Information and Enforcement in Informal Credit Markets

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Abstract

We study the problem of loan enforcement in an informal credit market with limited information flow. Specifically, credit histories of borrowers are not available, raising the possibility of endemic default. We show that if there is some minimum proportion of "natural defaulters" in the population, then there exists an equilibrium characterized by certain simple behavior rules for lenders and borrowers. The equilibrium is unique if certain restrictions are placed on strategies. This equilibrium takes the form that lenders must advance a "small" amount of credit (possibly at a high interest rate) to first-time borrowers. Credit limits are relaxed and the relationship is continued, conditional on repayment. We call this phenomenon *micro-rationing*. We then introduce the possibility of *macro-rationing*: the temporary exclusion of some borrowers from any source of credit. We show that in this case, (i) our "simple" equilibrium always exists regardless of the proportion of natural defaulters; though (ii) micro-rationing is always present in equilibrium, while (iii) macro-rationing arises if and only if the proportion of natural defaulters lies below a certain threshold. Finally, we show that if lenders have the option of privately collecting information on the credit histories of new clients, multiple equilibria in information collection could arise. Consequently, it is possible to interpret limited client information in informal credit markets as coordination failure among moneylenders.

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1. Introduction

There is a common belief among development economists that the markets for international debt markets and informal village credit have more to do with each other than with the formal credit market in developed countries. In both the first two cases — and often in stark contrast to the third — there is little reliance on a court of law, and equally little faith in the ability to seize collateral. Rather, lenders often supervise borrower activities (and invest resources in debt collection), and the main deterrent to default is the threat that no future loans will be forthcoming, sometimes enhanced by the fear of community sanctions.

Informal rural credit markets, which have operated for centuries, have traditionally relied on the means described above to ensure loan recovery. Moneylenders often monitor borrowers' actions closely and visit their farms before the harvest, making it difficult for the borrower to make off with the proceeds of the invested loan without making any repayment. In addition, there is the fear of losing access to credit in the future, which is probably the strongest deterrent of all. While such an instrument is easily available to a monopolist lender, the incentives to comply can still be strong in informal markets with multiple sources of credit. For instance, Udry's (1990) study of credit markets in northern Nigeria shows how default attracts strong censure from the community, and possible stoppage in dealings with other community members.[1]

To be sure, the enforcement problem is not limited to informal credit alone. Symmetric insurance relationships have often been modeled with the enforcement constraint in mind (see, e.g., Coate and Ravallion (1993) or Ligon, Thomas and Worrall (2001)). There is also a literature on contractual compliance; see, e.g., Greif (1993) for a description of compliance issues in medieval trade.

It is *imperative* to note, however, that the effectivity of these enforcement policies critically depends on the flow of information. It is true that an affronted lender will be aware of a borrower's misdemeanors, and may take steps to cut off future credit to that borrower. But if there are other lenders who are active, more is required: there must be some degree of information-sharing among lenders regarding their clients, and consequently some kind of public knowledge about individual borrowers' credit histories. To be sure, there still remains the question of making sure that all the agents act in the required way to make the credit market run (see, for instance, the large-population models analyzed by Kandori (1992)), but this is all conditional on the information being actually available.

The ease of information flow is a plausible assumption for immobile, insular village societies. Indeed, this plausibility creates the parallel with soveriegn debt markets in the first place. Our contention is, however, that mobility and anonymity in developing societies is on the rise, and that this may result in reduced information flow. In fact, the more general possibility that information flow follows a U-shape with respect to the level of "development" (the latter measured, for instance, by the degree of industrialization or per-capita GDP) is an intriguing and important hypothesis that deserves serious empirical attention.

In particular, several recent case studies for the informal credit market suggest that for present-day developing countries (even in their rural areas) information flows may be pretty bad, or at least very costly. Aleem's (1993) study of the Chambar region of Pakistan reveals

[1] The parallel to sovereign debt is, of course, unmistakeable. See Eaton and Gersovitz (1981) for the pioneering analysis of this issue.

that there are as many as 60 different moneylenders serving the local informal credit market, which envelops several villages over a large radius. The same study also records the fact that collecting information on new clients from other lenders is a highly costly activity, and such information sharing probably remains incomplete, as evidenced by lenders' reluctance to lend large sums even to clients on whom some enquiries have been made. Studies by Siamwalla et al (1993) on Thailand and Bell (1993) on India reveal a similar emerging pattern: credit markets with many lenders and weak informational links between them.

Our aim in this paper is to analyze some implications of the reduced information-flow assumption. A central issue is that absent punishment, credit markets must break down. Where, then, do punishments come from when information is missing? One possibility is to extend an efficiency-wage argument of the sort analyzed in Shapiro and Stiglitz (1984), in which some part of the population is "involuntarily excluded" from the credit market. The possibility of having to join this arbitrarily excluded pool may then retain incentives, in the absence of any information flow whatsoever. While we allow for this feature, our main focus is elsewhere. We stress the heterogeneity of borrower types, and the need for a lender to screen them through the use of an initial testing phase in the credit relationship. The main insight is that the presence of such a testing phase may serve as a punishment for would-be deviators in the mature phase of their credit relationship. Once we understand that there would be no need for a testing phase if there were no bad types around, we may conclude that the presence of such types actually helps to stabilize credit markets.

Specifically, we consider a model with many borrowers and lenders, and study repeated borrowing to finance working capital requirements. We introduce borrower heterogeneity: while one group of borrowers value future payoffs (i.e, have positive discount factors), the rest are myopic and are concerned with current payoffs alone (we call these good and bad borrowers respectively). A borrower's type, as well as his credit history, is not known to a lender who has never dealt with him in the past. However, since bad borrowers always default, while good ones meet their obligations (in equilibrium), such information is revealed to the lender after one period of interaction.

We show that the presence of bad borrowers, and the associated hazard of lending to unknown clients, can create a mechanism for the market to function. Due to high default risk, only small "testing loans" are advanced to first-time borrowers. Repayment of the loan signals a good type, and leads to a continuation of the relationship, relaxing of the credit limit, (in some cases) a drop in the interest rate and an increase in borrower payoff. It is this testing phase which ultimately preserves a good borrower's incentive to repay his debt. Default at any stage leads to termination of the existing credit relationship, and the need to go through a painstaking testing period with another lender, during which the volume of credit is not only severely restricted, but also costly. The imputed losses from the latter may outweigh the temporary gain from default. We find that if the proportion of bad borrowers in the population is above a certain threshold (so that the initial caution is strong enough), then there exists an equilibrium in simple, stationary symmetric strategies that sustains positive (but less than first-best) amounts of borrowing and lending in the market. The model is set up and the above results derived in Sections 2–5.

The rationing of credit to first-time borrowers is referred to as *micro*-rationing in this paper. In Section 6, we introduce the possibility of another kind of rationing—the rationing of *borrowers* as opposed to *borrowing* (we call this *macro* rationing). Macro rationing arises when lenders discriminate among otherwise identical agents, and lend to some new loan applicants but not others. [This is the involuntary-exclusion phenomenon alluded to above.] We show that when both forms of rationing are allowed in the model, the existence of equilibrium (of the type selected by us) is guaranteed for all parameter values. While micro rationing is an intrinsic feature of every equilibrium, macro rationing arises only if the proportion of bad borrowers is too low.

Section 7 carries out a further extension of the model, endogenizing the information structure. We allow lenders the *option* of incurring a cost to collect information on a new client's credit history, before deciding whether to lend to him. Such information has two aspects: it leads to better screening for the lender who incurs the cost, and it tightens incentive constraints for borrowers (by making default more widely detectable, and hence more costly). Our analysis shows that the second aspect also creates strategic complementarities across lenders: there is a greater incentive to collect information and screen if other lenders are doing so. For intermediate values of the cost of information, there are multiple equilibria: one in which no lender screens her clients, another in which everyone does. Thus, information failures in credit markets (regarding borrower credit histories) can be interpreted as an outcome of coordination failure among lenders.

Proofs of all propositions are collected in the Appendix.

We end this introduction by citing closely related research. In the context of credit markets, a paper that asks similar questions (regarding information and enforcement) is Hoff and Stiglitz (1998). In their model, repayment is assured through a combination of private collection efforts and the threat of reputational loss in case of default. The departure from the earlier literature lies in their recognition that the strength of the reputational factor depends on the degree of information sharing, which in turn varies with the number of lenders in the market. It is this emphasis on information flow that the two papers have in common, though in the exercise that follows we emphasize entirely different features.[2]

Ghosh and Ray (1996), Kranton (1996) and Watson (1999) analyze bilateral matching models of population games with no information flows among players. Moreover, the general notion that limited information may entail the gradual build-up of a relationship is present in these papers, as well as in the earlier contribution of Datta (1993) and the more recent work of Lindsay, Polak and Zeckhauser (2000). None of these models, however, are directly applicable to the present context, because the stage game in this paper exhibits one-sided rather than two-sided moral hazard. Moreover, our paper contains an explicit model of market interaction (in which lenders compete for borrowers and dissipate all rents upfront), instead of a matching framework which all the above citations employ. Finally, in this paper we endogenize (to some extent) the information structure itself. Thus, while our results complement the findings of

[2]In the Hoff-Stiglitz model, government programs such as provision of subsidized formal credit to moneylenders, could create entry or exit from the moneylending business, thereby changing the informational structure of the market, which in turn affects the resources to be spent on private collection activity, and hence the rate of interest (sometimes in a perverse way). In contrast, we focus on a distinct— though complementary — mechanism through which the market may prevent default (relying on the two forms of credit rationing mentioned above). Similarly, while — like Hoff and Stiglitz — we consider endogenous informational structures, we emphasize the dependence of such structures on the information collection decisions of individual lenders (as opposed to exogenous entry or exit). Thus we focus on the private-cum-public good aspect of this kind of information, which gives rise to the intriguing possibility of multiple equilibria for some parameter values.

these papers, they must be entirely derived on their own, and rely heavily on the credit-market structure that is fundamnental to this exercise.

