post* output-contingent contracts between the borrowers. The timing of events can be described as follows:

- At time 1, borrowers form random pairs.
- At time 2, each pair decides whether or not to request a loan.
- At time 3, banks compete à la Bertrand to finance the pairs that request a loan. In equilibrium, banks end up charging the same break-even rate r_b to all pairs of borrowers.
- At time 4, production takes place. Nature decides about return realisations, and the banks are reimbursed according to the joint liability clause.

We shall distinguish between two types of equilibria: a first equilibrium where only S-borrowers are willing to request a loan. We shall refer to this equilibrium as a *separating* equilibrium $\{(S, S)\}$, since only safe pairs are formed. A second equilibrium where both S- and R-borrowers are willing to request a loan. We shall refer to this equilibrium as a *pooling* equilibrium $\{(S, S); (S, R); (R, R)\}$ since all kinds of pairs would be allowed into the credit market.

First, it is easy to show that, because the mean returns on both types of borrowers are the same, a separating equilibrium simply does not exist. For if it did, then, the break even interest rate would be $r_b = r$ and the existence of a separating equilibrium would lead us to the inequalities $h \geqslant r > H$ which, in turn, contradicts the assumption that $pH = h$.[8]

Now, consider a pooling equilibrium where both types of individuals request a loan. In this case, the break even loan rate is such that

$$\pi^2 r_b + 2\pi(1-\pi)\left\{ pr_b + (1-p)\left[\min\left(r_b, \frac{h}{2}\right) - c|_{h/2<r_b}\right]\right\}$$
$$+ (1-\pi)^2\left\{ p^2 r_b + 2p(1-p)\left[\min\left(r_b, \frac{H}{2}\right) - c|_{H/2<r_b}\right] - (1-p)^2 c\right\} = r \quad (3)$$

which can be explained as follows: the probabilities of having a pair (S, S), (S, R) or (R, R) are, respectively, equal to π^2, $2\pi(1-\pi)$ and $(1-\pi)^2$. If there are two S-borrowers in a pair, the default risk is zero. If there is one R-borrower and one S-borrower, the loan is fully reimbursed with probability p. With probability $1-p$, the R-borrower defaults. And, due to joint responsibility, the bank can extract a repayment from the S-borrower on behalf of his defaulting partner. But the S-borrower cannot repay more than $h/2$ per dollar borrowed. Finally, if the two R-borrowers form a pair, both projects will be simultaneously successful with probability p^2. With probability $2p(1-p)$ only one project succeeds, in which case the bank will get the $\min(r_b, H/2)$ per borrower. And with probability $(1-p)^2$ the two projects are unsuccessful in which case the bank does not get anything.

The two 'min' terms in (3) capture the *collateral* effect of peer group formation: the presence of these two terms allows for a reduction of the break even rate which can, in turn, potentially eliminate the credit rationing problem of safe borrowers in the absence of peer groups. Specifically, let us suppose that H is larger than $2r_b$, i.e. that an R-borrower who is 'lucky' is able to repay the loan of her 'unlucky' partner. Given this assumption, two cases are to be considered.

Suppose first that h is larger than $2r_b$. Then, (3) yields

$$r_b = \frac{r + (1-\pi)^2(1-p)^2 c}{1-(1-\pi)^2(1-p)^2} \quad (4)$$

where the denominator on the RHS is simply probability of no default by a pair. Notice that r_b is less than $[r + (1-p)c]/[\pi + (1-\pi)p]$. This, again, captures a 'collateral effect'. Put simply, the reduction in the loan rate is a direct consequence of the bank effectively transferring part of the default risk onto the peer group.

A necessary condition for such a pooling equilibrium to exist is that S-borrowers actually request a loan, i.e. that

[8] More generally, if the mean returns on the two types of projects were allowed to differ, a separating equilibrium $\{(S, S)\}$ would exist whenever S-borrowers only obtain a loan without peer groups, i.e. if and only if $h \geqslant r > H$. In particular, no separating equilibrium $\{(S, S)\}$ can solve inefficient credit rationing.

$$\pi(h - r_b) + (1 - \pi)[p(h - r_b) + (1 - p)(h - 2r_b)] \geqslant 0. \tag{5}$$

