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## **Reputation, Trust and the Logic of Group Lending**

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**Abstract:** This paper analyzes the interaction between the success of group lending institutions and the stock of social capital (modeled by the level of trust) in the community where the group lending programs are located. Agents play a finitely repeated “trust game” in parallel with a finitely repeated “microcredit game.” There are two agent types: “regular” and “trustworthy,” and these types are private information. Moral hazard problems are present in both games. The model shows that there are conditions under which the presence of trust as an equilibrium of the trust game can enhance the success of the group lending program. Similarly, there are conditions under which success of the group lending program can enhance the development of trust.

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# 1 Introduction

Since the widely recognized success of the Grameen Bank in Bangladesh, microfinance schemes have become a major instrument of development planning. Microfinance was originally conceived as a means of making credit available to poor families in developing countries, thus enabling productive investments that can potentially lift these families out of poverty. In recent years, however, group lending is increasingly viewed as a vehicle for developing social capital in such countries, which itself is a catalyst of poverty alleviation.<sup>1</sup>

Social capital, in turn, is thought to be crucial to the success of group lending programs, for at least two reasons:

- One of the main advantages of group lending over individual lending is believed to be the relatively good information that group members have of each other's creditworthiness and use of loans. Thus group lending can solve moral hazard and adverse selection problems that severely limit the effectiveness of conventional financial intermediaries in the context of developing countries. Social ties (one form of social capital) are important in facilitating this informational advantage.
- An important feature of group lending programs is *joint liability*: group members are liable for repaying each other's debts to the lending institution. While joint liability provides "social collateral" which substitutes for the individual collateral that poor borrowers lack, it potentially causes incentive problems that may have a negative impact on repayment performance. Groups embedded in a community

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<sup>1</sup>For example, Berenbach and Guzman (1992, p. 4), write:

The mutual trust arrangement itself, at the heart of the group guarantee, has profound social implications. The solidarity group, because of its basis in mutual support, frees borrowers from ... dependent relationships. Further, the peer group itself, becomes the building block to a broader social network... The social objectives of mutual self-help and poverty alleviation, remain fundamental to the broader goals of these peer group lending schemes...[Quoted by Montgomery, (1996)]

with a large stock of social capital can better overcome these incentive problems.

Much of the logic of group lending can best be understood in the framework of a repeated game, yet relatively few theoretical studies have modeled group lending in such a framework.<sup>2</sup> The present paper helps correct this imbalance, by providing an analysis of the relationship between social capital and repayment performance in a repeated game with moral hazard.

The concept of social capital has been defined differently by economists, political scientists, sociologists, and others in the social sciences.<sup>3</sup> Sociologist James Coleman (1988), the originator of the term, defined social capital as a “social structure that facilitates certain actions of actors within the structure.” Coleman emphasized the roles of mutual obligation, expectations and trustworthiness, social norms and sanctions, and the transmission of information. While the concept as defined by Coleman refers to a stock of capital characterizing a community or nation, some economists (e.g., Glaeser et al., 2002) define social capital simply as the “social component of human capital.”<sup>4</sup>

The literature on social capital is very extensive. Political scientist Robert Putnam has described the decline of social capital in the United States (Putnam, 1995) and has explained differences in political culture between northern and southern Italy in terms of differences in the stock of social capital between these regions (Putnam, 1993). Putnam’s study of Italy builds on the pioneering work of Banfield (1958) on a small, economically backward community in southern Italy. Formal econometric tests, supporting the hypothesis that social capital is a key to financial develop-

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<sup>2</sup>Two notable exceptions are Wydick (2001) and Guttman (2008). For recent surveys of the literature on both of the points listed above, see Ghatak and Guinnane (1999), Guttman (2006), and Hermes and Lensink (2007).

<sup>3</sup>See Sobel (2002) for a review of this literature.

<sup>4</sup>Glaeser, et al. (2002) write:

In our analysis, we define individual social capital as a person’s social characteristics — including social skills, charisma, and the size of his Rolodex — which enables him to reap market and non-market returns from interactions with others.

ment in Italy, have been performed by Guiso et al. (2004). There is also cross-country econometric evidence that social capital is positively correlated with economic growth (Knack and Keefer, 1997; Zack and Knack, 2001).

This paper adopts Coleman’s concept of social capital and focuses specifically on the level of trust in a community. The paper develops a game-theoretic model of the interaction of trust and the success of a group lending program. One purpose of this model is to provide a theoretical explanation of empirical findings that trust and social networks are important to the success of group lending schemes.<sup>5</sup> A second purpose, however, is to show how the existence of a group lending program can have a positive effect on the stock of social capital (the level of trust) in the community where the program is located. Thus it will be demonstrated that the causality between social capital and repayment performance can work in both directions.