2. Description of the Model

2.1. Production.

2.1. Production. Consider a credit market consisting of M moneylenders and a continuum of borrowers. Loans finance working capital, with a twice continuously differentiable production function given by $F(L)$, where L is the size of the loan. We impose familiar restrictions on the production function:

$$F(.) \geq 0, F^{'}(.) > 0, F^{''}(.) < 0, F^{'}(0) = \infty \text{ and } F^{'}(\infty) = 0 \tag{1}$$

We assume that only borrowers have access to this production function and not lenders. Lenders, on the other hand, can lend money at a constant opportunity cost of r per dollar lent. No individual lender is capacity constrained.[3]

2.2. Preferences. The model is dynamic, set in discrete time. All agents live for an infinite number of periods, and maximize discounted sum of expected monetary payoffs. Lenders have a discount factor of β. Borrowers in this model come in two different "types"—a fraction π^* of all borrowers are patient and have a discount factor $\delta > 0$. The rest of the borrowers are completely myopic, i.e, have a discount factor of zero. We shall often refer to borrowers of the former type as "good" ones, and those of the latter type as "bad" ones. In our model, loans are not collateralized, nor is there a legal machinery that enforces contracts. Hence, repayment can be achieved only through incentives. Since bad borrowers place no stake on future payoffs, these borrowers always default on any loan contract. Moneylending can be profitable only if loan contracts are designed in such a way as to induce good borrowers to repay.

We make the additional assumption that borrowers have no access to a saving technology, and cannot carry over funds from one period to the next. Hence, they have to rely on the credit market every period for their working capital needs. The model could be made more realistic, at the cost of complicating the analysis, by allowing for saving, but specifying a stochastic production function with some probability of crop failure. The borrower will then have to return to the credit market infinitely often, and cannot operate by merely recycling an initial pool of funds. We believe that the spirit of our results will be preserved in such an extended model.

2.3. Information. We assume that there is no pool of public information about individual borrowers' credit histories—a lender, on facing a new client, knows nothing about the latter's past behavior, including any incidence of default. Knowledge about a borrower's characteristics can come only through dealing with him personally, though such knowledge acquired by one lender cannot be passed on to another. This assumption is admittedly extreme, but the motivation behind it is discussed at length in the introduction. In section 7, we extend the basic model and allow lenders to collect (costly) information on new clients' credit histories, if they *choose*.

[3] A natural interpretation of r is that it is the rate at which a lender can borrow from formal sector institutions. Since formal sector loans are usually collateralized, not everyone can be a lender.

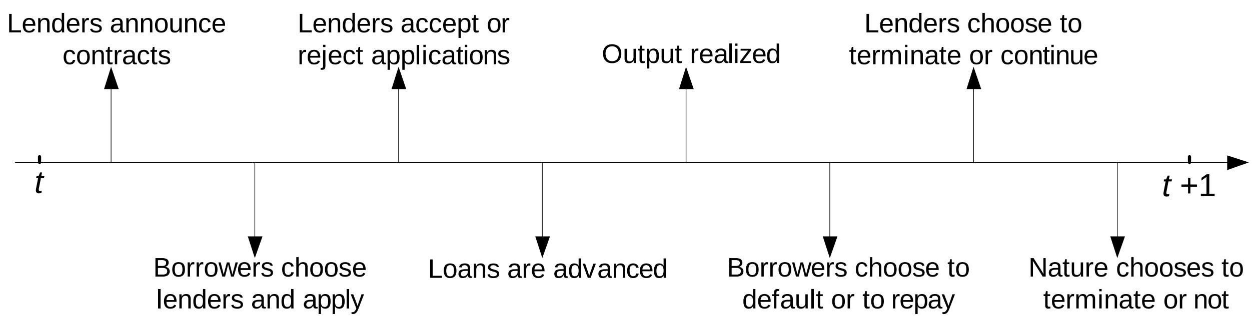

Figure 1. The Sequence of Moves.

2.4. **Timing and moves.** We now sketch out the exact sequence of moves by various parties. At the beginning of each period, lenders simultaneously announce or offer credit contracts to all borrowers in the market. Each contract has the form (L, R), where L is the loan offered, and R is the repayment asked for. Lenders commit to the announced contracts for one period. It is assumed that commiting to longer term contracts is not possible.

At every date, a lender faces two groups of clients: "new borrowers" and "old borrowers". Old borrowers are those with whom she has dealt in the past. The rest are new borrowers, i.e, first time clients[4]. Lenders can, and usually will, offer different contractual terms to new and old borrowers, since the information available on the two groups are not the same.

After lenders announce contracts, each borrower selects one lender [5] and applies for a loan on that lender's announced terms. In sections 2 through 5, we will assume that all applications are automatically accepted. However, in sections 6 and 7, we will give lenders the power to reject some credit applications. In section 6, such rejections will be used randomly by lenders

[4]We assume, for technical reasons, that if a borrower leaves a lender and borrows from someone else, but returns later, the lender cannot identify him and treats him as an agent with whom she had no past interaction. With a continuum of borrowers, and under the particular equilibrium we focus on, this is a zero probability event at any rate.

[5]We assume exclusivity, i.e, each borrower can receive credit from only one lender in any given period. This assumption is crucial for the analysis, and seems to be justified by standard practice in informal credit markets. How borrowers guarantee exclusivity is a question we do not address; see Siamwalla et al. (1993) for some interesting accounts from field studies.

in equilibrium. In section 7, lenders will reject those applicants whose background checks reveal negative information. A borrower whose loan application has been rejected must wait till the next period to approach another lender and make a fresh application (such delay can be attributed to the review and processing time for the first application). Applicants who are accepted get loans right away.

After the loan is advanced, the money invested, and the proceeds realized, borrowers decide whether to repay the promised amount R, or whether to default. Lenders respond by either terminating relationship with the borrower, or continuing it. Even if the lender decides to continue, Nature may yet choose to break up the relationship with probability θ for exogenous reasons. After this, the period ends and the next period starts, and a fresh round of credit contracts is offered. The sequence of actions taken within any given period is depicted in Figure 1.

2.5. **Equilibrium Selection and Payoffs.** Perfect equilibria of this model are numerous, including the trivial one in which no lending activity takes place. We feel that not all of these equilibria are equally plausible. It seems that equilibria involving "social norms" and simple "rules of behavior" that stay unchanged over time and condition on the barest minimum eventualities are the natural focal points in this type of a situation which involves a very large number of agents. Therefore, we restrict attention to equilibria with the following properties:

(1) All lenders adopt the same stationary strategy. The same is true for all borrowers (of the same type).
(2) Lender's strategies are "simple", in the sense that they condition on only three different kinds of information—(i) whether a borrower is new to her (call him an N-borrower) (ii) whether a borrower is an old one (an O-borrower), with a perfect repayment history, and (iii) whether a borrower is old (O-borrower), but with a history of default.
(3) Call a particular lender's interaction with a new borrower the N-Phase, and her interaction with an old borrower who has repaid his debt, the O-Phase. We require that in the class of equilibria satisfying (1) and (2), the one we select should give the *lender* the maximum discounted payoff (obtained from the individual borrower) in the O-Phase.

A word or two is in order for the last criterion listed above, since it is more than a simplifying device. In this model, a lender has quasi-monopoly power over her known clients. This is because the borrower's type has been revealed to the lender with whom he has dealt, but this information is unavailable to other lenders in the market. This makes possible the provision of larger loans to the known borrower, generating more surplus in the relationship than would have been generated with other, first-time lenders. Naturally, it may be expected that the lender will extract some informational rent out of this situation. Criterion (iii) above calls for selecting that symmetric, stationary equilibrium which gives the lender the maximum informational rent, without violating the borrower's incentive to repay. This is in keeping with the traditional principal-agent literature, where the principal is supposed to have all the "bargaining power". Obviously, other formulations are possible: for example, we could select equilibria that maximize a weighted average of the lender's and borrower's payoffs, without violating the incentive constraint, reflecting some bargaining power for both parties. We conjecture that such equilibria will have similar qualitative properties as the ones studied here.

Let (L_O, R_O) denote the contract offered by a lender to an old borrower in good standing, and (L_N, R_N) the contract offered by a lender to an N-borrower. We look for equilibria with "firing strategies", i.e, ones in which lenders stop lending to their defaulting clients. Further, let V_O denote the expected (normalized) lifetime payoff of a good borrower who is an old client to his moneylender (and has no incident of default against her). Similarly, let V_N denote the lifetime expected payoff of a good borrower who is currently borrowing from a new source.[6]

In equilibrium (described more completely below), since repayment of loans is incentive compatible for good borrowers, the values V_O and V_N are determined in the following way:

$$V_O = (1-\delta)[F(L_O) - R_O] + \delta[(1-\theta)V_O + \theta V_N] \tag{2}$$

and

$$V_N = (1-\delta)[F(L_N) - R_N] + \delta[(1-\theta)V_O + \theta V_N] \tag{3}$$

Interpretation of these expressions is straightforward. In the O-Phase, a good borrower who repays his debt enjoys a payoff of $F(L_O) - R_O$. In the next period, he either remains with the lender with probability $1-\theta$, and enjoys V_O once again, or else the relationship is terminated exogenously, with probability θ, in which case he returns to the market, approaching a new lender. The lifetime payoff obtained in that event is V_N. The expression for V_N is justified similarly, the only difference being that the first period payoff is $F(L_N) - R_N$.