With probability π, the peer is an S-borrower and, thus, does not generate a joint responsibility risk. With probability $(1 - \pi)$, the peer is an R-borrower, and, thus, generates a joint responsibility risk. Condition (5) can be rewritten as follows:

$$h \geqslant [1 + (1 - \pi)(1 - p)] r_b, \tag{6}$$

or, equivalently, using (4):

$$h \geqslant \frac{r + (1 - \pi)^2(1 - p)^2 c}{\pi + (1 - \pi)p}. \tag{7}$$

This shows, first, that the reduction in the break even rate, due to the collateral effect, is just compensated by the joint responsibility risk incurred by S-borrowers. Indeed, if c was equal to zero the critical level of h at which S-borrowers request a loan would be the same as that without peer groups! However, group lending under joint responsibility reduces the expected monitoring cost incurred by the bank as it reduces the probability of default. Indeed, we have that $[r + (1 - \pi)^2(1 - p)^2 c]/[\pi + (1 - \pi)p]$ is smaller than $[r + (1 - \pi)(1 - p)c]/[\pi + (1 - \pi)p]$.

PROPOSITION 1. *Suppose that potential borrowers do not have information about each other's type, and that the returns generated by S-borrowers are high enough that they can always repay for their defaulting partners. Then, if there is no auditing cost, peer group formation does not solve inefficient credit rationing. If the auditing cost is positive, peer group formation can solve inefficient credit rationing because it reduces the probability of audits.*

Now, suppose that $h < 2r_b$, so that S-borrowers cannot repay the entire debt of their defaulting partners. Using (3), we have

$$r_b = \frac{r - \pi(1 - \pi)(1 - p)h + 2\pi(1 - \pi)(1 - p)c + (1 - \pi)^2(1 - p)^2 c}{[\pi + (1 - \pi)p]^2 + 2(1 - \pi)^2 p(1 - p)}. \tag{8}$$

A necessary and sufficient condition for a pooling equilibrium to exist, i.e., for both types of borrowers to participate given the interest rate r_b, is simply:

$$\pi(h - r_b) + (1 - \pi)p(h - r_b) \geqslant 0 \tag{9}$$

or, equivalently, using condition (8):

$$h \geqslant E_1 = \frac{r + 2\pi(1 - \pi)(1 - p)c + (1 - \pi)^2(1 - p)^2 c}{\pi + (1 - \pi)p + (1 - \pi)^2 p(1 - p)}. \tag{10}$$

Notice that the denominator in the RHS of this expression is greater than $\pi + (1 - \pi)p$. Therefore, whenever $E_1 \leqslant h < E_2$ where $E_2 = [r + (1 - \pi)(1 - p)c]/[\pi + (1 - \pi)p]$, S-borrowers that were credit rationed in the standard lending case will be able to access credit under a peer group system.

Our analysis in this section can be summarised as follows:

PROPOSITION 2. *Suppose that potential borrowers ignore each others' type. Then, provided h is not too large so that S-borrowers do not fully incur the cost of repaying for risky partners, a pooling equilibrium* $\{(S, S); (S, R); (R, R)\}$ *may exist which solves inefficient credit rationing,*[9] *whenever* $h \in [E_1, E_2]$.

Hence, the collateral effect in peer group systems can potentially counteract the joint responsibility effect. The intuition as to why group lending under imperfect information improves efficiency in this case is the following: whilst group lending implies that both risky *and safe* borrowers may match with risky borrowers, whenever a risky partner fails then a safe borrower suffers relatively less than a risky borrower. In fact, in this particular case where $h < 2r_b < H$, if her partner fails, a safe borrower loses less than the full amount of the partner's debt, whilst if her partner fails a risky borrower can – and has to – pay the full amount of the partner's debt.[10] In fact, what group lending does in this case is to make repayment rates be random for both types of borrowers, but it does so in a way that reduces the extent to which risky borrowers can take advantage of being pooled with safe borrowers in the same – unsegregated – credit market whilst at the same time saving on auditing costs.[11]

We conclude our analysis in this section with the following two remarks. First, in comparing between standard lending and peer group lending we have somewhat disregarded the banks' standpoint. That is, we have not attempted to answer whether banks, when given the choice amongst various contracts, will actually choose a peer group contract over an individual (bank-borrower) contract. Our assumption about banks being competitive allows for a trivial answer to this question: for parameter values such that lending will take place in equilibrium with and without peer groups, the bank will be indifferent between these two contracts since it breaks even in either case. However, for parameter values such that lending takes place only with group lending, and under the implicit assumption that being in operation provides a positive private benefit to the bank manager, the bank will be unambiguously better off under a group lending regime. Now, what about if we allow for groups of size $n > 2$, and assume that banks can compete on the size of peer groups to which they can lend? This is a somewhat difficult question which we leave for future research.