Section 2 of this paper outlines the model. Section 3 solves the model, and Section 4 analyzes the interaction between the two games played by the agents in the model: a trust game and a microcredit game. Section 5 concludes.

## 2 Model

In the model, individuals are randomly matched to play, in parallel, two repeated games. In one game, agents play a “trust game”—essentially a sequential Prisoner’s Dilemma—which models a bilateral market or non-market interaction in which trust is required in order to lead to the jointly optimal outcome. In the second game, agents are matched into two-person borrowing groups, which jointly borrow from a microcredit institution.<sup>6</sup> Before presenting the setup of the model, however, a critical modeling issue is discussed.

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<sup>5</sup>See, for example, Wenner (1995), Zeller (1998), Wydick (1999), Karlan (2005, 2007), and Cassar et al. (2007).

<sup>6</sup>For similar models in which a trust game is played in parallel with another game, see Guttman (2001a, 2001b).

## 2.1 Infinite or finite repetition?

A crucial choice must be made whenever one models repeated games. The game can be modeled either as (a) an infinitely repeated game or, equivalently, a finitely repeated game in which the endpoint is completely unknown to the players, or (b) a finitely repeated game with a commonly known endpoint. The well-known Folk Theorem states that if a game is infinitely repeated (or *indefinitely* repeated) and the discount rate that players apply to future payoffs is sufficiently small (i.e., future payoffs are sufficiently important), then there are infinitely many Nash equilibria, including (for example, in the Prisoner's Dilemma) joint cooperation throughout the game and joint defection throughout the game. Cooperation can be supported by various strategies (e.g., the “trigger” strategy) that punish opponents who choose to reap the instantaneous gain of unilateral defection in the current stage by delivering the low payoff of joint defection in future stages. In contrast, when the game is finitely repeated and the game's endpoint is commonly known to the players, and in addition the players' rationality is commonly known to them and they have complete information of each other's payoffs, the standard backwards induction argument implies that—in the unique equilibrium—both players defect throughout the game.

If the players have a limited amount of information of when the end of a finitely repeated game will occur, the equilibrium or equilibria of the game will depend on “how limited” is this information. Consider the real-world case of two individuals whose lifetimes and careers are (of course) finite, but the exact date at which they will die or become incapable of playing the game is unknown. Nevertheless, the players will have a subjective probability that there will be an additional stage of the game, and this subjective probability decreases as the game proceeds. Stated in more mundane terms, the probability that a person will die or retire (which could be forced by illness or other unforeseen circumstances, and in any case its timing need not be known to the player's opponent) increases as he or she becomes older.

Recall that the Folk Theorem can “explain” cooperation only when the agent's discount rate is sufficiently small (or, equivalently, the agent's dis-

count coefficient  $\delta$  is sufficiently large).<sup>7</sup> For simplicity, consider an individual without time preference and facing a zero interest rate (or without access to the capital market). If such an agent were certain that there will be another stage in the game, then  $\delta$  would be unity. But suppose that the agent assigns a probability *less* than unity to the proposition that there be another stage in the game. In this case,  $\delta$  equals this probability, since the expected value of a payment of 1 in the next period equals the probability that there *will be* another period, times 1.

Thus, in the real-world case that the probability of dying or retiring increases over time,  $\delta$  will decrease over time, and may go below the critical level required by the Folk Theorem to “explain” cooperation (this critical level depends on the entries in the payoff matrix of the game). Let us denote this stage, if it exists, by  $T$ . If  $T$  is commonly known to the players, then as far as the players are concerned, *ex ante*,  $T$  effectively becomes the last stage of the game—even though, *ex post*, there may well be further stages in the game. At stage  $T$  the players discount future payoffs at a sufficiently high rate (i.e.,  $\delta$  is sufficiently small) that it will not be optimal to cooperate in the repeated Prisoner’s Dilemma, because the expected value of future payments is too small to deter defection at stage  $T$ . Thus, at stage  $T$ , there will joint defection. It follows, by backwards induction, that there will be joint defections throughout the game if  $T$  is commonly known to the players.

The backwards induction argument, however, also assumes (as noted above) that there is common knowledge of rationality and complete information of payoffs. If either of these assumptions is relaxed, reputations can be developed (as in Kreps, et al., 1982) which support cooperation as the unique perfect Bayesian equilibrium for the initial stages of the game.