We can express V_N and V_O explicitly in terms of the primitive payoff functions from the pair of simultaneous equations above. Thus, we obtain:

$$V_O = (1-\delta\theta)[F(L_O) - R_O] + \delta\theta[F(L_N) - R_N] \tag{4}$$

$$V_N = \delta(1-\theta)[F(L_O) - R_O] + [1-\delta(1-\theta)][F(L_N) - R_N] \tag{5}$$

On subtraction

$$V_O - V_N = (1-\delta)[\{F(L_O) - R_O\} - \{F(L_N) - R_N\}] \tag{6}$$

2.6. **Composition of the borrower pool.** The population of unattached borrowers is subject to the usual adverse selection problem. Every period, members of this pool are advanced fresh loans by new moneylenders, but while the good ones repay their debt and are retained, bad ones default and get thrown out. This outflow of good borrowers from the pool is matched, however, by an inflow from two sources: (i) good borrowers whose credit relationships have ended for exogenous reasons, and (ii) influx of new borrowers (say at the rate n) every period,

[6]Notice that since we are focusing on symmetric, stationary equilibria, time and individual subscripts are dropped. The only subscripts are N and O, which are the only two information sets (apart from default) lenders condition their offers on. Also note that we are merely describing *equilibrium* strategies, which are simple. The equilibria we investigate are true equilibria, in the sense that they are robust to deviation through more complicated strategies. To avoid clutter of notation, discussion of such deviations will be kept minimal and informal.

with a genetic proportion π^* of good borrowers. We focus on the case where the composition of the pool has reached a steady state: the rate of inflow is matched by the rate of outflow.

It is easy to derive an expression for this steady state composition. Taking the measure of all borrowers at the previous date to be unity, the pool of borrowers seeking new lenders consists of a measure $1 - \pi^*$ of bad borrowers who have been fired, and a measure $\theta\pi^*$ of good ones, who have been dislocated from their past credit relationships due to exogenous reasons. In addition, there are new entrants of measure n, of which a measure $n\pi^*$ are good borrowers. Hence, the probability that a randomly drawn client drawn from this pool will turn out to be good is given by

$$\pi = \frac{\theta\pi^* + n\pi^*}{1 - \pi + n + \theta\pi^*} \tag{7}$$

3. Equilibrium

Each individual moneylender follows a strategy of offering loan packages that maximize her expected returns, *given the strategy of other moneylenders and borrowers.* Similarly, borrowers maximize their lifetime utility in making acceptance and default decisions. The interdependence of lenders' decisions is a crucial element in this model—it arises because an individual borrower's default incentives depend on his "outside option", which in turn depends on the lending strategies followed by lenders *other than the one with whom he is currently dealing.* A second source of interdependence between lenders' decisions arises from the competition for clients—a lender will bid away clients from other lenders if she can profitably do so. This leads to the zero-profit condition discussed later.

As mentioned before, due to differences in available information, a lender will typically offer different contracts to new and old borrowers. Since a bad type always defaults, an old borrower who has not reneged on his loans in the past is known to be a good type with probability 1. A new borrower, on the other hand, is good only with probability π.

3.1. **The O-Phase.** We first turn to the O-phase problem. This is exactly like a repeated principal-agent problem, with the borrower's "outside option" value given by V_N (which is endogenous in the model as a whole, but fixed for the purposes of this component of it). Formally, the O-phase contract is the outcome of the following constrained optimization problem:

$$\max_{R_O, L_O} R_O - (1+r)L_O \tag{8}$$

subject to the constraint:

$$(1-\delta)[F(L_O) - R_O] + \delta[\theta V_N + (1-\theta)V_O] \geq (1-\delta)F(L_O) + \delta V_N \tag{9}$$

Substituting the value of V_O into the incentive constraint, and after simple manipulation, we obtain

$$R_O \leq \delta(1-\theta)[F(L_O) - V_N] \tag{10}$$

9 is the standard incentive constraint: the borrower should obtain no higher a lifetime payoff from defaulting (the expression on the right hand side) than from sticking to repayment (the expression on the left hand side).

3.2. **The N-Phase.** The problem of contract design in the N-Phase is very different in spirit. At this stage, no lender has any informational advantage over others. Lenders will compete with each other for new clients, even willing to incur *expected* losses for one period, in the knowledge that these losses can be recovered later through the exercise of quasi- monopoly power if the borrower turns out to be good. In the true fashion of Bertrand competition, lenders' *lifetime* expected profit from taking on a new customer must be driven down to zero.

Lifetime expected profits from dealing with a client in either phase (assuming it is incentive compatible for good borrowers to repay) can be expressed in a recursive fashion as follows. Denote by Π_N a lender's time averaged *per period* expected net profit from dealing with a single new client. Π_O denotes the same in the case of an old client. Let β denote the discount factor of each lender. Then, the following pair of simultaneous equations completely describe these profits:

$$\Pi_N = (1-\beta)[\pi R_N - (1+r)L_N] + \beta\pi(1-\theta)\Pi_O \tag{11}$$

$$\Pi_O = (1-\beta)[R_O - (1+r)L_O] + \beta(1-\theta)\Pi_O \tag{12}$$

The value of Π_N will be important for our analysis below. Hence, we obtain explicit solutions for Π_O and Π_N as follows:

$$\Pi_O = \frac{1-\beta}{1-\beta(1-\theta)}[R_O - (1+r)L_O] \tag{13}$$

$$\Pi_N = (1-\beta)[\{1-\beta(1-\theta)\}\{\pi R_N - (1+r)L_N\} + \pi\beta(1-\theta)\{[R_O - (1+r)L_O\} \tag{14}$$

We next turn to the N-Phase problem. Since lenders cannot commit to a contract for more than one period (and will hence extract informational rent once a good borrower's type is revealed), they compete for new borrowers by offering the most attractive *one period* package, subject to satisfying the incentive constraint. and their own break-even condition. This amounts to the following optimization exercise:

$$\max_{L_N, R_N} F(L_N) - R_N \tag{15}$$

subject to the constraints:

$$(1-\delta)[F(L_N) - R_N] + \delta[(1-\theta)V_O + \theta V_N] \geq (1-\delta)F(L_N) + \delta V_N \tag{16}$$

and

$$[1-\beta(1-\theta)][\pi R_N - (1+r)L_N] + \pi\beta(1-\theta)[R_O - (1+r)L_O] \geq 0 \tag{17}$$

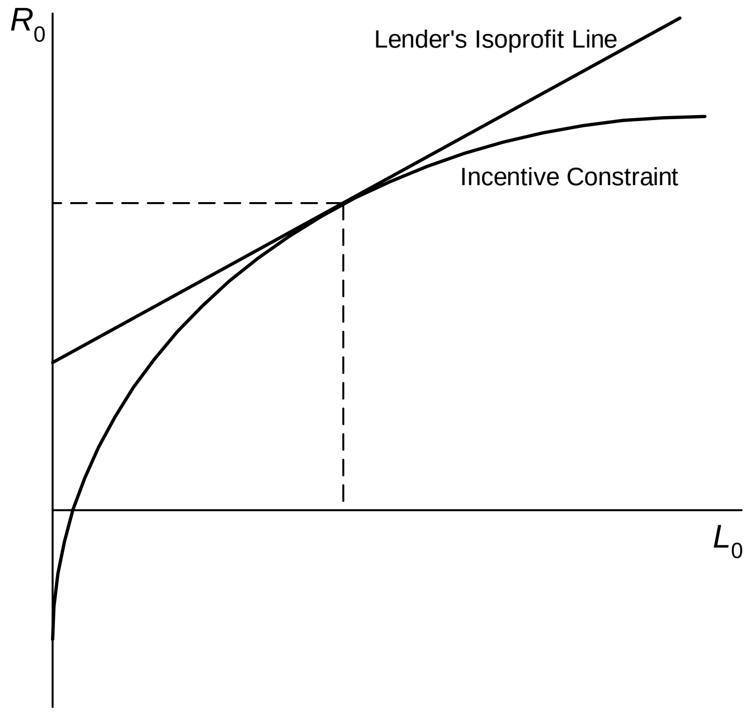

Figure 2. The O-Phase Problem.

(16) is the incentive constraint of the borrower. The expression on the left hand side represents the borrower's lifetime expected payoff in the case of repayment. The expression on the right hand side represents the same in case of default. Incentive compatibility requires the former be no less than the latter.

The second constraint (17) is the lender's break-even constraint. It is obtained by setting $\Pi_N \geq 0$ and recalling the expression for Π_N from (14).

We are now in a position to give a precise definition of market equilibrium. An equilibrium is a pair of contracts (L_O^*, R_O^*) and (L_N^*, R_N^*), and associated values V_O^*, V_N^* such that

(1) (L_O^*, R_O^*) is the solution to the O-Phase problem, given $V_N = V_N^*$.
(2) (L_N^*, R_N^*) is the solution to the N-Phase problem, given $V_O = V_O^*$, and $V_N = V_N^*$.
(3) V_O^* and V_N^* are the continuation values obtained by substituting $L_O = L_O^*$, $R_O = R_O^*$ in equations (4) and (5).

Informally speaking, individual agents conjecture on the values of V_O and V_N and play best responses, given these conjectures. In equilibrium, we require that the conjectures be correct.