Second, we have assumed away penalties which the bank could impose in order to ensure debt repayment. Introducing default penalties would not affect our results. First, when $h > 2r_b$, setting a very large default penalty guarantees that an S-borrower, when paired with an R-borrower, will fully

[9] This equilibrium is not unique. There also exist other equilibria which do not improve upon the equilibrium outcome without peer grouping, including semi-separating equilibria in which only a fraction of risky borrowers requests a loan (See, Armendariz de Aghion and Gollier (1996)) .

[10] We are very grateful to a referee for suggesting this precise intuition for our main result.

[11] In particular, group lending can be shown to improve upon random individual lending contracts: whilst these also reduce the extent to which risky borrowers can take advantage of safe borrowers, they also result in higher auditing costs for the bank. In order to cover the corresponding extra cost of auditing, the bank may then have to charge an interest rate which will again deter one group of borrowers from participating.

cover the debt repayment obligation of her risky partner whenever the latter is 'unlucky', and, therefore, the individual rationality constraints for the bank and for the *S*-borrowers will again be expressed by (4) and (6) respectively. When $h < 2r_b$, the bank will find it optimal to offer a debt contract to each peer group whereby: (i) a very large penalty P_o is imposed upon the peer group if no repayment takes place, and (ii) a positive penalty q_o is imposed upon the group if only h ($< 2r_b$) is repaid to the bank. The penalty q_o may take the form of asset liquidation as in Hart and Moore (1989) or of non-renewal of loans as in Bolton and Scharfstein (1990). However, if there is no alternative use for the borrowers' assets then the IR-constraint of the S-borrowers will still be expressed by the above condition (9). On the other hand, if there is an alternative use for those assets, and L_o denotes the opportunity cost of liquidation, then (9) must be replaced by $\pi(h - r_b) + (1 - \pi)p(h - r_b) - (1 - p)L_o \geqslant 0$, where $L_o > r_b - h/2$ if we want to avoid non repayment by *S*-borrowers. (In particular, $L_o \geqslant r/p$ will do). In any case, insofar as safe borrowers remain protected by limited liability, Proposition 2 will continue to hold.

3. Concluding Remarks

In this paper we have argued that peer group systems can lower interest rates and circumvent credit market inefficiencies *even* in the case where borrowers are imperfectly informed about each others' types and *ex post* auditing by banks is costly. In particular, the scope for peer group replications goes beyond the perfect information case briefly considered in the following Appendix. Success in the no information case is due to a collateral effect whereby group lending reduces the negative externalities from risky to safe borrowers; whereas in the full information case it is due to a self selection effect whereby group lending simply insulates safe borrowers from potentially risky partners. We believe that financial intermediaries targeting the poor may find this distinction useful when attempting to design their optimal group lending policies.

Our framework could be extended to account for the possibility of (costly) information acquisition by borrowers about their peer's types. We know that information about potential partners is not free, even in village economies. Yet, recent reports suggest that, prior to the disbursement of the first loan by a peer group institution, would be borrowers undergo an initial period of search and recognition.[12]

Lastly, non assortative matching outcomes such as the ones highlighted in this paper, deserve further consideration. In our model, non assortative matching equilibria emerge naturally in the no information case where borrowers match with each other randomly, in a one period set up. Our conjecture is that non assortative equilibria could emerge sequentially in an extension of our model to a multiperiod set up, and that those equilibria could

[12] For a detailed description of such an initial process of search and recognition, see Yunus (1994), p. 4.

co-exist with assortative matching equilibria. Which of those two outcomes would be more robust to a multiperiod extension of our model, remains to be formally analysed. Such an analysis can undoubtedly be useful for policy design.