4. Equilibrium Characteristics

4.1. **Solutions to O-Phase and N-Phase Problems.** The feasible set and the solution to the O-Phase problem described above are illustrated in Figure 2. The feasible set is convex, and the lender's indifference curves are positively sloped (higher indifference curves representing

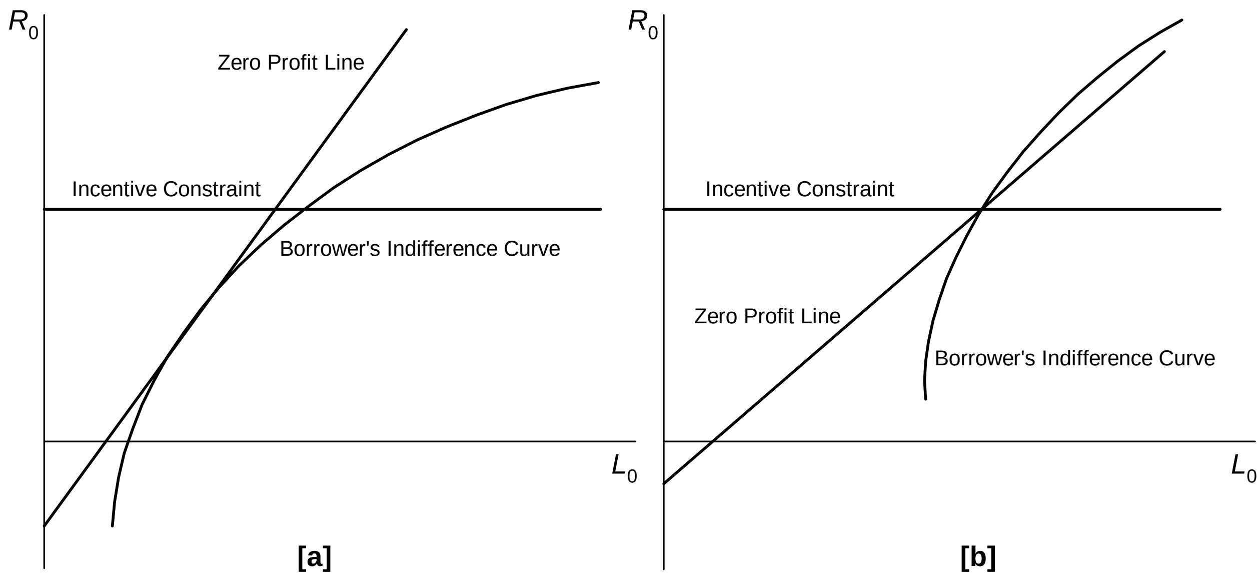

FIGURE 3. THE SEQUENCE OF MOVES.

higher profit levels), with gradient $(1+r)$. The maximum is obtained at the point of tangency. The following first order conditions completely characterize the unique solution to this problem:

$$\delta(1-\theta)F^{'}(L_O) \quad = \quad 1+r \tag{18}$$

$$R_0 \quad = \quad \delta(1-\theta)[F(L_O)-V_N] \tag{19}$$

Note that the incentive constraint for this problem always binds at the optimum. An interesting feature of the solution is that the optimal loan size for an old client is independent of the latter's outside option (V_N) or the composition of the population of borrowers (i.e, π), and is dependent only on the "effective" discount rate $\delta(1-\theta)$. These factors, however, affect the repayment asked for (i.e, the implicit rate of interest charged) through the binding participation constraint.

We now turn to characterize the N-phase problem. Figure 3 illustrates the feasible set and the nature of the solution to this maximization problem. The incentive constraint can be rewritten as follows:

$$R_N \leq \frac{\delta(1-\theta)}{1-\delta} \cdot [V_O - V_N] \tag{20}$$

This defines a frontier which is a horizontal line. The zero profit line, obtained by treating (17) as an equality, is a straight line with slope $(1+r)/\pi$ and intercept $-[\beta(1-\theta)]/[1-\beta(1-\theta)].[R_O-(1+r)L_O]$. Borrowers' indifference curves are a set of rising and concave curves, with lower indifference curves representing higher utility. It is clear from the diagram that the break even constraint must always bind, i.e, borrowers must earn zero profits. The solution is then easy to characterize. Two possible cases may arise. The first is shown in Figure 3(a). In this case, the optimum is obtained at the point of tangency between the borrower's indifference curve and the zero profit line. The incentive constraint is satisfied weakly. A second possibility is shown in Figure 3(b). Here, we have a corner solution, with both constraints binding.

The solution can be summarized as follows. Define $\hat{L}_N, \hat{R}_N$ to be the values of L_N and R_N for which both the incentive and the participation constraints hold with equality. Also, define $L_N(\pi)$ and $R_N(\pi)$ as follows:

$$\pi F'(L_N(\pi)) = 1 + r \tag{21}$$

and $R_N(\pi)$ is the value of R_N obtained by making the incentive constraint (20) binding, and substituting $L_N = L_N(\pi)$.

The solution to the optimization problem is then:

$$L_N = \min\{\hat{L}_N, L_N(\pi)\} \tag{22}$$

$$R_N = \min\{\hat{R}_N, R_N(\pi)\} \tag{23}$$

Basically, $L_N(\pi), R_N(\pi)$ is the solution to the optimization problem, ignoring the incentive constraint. If this lies within the feasible set of the more restrictive problem, then it is the true solution. If not, then the solution is obtained at the corner, where both constraints bind.

4.2. **Existence and Uniqueness of Equilibrium.** We have described the conditions for an equilibrium (satisfying certain properties) that sustains positive amounts of borrowing and lending, even though defaulting borrowers cannot be punished by being denied access to credit in the future. Our intuition is that if lenders are uncertain about new borrowers' types, then they will limit the volume of credit to such agents, and relax credit limits later when additional (and favorable) information on the borrower's type has been acquired. This caution on moneylenders' part creates a natural progression in the scale and payoff in any credit relationship over time, and therefore generates a cost of termination for the borrower. For agents with a stake in the future, default can be prevented if this cost outweighs the short-term gain from defaulting. However, such gains and losses are endogenous in the model, and the first issue we need to address is whether our solution concept is non-vacuous in this context. In other words, are there indeed *some* parameter values for which all conditions for the equilibrium described can be simultaneously satisfied? The answer turns out to be affirmative.

Proposition 1. *There exists a $\bar{\pi} \in (0,1)$ such that an equilibrium satisfying criteria 1 through 3 exists if and only if $\pi \leq \bar{\pi}$. Such an equilibrium, whenever existent, is unique.*

Thus, somewhat ironically, an equilibrium of the sort described above fails to exist if the proportion of bad borrowers in the pool is too low. In the initial phase of any credit relationship (when there is incomplete information), the presence of many "bad risks" in the population helps to keep the loan size small and even the competitive interest rate high, to cover for the risk factor. This imposes a high cost on terminating an existing credit relationship and entering into a new one. It is this cost which disciplines borrowers and gives them the incentive to repay. As π approaches 1, individual lenders lose all incentive to impose stricter credit limits at the beginning of a relationship, or charge a risk premium in the rate of interest. As a result, the cost of termination for borrowers grows arbitrarily small, and an equilibrium guaranteeing debt repayment becomes impossible.

4.3. **Comparison of N and O-Phases: Micro Rationing.** It is interesting to ask: how do the terms of credit (i.e, the loan sizes and the implicit interest rates) compare across the N and O-Phases? In terms of borrower utility, clearly there is a difference: the borrower must enjoy strictly higher utility in the O-Phase than in the N-Phase. It is this utility differential that keeps incentives to default at bay. However, posing the question in terms of observable variables is useful, since it gives the theory empirically testable shape.

Proposition 2. *In equilibrium, the borrower receives a strictly smaller loan in the N-Phase than in the O-Phase (i.e, $L_N^* < L_O^*$). Comparison of the implicit rate of interest is ambiguous. However, if the incentive constraint in the N-Phase is binding, the rate of interest charged an N-borrower is strictly greater.*

The observation that the loan sizes are always smaller in the first phase of a credit relationship accords very well with Aleem's (1993) documentation of the custom of providing small "testing loans" to new clients in informal rural credit markets in Pakistan. Regarding the comparison of interest rates, there are two factors: first, the "competition effect", which tends to lower the interest rate in the N- Phase relative to the O-Phase (when lenders extract informational rent by charging high interest), and second, the "risk premium" effect—in the N-Phase, lenders are uncertain about the borrower's type, and hence have to cover for default risk through the interest charged. While the first effect tends to make interest rates for new clients low, the second effect tends to make it high. The net effect is, therefore, ambiguous. In their study of Thai rural credit markets, Siamwalla et al. (1993) find larger loans tend to carry lower interest rates, but the effect disappears if the borrower's length of tenure with the lender is taken into account (the latter having a positive effect on loan size, and a negative effect on the interest rate). This, again, confirms our story.

5. Change in the Composition of The Borrower Pool

We have already observed that an improvement in the composition of the borrower pool (increase in π) poses the possibility of non-existence of the particular type of equilibrium we have examined. So long as an equilibrium exists, however, it is useful to ask: what is the welfare implication of an improvement in the composition of borrowers? Notice that lenders always make zero profit in this model, so that only the utility of borrowers needs to be tracked. Turning the question around, we might ask: what is the impact on borrower welfare, as well as the implications for the terms of credit (credit limits, interest rates, etc.) if the market is permeated by more and more "bad risks"? The question is relevant from a practical point of view, since in the process of development, with increased mobility between regions and professions, the borrower pool is likely to worsen in the manner described above.

The results of this exercise is summarized in the following Proposition.

Proposition 3. *An increase in π, the proportion of good types, has the following effect on equilibrium magnitudes: (i) an increase in V_N, the lifetime expected utility of a good borrower starting a new credit relationship (ii) an increase in V_O, the lifetime expected utility of a good borrower already in a long-term credit relationship (iii) the equilibrium loan size, L_O^* is unchanged, while there is a decrease in R_O^* (hence a decrease in the O-Phase interest rate).*

6. Rationing of Borrowers: Macro Rationing

The non existence of equilibrium in the previous sections for some parameter values is a problematic issue. How does the market function when an equilibrium of the above sort does not exist (i.e, when there are too many "good borrowers" in the pool)? Can the possibility of exclusion of some borrowers from the market, or the possibility of restricted access to credit provide a discipline device? Such mechanisms have been suggested elsewhere; for example in the Shapiro and Stiglitz (1984) model of involuntary unemployment, equilibrium always entails less than full employment, so that the threat of getting fired and staying unemployed for a period induces workers not to shirk on their job. A similar model appears in Eswaran and Kotwal's (1985) theory of two-tiered labor markets, where a select group of workers are paid a wage premium over others and assigned to sensitive tasks, disciplined by the threat of expulsion from this privileged group in case of negligence. We call such market exclusion macro rationing, to distinguish it from micro rationing discussed previously—whereby borrowers were not excluded from the market for certain periods, on termination of a credit relationship, but sharp credit limits are imposed on them. In this section, therefore, we allow lenders to reject some or all of the credit applications they receive [7]. We ask the following questions: can both forms of rationing work in conjunction in equilibrium? Which kind of rationing is more likely to appear under different circumstances? Is there always an equilibrium (possessing the simple properties we have laid down) possessing one of the two kinds of rationing as intrinsic feature? We answer these questions below.

One has to be careful, however, to apply such a theory to credit markets. The terms of a credit deal are much more flexible, and allows for a wide variety of possibilities than a simple wage labor contract. An equilibrium with macro credit rationing (in the sense that some borrowers have no access to credit) is feasible only if *individual* lenders have no way of deviating and offering credit contracts to excluded borrowers so as to squeeze profits out of them. In this section, we explore the possibility of such equilibria.

We first impose an additional restriction on the type of contracts that can be offered in the N-Phase. This restriction requires that repayment amounts cannot exceed the total revenue generated by the loan. This can be viewed as merely a feasibility requirement; if the borrower is to pay back more than the proceeds of his investment, he has to fall back on his own funds. It is precisely the lack of such funds that makes him dependent on the credit market in the first place. We call this constraint the cash constraint[8] (it is similar to a limited liability constraint).

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[7] Of course, in equilibrium, their acceptance or rejection decisions must be incentive compatible; we do check for such incentive compatibility in the analysis to follow.

[8] Careful readers may wonder why such a constraint is not simultaneously imposed on the O-Phase too. A little reflection will show that if the cash constraint is satisfied in the N Phase, in equilibrium, it will be automatically satisfied in the O-Phase. This is because, for incentive compatibility, the borrower must be allowed to retain a strictly higher amount of surplus in the O-Phase relative to the N-Phase.

The Cash Constraint: *The N-Phase problem should satisfy the additional restriction that $R_N \leq F(L_N)$.*

Notice that the introduction of the cash constraint does not drastically alter the nature of the solutions. Given values of V_O and V_N (and parameters), if the solution to the less restricted problem of the previous section also satisfies the cash constraint, then it continues to be the solution to the more restricted problem of this section. If not, then the feasible set is empty, and the solution involves no loan.

We now turn to the possibility of macro rationing. To this effect, let $\alpha \in [0,1]$ denote the probability that a borrower without a current source of credit will be accepted by some lender in a given period. Let V_N continue to denote the lifetime time averaged payoff of a borrower, *who is about to start a new credit relationship with a lender.* Of course, a borrower in the rationed market will, *ex ante*, find such a lender only with probability α, and may have to wait quite a few periods before he finds a source of loan. The lifetime *expected utility* of such a borrower can be expressed as follows:

$$\alpha V_N + (1-\alpha)\alpha\delta V_N + (1-\alpha)^2\alpha\delta^2 V_N + ...$$

$$= qV_N \qquad \text{where} \quad q = \frac{\alpha}{1-\delta(1-\alpha)}$$

Notice that $q \in [0,1]$, is increasing in α and $q = 0$ when $\alpha = 0$, and $q = 1$ when $\alpha = 1$. Though α is the fundamental parameter, representing the probability of resuming a credit relationship in any given period, we shall treat q as its proxy.

The recursive formulation of V_O and V_N has to be altered slightly to account for this modification. Thus, we have

$$V_N = (1-\delta)[F(L_N) - R_N] + \delta[(1-\theta)V_O + \theta q V_N] \tag{24}$$

$$V_O = (1-\delta)[F(L_O) - R_O] + \delta[(1-\theta)V_O + \theta q V_N] \tag{25}$$

On solving the pair of equations above, the values of V_O and V_N can be explicitly written as below:

$$V_N = \frac{1-\delta}{1-\delta+(1-q)\delta\theta}.[\{1-\delta(1-\theta)\}\{F(L_N) - R_N\} + \delta(1-\theta)\{F(L_O) - R_O\}] \tag{26}$$

$$V_O = \frac{1-\delta}{1-\delta+(1-q)\delta\theta}[\delta\theta q\{F(L_N) - R_N\} + (1-\delta\theta q)\{F(L_O) - R_O\}] \tag{27}$$

Under a rationing regime, the N and O-Phase optimization problems are the same as previously, except for the additional cash constraint, and the fact that in both incentive constraints, V_N is to be replaced by qV_N. Further, the expressions for V_O and V_N are to be modified as above.

We now introduce a condition under which rationing is admissible in equilibrium. Define α^*, and the corresponding value of $q = q^*$ to be the equilibrium degree of rationing. We require the following consistency requirement to hold:

Consistency: *If $q^* < 1$, then the cash constraint must be binding, i.e, $F(L_N^*) = R_N^*$.*

The intuition behind this requirement is clear. Suppose $F(L_N^*) > R_N^*$. In equilibrium, the feasible set of the N-Phase problem is non-empty. Then, if there are rationed borrowers in the market, a lender can earn strictly positive profits by offering a new contract to rationed borrowers, involving either a higher repayment amount than the equilibrium contract, or a smaller loan size (for the same repayment). This destroys the rationing scheme. Such a deviation is impossible if the equilibrium N-Phase contract already extracts all the proceeds of the investment from the borrower.

Introducing the possibility of rationing in this manner, the existence of equilibrium is restored for all parameter values. Whether the equilibrium will involve rationing of borrowers (macro rationing) will depend on parameter values. While micro rationing—credit limits on new borrowers—is a feature of every equilibrium, macro rationing emerges only when the proportion of bad borrowers in the pool becomes too small. The result of this section's analysis is captured in the following Proposition.

Proposition 4. *If a consistent rationing scheme for borrowers, as described above, is allowed for, an unique equilibrium satisfying criteria 1 through 3 exists for all parameter values. Further, there exists $\hat{\pi} \in (0, 1)$ such that the equilibrium involves exclusion of some borrowers from the market if and only if $\pi > \hat{\pi}$.*

These results demonstrate that in the absence of contract enforcability and lack of credit histories, the market may discipline borrowers through two different kinds of rationing: rationing of *borrowers* as well as rationing of *borrowing*. We have shown that both instruments may be operative in equilibrium, but while the latter is always in effect in some form, the former is present for some parameter values but not for others. More specifically, in markets with greater default risk (a larger proportion of bad borrowers), there is greater reliance on the initial credit crunch as a discipline device, rather than outright market exclusion.

7. Costly Information and Multiple Equilibria

The analysis so far has been based on an extreme assumption regarding the market environment—that lenders have no information about the credit histories of new clients, and have no way of sorting the good from the bad except through trial interactions. Lenders could alternatively spend resources to collect data on new clients' credit histories and use such information to decide whether to advance a loan. Credit markets in technologically advanced societies rely heavily on such background checks as a screening and enforcement device. The task is greatly facilitated, however, due to centralized, computerized record keeping by credit rating agencies. Individual banks and lending institutions can and do access this information at minimal cost. Such a store of public information is, for all practical purposes, absent in most of the informal credit markets that are the focus of our study. However, some information pertinent to the client's characteristics can still be privately collected by an enterprising lender, by meticulously tracking down and interviewing his past lenders, neighbors, business partners, etc. This paper has so far implicitly assumed that the cost of such private information collection is prohibitive and uneconomical.

Empirical research and field studies which have documented information gathering costs show that they indeed add a very high markup to the basic cost of lending (Aleem (1993)). Moreover, the reliability of such information is invariably limited, because the respondents to the potential lender's questions could well be interested parties who may not have an incentive for truthful reporting. Aleem's (1993) study reveals that lenders usually rely both on some amount of background checking as well as initial testing loans to screen good borrowers from the high risk ones. To the extent contracts are not legally enforcable but credit histories are available before loans are advanced, the resultant discipline on borrower behavior (through reputational effects and the threat of market exclusion) is well understood, and has been extensively analyzed in the literature.[9] However, the fact that lenders still go through a testing phase even after collecting information on new clients goes to show that such information is usually incomplete and only an imperfect indicator of the future behavior of the client. Since this paper is an attempt to understand the functioning of credit markets in limited information environments, we started out by making the extreme assumption that information on credit histories is absent, instead of being merely costly and imperfect.

If the private cost of collecting borrower information is extreme, it is easy to see what happens. When such costs are very low, all lenders will meticulously scan the past of new clients and will refuse to lend to past defaulters. Thus, default will be followed by market exclusion. The characteristics of such dynamic credit relationships are described in the standard reputation based models. On the other hand, if information collection costs are very high, lenders would choose to collect little or no information, but would rather screen through initial testing loans. The resulting pattern of interaction and its properties is described in this paper.

Interesting additional possibilities arise when the cost of information collection lies in an intermediate range. A little reflection will show that even *privately* collected information has a public good character to it, and confers externalities across lenders.[10] This raises the possibility of strategic complemantarities and multiple equilibria.

We illustrate the possibility by a very simple extension of our basic model from the last section. Suppose that before accepting a new loan applicant, a lender could incur a cost C[11] to learn about the former's entire credit history.[12] Alternatively, he could forgo this opportunity, and lend (or not lend) right away, without any specific knowledge about his client's default potential. Thus, a lender's dealing with a new client is now a two stage process, with information collection and loan decisions taken in sequence. Equilibrium requires each lender's decisions to be a best response, maximizing the lender's expected profit from each client at every stage, given the strategies of other lenders. As before, we focus on equilibria in symmetric stationary strategies. Two kinds of equilibria are possible:

[9] See, for example, Eaton and Gersovitz (1981).

[10] This is not the same thing as saying that information is potentially a public good. In the extended model presented here, every time a lender wants to know about a borrower's past, he has to incur an expense, independent of how many other lenders share that information. Thus, information is very much a private good in our framework.

[11] Assume that only a lender who has received a loan application from an agent can run a background check on him.

[12] This binary specification of information collection activity is admittedly simplistic. A more realistic version would describe information as a noisy signal of the borrower's history, which allows a past default to be detected with some probability, higher probability of detection (i.e, greater precision of the signal) entailing higher cost. The simple version adopted here allows us to make our basic point in a transparent way.