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Appendix: Peer Group Formation Under Complete Information

In this Appendix we want to complete our analysis of group lending in the no information case briefly, with the polar case where borrowers have perfect information about each other, but where the banks do not share this information. The timing of events is the same as before, except that we now add a preliminary stage at which agents observe each other's type.

We do not formalise the peer-group formation subgame. We just assume that its outcome is stable in that each of the would be borrowers in a pair is always better off by staying in the pair, as opposed to leaving the pair in order to go and search for another peer. Under complete information, this search process leads to assortative matching in the selection of peer members.[13] In other words, the only potential equilibria are, respectively, $\{(S, S)\}$, $\{(R, R)\}$ and $\{(S, S); (R, R)\}$; i.e., involve assortative matching. Our focus is in the latter equilibria which involves all types of borrowers participating to the credit market.

Observe that in this equilibrium banks do not extract any information from borrowers. Banks face exactly the same kind of uncertainty on the type of pairs as in the absence of peer groups, as they cannot discriminate between safe and risky pairs.[14]

Formally, the break even loan rate corresponding to such an equilibrium satisfies the following condition:

$$\pi r_b + (1-\pi)(p^2 r_b + 2p(1-p)\left[\min\left(r_b, \frac{H}{2}\right) - c|_{H/2<r_b}\right] - (1-\pi)^2(1-p)^2 c = r. \tag{11}$$

The pair applying for a loan is safe or risky, respectively, with probability π and $1-\pi$. If it is risky, only partial reimbursement will take place if at least one project is successful.

[13] Indeed, suppose that there are two heterogenous pairs (S, R) in the partition. This would not be stable because each of the two S-borrowers would be better off quitting their current R-counterpart, and, instead, forming a new pair together. Because R-borrowers do not have any wealth at the beginning of the period, and because we are ruling out output-contingent contracts, R-borrowers are unable to retain S-borrowers in the pair.

[14] The main difference here compared to our analysis in the no information case is that the only externality borne by S-borrowers works through the loan rate r_b. More precisely, S-borrowers do not bear any default risk, since the matching of borrowers is assortative. In this respect, S-borrowers do better by having full information. On the other hand, banks are less well insured. Indeed, the joint liability clause is less effective since R-borrowers only match with R-borrowers and, therefore, the scope for cross-subsidisation is limited. This yields a relatively higher break even rate compared to the case where borrowers had no information about the type of their potential peers.

This is true with probability p^2 and $2p(1-p)$. Obviously, it implies that r_b is strictly larger than r.

The necessary and sufficient conditions for an equilibrium $(\{S, S\}, \{R, R\})$ to exist, can then be expressed as

$$h - r_b \geqslant 0, \tag{12}$$

and

$$p^2(H - r_b) + p(1-p)\max(0, H - 2r_b) \geqslant 0. \tag{13}$$

When $H > 2r_b$, (13)-(15) imply:

$$h \geqslant \frac{\max(2p, 1)[r + (1-\pi)^2(1-p)^2 c]}{\pi + (1-\pi)p(2-p)}. \tag{14}$$

In particular, for $p \leqslant \frac{1}{2}$, the RHS (14) is obviously smaller than the break even interest rate in the absence of peer groups, so that for $h \in ([r + (1-\pi)^2(1-p)^2c]/[\pi + (1-\pi)p(2-p)],\ [r + (1-\pi)(1-p)c]/[\pi + (1-\pi)p])$, peer group systems with complete information (and therefore assortative matching) solve the credit rationing problem.

Interestingly, and in contrast with the non-information case analysed previously, group lending now solves the rationing problem even when $H < 2r_b$. For in this case, the break even rate r_b is determined by the equation

$$\pi r_b + (1-\pi)[p^2 r_b + p(1-p)H - 2p(1-p)c] - (1-\pi)^2(1-p)^2 c = r \tag{15}$$

or equivalently:

$$r_b = \frac{r - h(1-p)(1-\pi) + 2(1-\pi)p(1-p)c + (1-\pi)^2(1-p)^2 c}{\pi + (1-\pi)p^2}. \tag{16}$$

A pooling equilibrium with $H < 2r_b$ will exist whenever $r_b \leqslant h \leqslant 2pr_b$, which for $p > \frac{1}{2}$ defines a non-empty interval of h parameters for which S-borrowers were credit rationed in the absence of peer group formation and will now participate under peer group systems with complete information.

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