No-Information equilibrium: In this equilibrium, no lender chooses to incur the cost C to check a new client's background. The resultant loan sizes, interest rates, etc. are exactly as described in the previous sections. Let Π_O^* denote the lender's expected equilibrium profit in the)-phase (see (13)). By the zero profit condition, the expected profit from dealing with an unknown client is zero. A lender could, of course, collect information on a new client and jump from the N-phase to the O-phase right away. The net expected profit from doing so is $\pi\Pi_O^* - C$. If it is an equilibrium for lenders not to collect information, then it must be true that

$$C \geq \pi\Pi_O^* \tag{28}$$

Full information equilibrium: In this equilibrium, all lenders collect information on new borrowers. Hence, a defaulting borrower is always identified and excluded from transactions. Such a borrower's lifetime utility is therefore zero. The lender's O-phase problem then becomes:

$$\max_{R_O, L_O} R_O - (1+r)L_O \tag{29}$$

subject to the constraint

$$[F(L_O) - R_O] \geq (1-\delta)F(L_O) \tag{30}$$

Notice that a non-defaulting borrower always gets the same contract from all lenders, old and new. This is because a new lender, on incurring the cost C, will identify his type without delay, and will jump to the O-phase straight away. This explains the left hand side of the inequality, in particular why it is independent of the exogenous termination probability θ.

In this equilibrium, let $\tilde{\Pi}_O$ denote a lender's expected lifetime profit from dealing with a currently known borrower. This is obtained by using the solution to the above maximization problem in (13). The expected payoff from a new client (whose type or history is unknown), assuming the information collection cost is incurred, is given by $\pi\tilde{\Pi}_O - C$. Let $\tilde{\Pi}_N$ denote an individual lender's expected profit from a new client, if he chose not to directly collect information (and save C in the process), assuming all other lenders continued to follow the strategy of collecting information. $\tilde{\Pi}_N$ can be obtained from the following maximization problem:

$$\max_{R_N, L_N} R_N - (1+r)L_N \tag{31}$$

subject to the constraints

$$(1-\delta)[F(L_N) - R_N] + \delta[F(L_O) - R_O] \geq (1-\delta)F(L_N) \tag{32}$$

and

$$F(L_N) - R_N \geq F(L_O) - R_O \tag{33}$$

The first constraint is the incentive constraint. A non-defaulting new borrower gets the contract (L_N, R_N) today, and the contract (L_O, R_O) forever after. That explains the left hand side of the inequality. The second constraint is a new client's participation constraint. Since such a borrower could always go to another lender and obtain the contract (L_O, R_O) right away, the resultant payoff must still be guaranteed by a lender who chooses to save on the information collection cost.

For a full information equilibrium to exist, therefore, we require that

$$C \leq \pi\tilde{\Pi}_O - \tilde{\Pi}_N \tag{34}$$

The following proposition captures the fact that for intermediate values of the cost of information collection, multiple equilibria can indeed exist:

Proposition 5. *Given all other parameters of the model, there are values C_1, C_2 $(C_1 > C_2)$ such that if $C_1 \leq C \leq C_2$, then both the no-information equilibrium and the full information equilibrium exist. The values C_1 and C_2 are given as follows: $C_1 = \pi\Pi^*_O$ and $C_2 = \pi\tilde{\Pi}_O - \tilde{\Pi}_N$.*

The economic intuition behind the multiple equilibria result is as follows. The act of collecting borrowers' background information has two distinct benefits. The first is the purely private of better screening of applicants and avoiding bad loans. This part is completely internalized by the lenders. However, if one lender decides to screen his new clients, this confers a positive externality on *other* lenders, by reducing the payoff of defaulting borrowers (thereby making default less attractive). This second benefit is a pure public good for the lending community, and is not internalized by an individual lender making information collection decisions.

As shown in Cooper and John (1988), however, what is necessary for multiple equilibria is not just externalities but strategic complementarities. This condition is also satisfied in this model. If lenders, in general, do not look into credit histories before advancing loans, default is not too unattractive an option. Consequently, lenders in the O-phase have to limit the stipulated repayment, to prevent default. This keeps the O-phase rents for the lender low, thereby blunting his incentive to skip to this stage right away by identifying the client's type through a background check. On the other hand, if all lenders check on credit histories, default is more severely punished than in the former case. This allows greater rents to be extracted from borrowers in the O-phase, making the expected benefits of collecting borrower information larger. For intermediate values of the cost of information, the value of such information to an individual lender may fall short of the cost if no other lender collects such information, but may well exceed it if all other lenders do so.

8. Conclusion

We study the problem of loan enforcement in an informal credit market where credit histories of borrowers are not available to lenders, raising the possibility of serial default. We show that if there is critical minimum proportion of *natural defaulters* in the population, then there exists an unique equilibrium constituted by certain simple "behavior rules" for lenders and borrowers. This equilibrium always takes the form that lenders advance limited amount of credit (possibly at higher interest rate) to first time borrowers; credit limits are relaxed and the relationship continued, conditional on repayment. We call this phenomenon *micro-rationing*. We also introduce the possibility of *macro-rationing*– -at every date, the exclusion of some borrowers from any source of credit (similar to involuntary unemployment, a la Shapiro and Stiglitz (1984)). We observe (i) if both kinds of rationing are allowed, an unique equilibrium in simple, stationary strategies always exists (ii) micro-rationing is always present in equilibrium (iii) macro-rationing arises if the proportion of natural defaulters in the market is below a certain threshold. Some comparative static properties of changes in the composition of borrowers are also derived. Finally, we show that if lenders have the *option* of privately collecting information on the credit histories of new clients at a cost, multiple equilibria could arise for intermediate values of such costs. We thus interpret limited client information in informal credit markets as a possible outcome of coordination failure among moneylenders.

9. Appendix

Proof of Proposition 1: For the purpose of this proof as well as later ones, it will be convenient to represent the equilibrium as the fixed point of a certain single valued function. For this purpose, we define a mapping $\phi(x)$ as follows.

Arbitrarily assign a value x to V_N, the N-Phase borrower's lifetime utility. Now, taking this value as given, solve the O-Phase problem. Notice that the sign of the loan is determined exclusively by the *effective* discount rate, i.e, $\delta(1-\theta)$, and the cost of funds r. It is given by the condition $\delta(1-\theta)F^{'}(L_O) = 1+r$. Denote this value by L_O^* and note that it is independent of x. The repayment amount, R_O is, however, dependent on x, and can be expressed as follows (from the fact that the incentive constraint is binding), using (9).

$$R_O(x) = \delta(1-\theta)[F(L_O^*) - x] \tag{35}$$

Next, we express the value of V_O in terms of x, utilizing the solution to the O-Phase problem listed above. Using (4), we have

$$V_O(x) = \frac{1-\delta}{1-\delta(1-\theta)}[F(L_O^* - R_O(x)] + \frac{\delta\theta}{1-\delta(1-\theta)}x \tag{36}$$

On substituting the expression for $R_O(x)$ obtained above and simplifying, we have

$$V_O(x) = (1-\delta)F(L_O^*) + \delta x \tag{37}$$

It is also useful to write down the difference in expected lifetime utilities between the old and new phases, i.e, the expression for $V_O - V_N$, as a function of x. This is as follows:

$$V_O(x) - x = (1-\delta)[F(L_O^*) - x] \tag{38}$$

We now turn to the N-Phase problem, taking, once again, $V_N = x$ and $V_O = V_O(x)$. The maximization problem can be written as:

$$\max_{L_N, R_N} F(L_N) - R_N \tag{39}$$

subject to

$$R_N \leq \delta(1-\theta)[F(L_O^*) - x] \tag{40}$$

and

$$R_N \geq \frac{1+r}{\pi}L_N - \frac{\beta(1-\theta)}{1-\beta(1-\theta)}[\delta(1-\theta)F(L_O^*) - (1+r)L_O^* - \delta(1-\theta)x] \tag{41}$$

Closely following our previous notation, but introducing influential variables more explicitly, let $\hat{L}_N(x,\pi), \hat{R}_N(x,\pi)$ denote the coordinates of the point where both constraints bind, and let $L_N(\pi), R_N(\pi; x)$ be defined as before (i.e, the latter denotes the solution to the maximization problem if the incentive constraint is ignored). The full solution is then given by

$$L_N(x) = \min\{L_N(\pi), \hat{L}_N(x)\} \tag{42}$$

$$R_N(x) = \min\{R_N(\pi; x), \hat{R}_N(x)\} \tag{43}$$

The function $\phi(x)$ is now defined as follows. It is the value of V_N, computed from (5), after substituting the solutions to the N and O-Phase problems calculated above (as functions of x). In other words, we calculated lender's choices of loan size and repayment amounts, taking an arbitrary value x as a defaulting borrower's continuation payoff. This, in turn, gives rise to a new continuation payoff, which we denote by $\phi(x)$. Using (5), we can explicitly write down the expression for ϕ as follows:

$$\phi(x) = \delta(1-\theta)[\{1-\delta(1-\theta)\}F(L_O^*) + \delta(1-\theta)x] + [1-\delta(1-\theta)][F(L_N(x)) - R_N(x)] \tag{44}$$

Rational expectations requires that $\phi(x) = x$ in equilibrium. Thus, the fixed point of $\phi(.)$ pins down the equilibrium. The proof now proceeds by establishing certain properties of the ϕ function. Possible non-existence, then, arises from a discontinuity in $\phi(x)$, whereas uniqueness arises from the fact that the slope of the ϕ function is everywhere less than 1.

Lemma 1. *There exist $x^{'}$ and $x^{''}$ ($x^{'} < x^{''}$) such that for $x \leq x^{'}$, $L_N(x) = L_N(\pi)$ (i.e, the N-Phase incentive constraint does not bind), for $x^{'} < x \leq x^{''}$, $L_N(x) = \hat{L}_N(x)$ (the constraint binds), and for $x > x^{''}$, the N-Phase feasible set is empty, so that lenders cease to provide loans and $\phi(x) = 0$.*

Proof: Consider any value of x for which $L_N(x) = L_N(\pi)$. Consider a lower value of x. Notice that both the constraints (40) and (41) are relaxed, hence the feasible set is strictly larger for this value. In particular, $\hat{L}_N(x)$ is higher as a result. Recalling the definition of $L_N(x)$, it is clear that $L_N(x) = L_N(\pi)$ for this lower value of x. The existence of the switch point $x^{'}$ is thus proved.

Next, observe that the right hand side of the incentive constraint in (41) (the upper bound on R_N) decreases monotonically and unboundedly as x grows large, while the RHS of the break even constraint in (41) (the lower bound on R_N) increases monotonically and unboundedly as x increases. This proves the existence of the second threshold $x^{''}$ beyond which the feasible set is empty. The value of $x^{''}$ can be explicitly calculated by letting $L_N = 0$ and setting the two bounds on R_N mentioned above, equal. ■

Lemma 2. *$\phi(x)$ is continuous, except at $x = x^{''}$, differentiable except at $x^{'}$ and $x^{''}$, and has a slope less than one wherever defined.*

Proof: It is easy to see that the loan and repayment choices are continuous for $x < x^{''}$ (since objective functions are continuous, and the feasible sets for each problem are convex and continuous in x). In addition, V_N is a continuous function of these variables. Proving differentiability is similar. The discontinuity at $x^{''}$ arises because, as no loans are provided in the N-Phase, borrower's type is not revealed, and hence, the loan size in the O-Phase, too, abruptly falls to zero.[13]

For the result on the slope, first take the case: $x \leq x^{'}$. In this case, we have

$$\phi(x) = \delta(1-\theta)[\{1-\delta(1-\theta)\}F(L_O^*) + \delta(1-\theta)x] + [1-\delta(1-\theta)][F(L_N(\pi)) - R_N(x;\pi)]$$

Hence, $\phi^{'}(x) = \delta^2(1-\theta)^2 - \delta(1-\theta).\partial R_N/\partial x$. It is easy to see that the last derivative is positive, so that $\phi^{'}(x) < \delta^2(1-\theta)^2 < 1$.

Now turn to the case: $x > x^{'}$, where the N-Phase IC is binding, so that $L_N(x) = \hat{L}_N(x)$ and $R_N(x) = \hat{R}_N(x)$. Observe, by comparing (10) and (15), that the incentive constraints in the N and the O-Phase are essentially the same, so that $\hat{R}_N(x) = R_O(x)$. Using this and the expression for $R_O(x)$ in the expression for $\phi(x)$, we obtain

$$\phi(x) = \delta(1-\theta)x + [1-\delta(1-\theta)]F(\hat{L}_N(x))$$

As argued in the proof of the previous lemma, the feasible set shrinks as x increases, so that $\hat{L}_N(x)$ is decreasing in x. Hence, in this case, $\phi(x) < \delta(1-\theta) < 1$. That establishes the result. ∎

For the next result on equilibrium existence, as well as the later comparative static result on the effect of changes in the composition of the borrower pool, we need to know how the function ϕ behaves with respect to changes in the parameter π. For this purpose, introduce π explicitly in the function: $\phi = \phi(x;\pi)$..

Lemma 3. *$\phi(x;\pi)$ is increasing in π, and $x^{''}$ is independent of π.*

Proof: Observe that, for a fixed x, the feasible set of the N-Phase problem strictly expands with an increase in π. This is because the break even constraint (examine (41)) is now more easily satisfied, due to the decrease in lending risk. Given that the objective function is strictly monotone in both L_N and R_N, it follows that the maximized value $F(L_N(x)) - R_N(x)$ is strictly increasing when π increases. On the other hand, the first term in the expression for $\phi(x)$ is independent of π (see (44)), since the O-Phase choices, made under full information about borrower's type, do not directly depend on π. It follows that $\phi(x,\pi)$ is an increasing function of π; with a parametric increase in the latter, the $\phi(x)$ schedule jumps up.

For the last part of the claim, observe how $x^{''}$ is defined. It is obtained by equating the right hand sides of (40) and (41), putting $L_N = 0$. Clearly, π plays no role in the determination of this value. ∎

The proof now follows easily from the preceeding lemmas. Given some π, it is not hard to see that a necessary and sufficient condition for the existence of a fixed point is that $\phi(x^{''}) < x^{''}$, i.e, at the point of discontinuity, the function lie below the 45 degree line. This follows from the intermediate value theorem, using the fact that $\phi(0) > 0$, and ϕ is a continuous function in the range $[0, x^{''}]$. Now, suppose a fixed point exists for $\pi = \pi_1$. Consider some $\pi_2 < \pi_1$. By Lemma 3, $\phi(x^{''}, \pi_2) < \phi(x^{''}, \pi_1)$. Since an equilibrium exists for π_1, by the preceeding argument, it

[13]This is not made explicit in the mathematical formulation of the problem, but is clearly the sensible depiction.

follows that $\phi(x'', \pi_1) < x''$. Combining the last two inequalities, we have $\phi(x'', \pi_2) < \pi_2$, which implies existence for $\pi = \pi_2$.

Uniqueness follows from the fact that the slope of $\phi(x)$ is everywhere less than one. ■

Proof of Proposition 2: It can be easily checked that, *in equilibrium*, the incentive constraints of the two optimization problems define *identical* bounds on the repayment amounts, R_O and R_N. This is because, on default, the borrower loses the same payoff from termination– -$(V_O - V_N)$, appropriately discounted, since on default in any phase, the borrower returns to the beginning of a new relationship. Since the incentive constraint in the O-Phase is always binding, it follows that $R_N^* \leq R_O^*$. Now, if possible, let $L_N^* \geq L_O^*$. Then, from (6), $V_O^* - V_N^* = (1-\delta)[\{F(L_O^* - F(L_N^*)\} + \{R_N^* - R_O^*\}] \leq 0$, which is impossible, since the incentive constraint cannot be satisfied.

If the N-Phase incentive constraint is binding, $R_N^* = R_O^*$, implying $R_N^*/L_N^* > R_O^*/L_N^*$. That proves the last part of the result. ■

Proof of Proposition 3: The proof for part (i) follows straight from Lemma 3. Since the function $\phi(x)$ undergoes an upward shift as π increases, it follows that the value of the fixed point x^* goes up. However, x^* is nothing but the equilibrium value of V_N.

For part (ii), utilize the fact that the incentive constraint in the O-Phase problem is binding. Thus, utilizing (37) at the equilibrium fixed point, we have

$$V_O(x^*) = (1-\delta)F(L_O^*) + \delta x^* \tag{45}$$

Since L_O^* is independent of π (as argued previously), and x^* increases as π increases, the equilibrium value of V_O given by $V_O(x^*)$ also increases as a result.

For part (iii), suffice it to notice from (18) that L_O^* is determined entirely by the “effective” discount rate, $\delta(1-\theta)$. Further, since the incentive constraint (9) binds in equilibrium, and as shown above, the equilibrium value of V_N increases as π goes up, we conclude that R_O^* decreases with an increase in π. ■

Proof of Proposition 4: We start with the following lemma:

Lemma 4. *Construct the $\phi(x)$ function exactly as before, with the cash constraint imposed as an additional requirement. Then, there exists $\bar{x}$ such that for $x \leq \bar{x}$, the new function is identical to the old one, whereas for $x > \bar{x}$, $\phi(x) = 0$.*

Proof: Examine the N-Phase problem from the previous section, i.e, without the cash constraint. Notice that $F(L_N(x)) - R_N(x)$ is decreasing in x (since the feasible set shrinks as x increases; recall the proof of Lemma 1). Choose $\bar{x}$ such that $F(L_N(\bar{x})) = R_N(\bar{x})$. The proof is now obvious. ■

Redefine the function $\phi(x)$ by introducing the rationing parameter q as follows. For any x and q, redefine the N and O-Phase problems exactly as before, with the term qx replacing x in the incentive constraints. For ease of understanding, introduce q explicitly in all functional forms; thus $L_N = L_N(x,q)$, $R_N = R_N(x,q)$ $R_O = R_O(x,q)$ and in particular, define$\Phi(x,q)$ as follows

(46)

$$\Phi(x,q) = \frac{1-\delta}{1-\delta+(1-q)\delta\theta}[\{1-\delta(1-\theta)\}\{F(L_N(x,q)-R_N(x,q)\}+\delta(1-\theta)\{F(L_O^*)-R_O(x,q)\}]$$

The above expression is merely the value of V_N, calculated by assuming that on termination of a contract, a borrower faces a lifetime utility of x, *if rehired immediately*, the probability of finding a new credit source in any date being captured in the parameter q.

Now, for any given x, define $q(x)$ as follows.

$$
\begin{aligned}
q(x) &= 1 \quad \text{if } F(L_N(x,1)) \geq R_N(x,1) \\
&= \tilde{q} \in (0,1) \quad \text{if } F(L_N(x,\tilde{q})) = R_N(x,\tilde{q})
\end{aligned}
\tag{47}
$$

This formulation incorporates the consistency requirement imposed above. The nature of $q(x)$ is summarised in the following lemma.

Lemma 5. *For every x, there exists an unique $q(x)$, which can be characterized as follows. For $x \leq \bar{x}$, $q(x) = 1$. For $x > \bar{x}$, $q(x) = \bar{x}/x$.*

Proof: Fix x. Notice that as q is reduced, both the incentive and the break even constraints in the N-Phase problem are relaxed. Hence, the maximized value of the objective function $F(L_N(x,q)) - R_N(x,q)$ is nondecreasing as q increases. This guarantees uniqueness.

Next, assume $q(x).x = \bar{x}$. It has to checked that the consistency requirement is satisfied. Notice that since all constraints in the two maximization problems depend only on the term qx, the solutions to these problems would be unchanged if $q(x)$ were replaced by 1, and x by $\bar{x}$. Now, by definition of $\bar{x}$, $F(L_N(\bar{x})) = R_N(\bar{x})$. Hence, $F(L_N(x,q(x))) = R_N(x,q(x))$, implying that the consistency requirement is satisfied for the above formulation of the function $q(x)$. That completes the proof. ∎

Now, redefine the function $\phi(x)$ of the previous section as follows: $\phi(x) = \Phi(x, q(x))$. The following lemma is crucial in guaranteeing existence.

Lemma 6. *The function $\phi(x)$, as defined above, is continuous at all points, and almost everywhere differentiable. For $x \leq \bar{x}$, the function takes the form exactly as defined in the previous section. For $x > \bar{x}$, $\phi(x)$ has a negative slope.*

Proof: For $x \leq \bar{x}$, $q = 1$ satisfies the consistency requirement (see Lemma 4). From the uniqueness of $q(x)$ (Lemma 5), it follows that in this range, $\phi(x)$ is identical to that in the previous section.

Next, turn to the case where $x > \bar{x}$. Notice that all the constraints in the N and the O-Phase problems depend only on the factor qx. Since $xq(x) = \bar{x}$ from Lemma 5, it follows that $L_N(x,q(x)) = L_N(\bar{x},1)$, $R_N(x,q(x)) = R_N(\bar{x},1)$ and $R_O(x,q(x)) = R_O(\bar{x},1)$. Using these observations, and the fact that $q(x) = \bar{x}/x$ by Lemma 5, we have

$$\Phi(x,q(x)) = \frac{(1-\delta)x}{(1-\delta)x + \delta\theta(x-\bar{x})}.\Phi(\bar{x},1) \tag{48}$$

Recalling the new definition of $\phi(x)$, we have

$$\phi(x) = \frac{(1-\delta)x}{(1-\delta)x + \delta\theta(x-\bar{x})}.\phi(\bar{x}) \tag{49}$$

On examination of the above equation, it becomes clear that $\phi(x)$ is continuous and negatively sloped in the interior of this range. Further, observe from above that

$$\lim_{x \to \bar{x}-} \phi(x) = \phi(\bar{x}) \tag{50}$$

which proves continuity throughout. ■

The existence result follows trivially from the previous two lemmas. ■

Proof of Proposition 5: As before, let $R_O(x)$, L_O^* denote the solution to the O-phase problem when the defaulting borrower's continuation payoff is x. Also, let $\Pi_O(x)$ denote the resultant lifetime expected profit of the lender. Using (13) and (35), we have:

$$\Pi_O(x) = \frac{\beta}{1-\beta(1-\theta)}[\delta(1-\theta)F(L_O^*) - (1+r)L_O^* - \delta(1-\theta)x] \tag{51}$$

It is easy to see that the function is continuous and differentiable in x. On taking derivatives:

$$\Pi_O^{'}(x) = -\delta(1-\theta).\frac{1-\beta}{1-\beta(1-\theta)} \tag{52}$$

We now turn our attention to a different maximization problem. Consider the problem of devising an N-phase contract $(\tilde{L}_N(x), \tilde{R}_N(x))$ which maximizes the lender's lifetime expected profit, subject to the borrower's usual incentive constraint (assuming the continuation payoff to be x in case of termination), and a participation constraint which requires the N-borrower's lifetime utility to be at least as great as that of an O-borrower. Notice that this problem is slightly different from the dual of the problem described in (39) through (41). The participation constraint of that dual problem requires an individual lender's contract to provide at least as much expected payoff to the N-borrower as that provided by any other lender *in the N-phase*. The reason for this difference will be clear in a moment.

The problem described above can be written as follows:

$$\max_{R_N, L_N} \pi R_N - (1+r)L_N \tag{53}$$

subject to

$$(1-\delta)[F(L_N) - R_N] + \delta(1-\theta)V_O(x) + \delta\theta x \geq (1-\delta)F(L_N) + x \tag{54}$$

and

$$[F(L_N) - R_N] \geq F(L_O^*) - R_O(x) \tag{55}$$

The incentive constraint, equation (54) above, can be rewritten, using the value of $V_O(x)$ from (37), to obtain

$$R_N \leq \delta(1-\theta)[F(L_O^*) - x] \tag{56}$$

Denote by $(\tilde{L}_N(x),\ \tilde{R}_N(x))$ the optimal solution to this problem, and let $\tilde{\Pi}_N(x)$ denote the corresponding expected payoff of the lender (using the value of $\Pi_O(x)$ derived above in (51)). Thus, we have

$$\tilde{\Pi}_N(x) = (1-\beta)[\pi\tilde{R}_N(x) - \tilde{L}_N(x)] + \pi\beta(1-\theta)\Pi_O(x) \tag{57}$$

Let $\psi(x) = \pi\tilde{R}_N(x) - \tilde{L}_N(x)$. Then

$$\tilde{\Pi}_N^{'}(x) = (1-\beta)\psi^{'}(x) + \pi\beta(1-\theta)\Pi_O^{'}(x) \tag{58}$$

Subtracting (58) from π times (52), we have

$$\pi\Pi_O^{'}(x) - \tilde{\Pi}_N^{'}(x) = -(1-\beta)[\psi^{'}(x) + \pi\delta(1-\theta)] \tag{59}$$

Lemma 7. $\pi\Pi_O^{'}(x) = \tilde{\Pi}_N^{'}(x)$ *for all* x.

Proof: Note that the participation constraint in the N-phase problem above always binds. If not, the value of the objective function can be increased by reducing L_N, keeping R_N fixed (the incentive constraint continues to be satisfied). The incentive constraint may or may not bind at the optimum. Thus, two possible cases arise. We deal with each of them separately.

Case 1: (The incentive constraint is slack). In this case, the first order conditions require that the lender's isoprofit curve be tangent to the participation constraint at the optimum point. This implies $\tilde{L}_N(x) = L_N(\pi)$ (where $\pi F^{'}(L_N(\pi)) = 1 + r$) and is independent of x. From the binding participation constraint, we have:

$$\tilde{R}_N(x) = F(L_N(\pi)) - [1-\delta(1-\theta)]F(L_O^*) - \delta(1-\theta)x \tag{60}$$

Using this in the definition of $\psi(x)$ and on differentiating, we obtain:

$$\psi^{'}(x) = -\pi\delta(1-\theta) \tag{61}$$

Using this in (58), we have

$$\pi\Pi_O^{'}(x) - \tilde{\Pi}_N^{'}(x) = 0 \tag{62}$$

which establishes the result for this case.

Case 2: (Both constraints bind). Treating (54) and (55) as equalities, and on eliminating R_N, we have $F(L_N) = F(L_O^*) - R_O(x) + \delta(1-\theta)[F(L_O^*) - x] = F(L_O^*]$, implying $\tilde{L}_N(x) = L_O^*$. Then, from (55), we have $\tilde{R}_N(x) = R_O(x) = \delta(1-\theta)[F(L_O^*) - x]$. Using these values in the definition of $\psi(x)$, we have

$$\psi^{'}(x) = -\delta(1-\theta) \tag{63}$$

as in the previous case. Therefore the lemma holds in this case too. ■

Denote, as before by x^*, the fixed point of the equilibrium correspondence, i.e, $\phi(x^*) = x^*$.

Lemma 8. *(i)* $\Pi_O^* = \Pi_O(x^*)$
(ii) $\Pi_N^* = 0 > \tilde{\Pi}_N(x^*)$
(iii) $\pi\tilde{\Pi}_O - \tilde{\Pi}_N = \pi\tilde{\Pi}_O(0) - \tilde{\Pi}_N(0)$

Proof: Part (i) follows from definition. For (ii), observe that at the fixed point, $V_O^* > V_N^*$, which implies $F(L_O^*) - R_N^* > F(L_N^*) - R_N^*$, so that at $x = x^*$, the participation constraint in the variant of the N-phase problem described in (53) through (55) is strictly tighter than that in the dual of the *true* N-phase problem outlined in (39) through (41). Consequently, the value of the objective function is strictly lower, i.e, $\tilde{\Pi}_N(x^*) < \Pi_N^*$.

Coming to part (iii), we show that $\pi\tilde{\Pi}_O > \pi\Pi_O(0)$ and $\tilde{\Pi}_N > \tilde{\Pi}_N$, but by the same margin.[14] Turning to the O-phase first, utilizing the fact that L_O^* is the optimal loan size in either problem, and the fact that the respective incentive constraints are binding, we obtain using (32), $\tilde{R}_O = \delta F(L_O^*)$, and from (56), $\tilde{R}_O(0) = \delta(1-\theta)F(L_O^*)$. Using these values in the definition of Π_O from (13), we obtain

$$\tilde{\Pi}_O - \Pi_O(0) = \frac{\delta\theta(1-\beta)}{1-\beta(1-\theta)} \cdot F(L_O^*) \tag{64}$$

Next, observe by comparing (32) with (54), and by noting the difference in value between $\tilde{R}_O$ and $R_O(0)$, that for any given value of L_N, both the incentive and the participations constraints of the *true* N-phase problem (as defined in (31) through (33)) are higher than the corresponding ones defined in (54) and (55), by an identical magnitude given by $\delta\theta F(L_O^*)$. It is easy to see from the diagrammatic depiction of the N-phase problem, that $\tilde{L}_N = \tilde{L}_N(0)$, while $\tilde{R}_N - \tilde{R}_N(0) = \tilde{R}_O - \tilde{R}_O(0) = \delta\theta F(L_O^*)$. Using this in the definition of Π_N from (14), we obtain

$$\tilde{\Pi}_N - \tilde{\Pi}_N(0) = \frac{\pi\delta\theta(1-\beta)}{1-\beta(1-\theta)} \cdot F(L_O^*) \tag{65}$$

Comparison of (64) and (65) yields part (iii) of the Lemma. ■

The proof of Proposition 5 is now straightforward. From Lemma 7, $\pi\Pi_O(0) - \tilde{\Pi}_N(0) = \pi\Pi_O(x^*) - \tilde{\Pi}_N(x^*)$. Using Lemma 8, it follows that $\pi\tilde{\Pi}_O - \tilde{\Pi}_N > \pi\Pi_O^* - \Pi_N^*$, which completes the proof. ■

[14] The difference arises because while the *true* incentive constraints ((30) and (32)) assume that a non-defaulting borrower gets an identical contract elsewhere on exogenous termination, the incentive constraints in (35) and (54) (with $x = 0$) assume that the borrower receives zero subsequent payoff on exogenous termination, even if he has no history of default.

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