There are two advantages to treating the repeated games played by the individuals in the present model in the manner outlined in the preceding paragraphs, rather than assuming an infinitely repeated game, even though the latter modeling choice is more common in the literature. The first ad-

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<sup>7</sup>Denote the individual’s discount rate by  $\rho$ . (If the individual can borrow and lend in the capital market and he or she is at an interior solution,  $\rho$  will equal the interest rate that he or she faces.) Then  $\delta$  is defined as  $1/(1 + \rho)$ .

vantage is realism: people do not live forever and the probability of the game ending indeed increases as the game proceeds. The second advantage is predictive power. In infinitely repeated games (or finitely repeated games in which players always believe with a high enough probability that the game will continue), there are infinitely many equilibria (if  $\delta$  is sufficiently large), so that such models cannot *predict* any specific outcome. In contrast, in a finitely repeated game with incomplete information, at least for the initial stages of the game there is typically a unique equilibrium.

For these reasons, the model in this paper assumes that players behave “as if” the repeated game has a commonly known endpoint. That is, there is assumed to be a commonly known stage  $T$  at which players assign a sufficiently small probability to the proposition that the game will continue, so that this stage becomes the *ex ante* endpoint of the game in the determination of the players’ strategies.

## 2.2 The trust game

The trust game is modeled as an extensive form game (see Figure 1). Although the game applies both to market and non-market interactions, let us refer specifically to a market interaction between a buyer and a seller. The first mover, the buyer, decides whether or not to trust the seller. “Trusting” means paying the seller in advance of the delivery of the product or service being sold.<sup>8</sup> The product can be either high or low quality. If the product is high quality, the buyer receives utility equal to  $u_H > 1$ , expressed in monetary units; if the product is defective (low quality), then the buyer receives utility equal to  $u_L < 1$ . The price of the product is set in a competitive market and is normalized to unity. Thus the buyer’s payoff if supplied with a high quality good is  $u_H - 1$ , which is positive since  $u_H > 1$ , while if she is supplied with a low quality good, her payoff is  $u_L - 1$ , which is negative since  $u_L < 1$ .

The seller can exert high or low effort in supplying the good. Exerting the high level of effort costs the seller  $c \in (0, 1)$ , while exerting the low

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<sup>8</sup>If the order of payment and delivery were reversed, the roles of the buyer and seller would be reversed in the trust game, but the results of the analysis would not change.

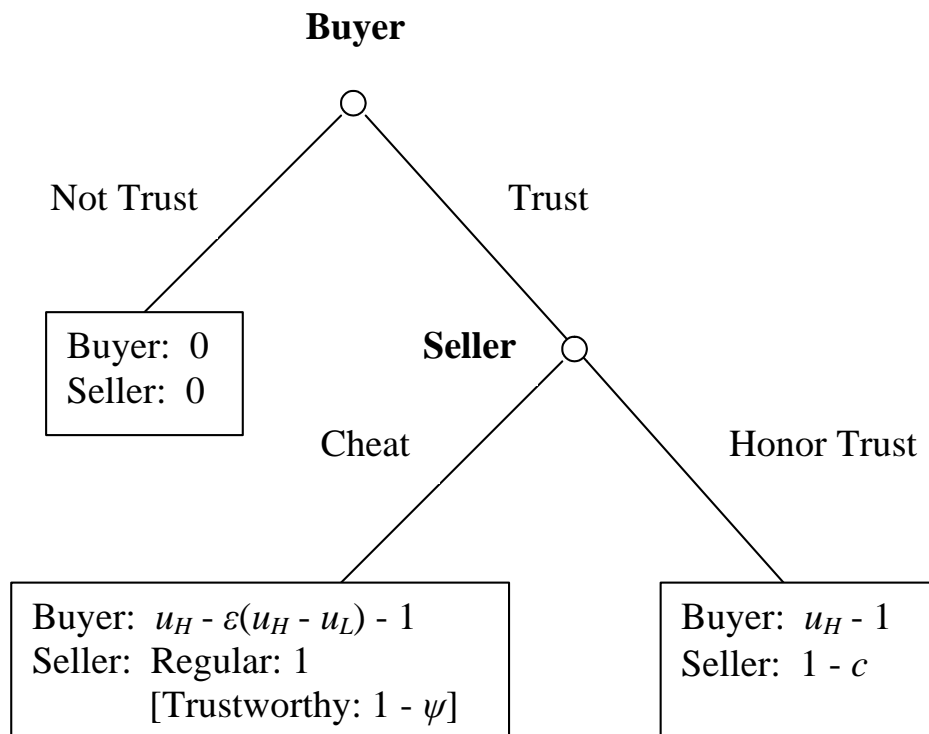


Figure 1: Trust game

level of effort costs him nothing. If the seller exerts the high level of effort, which we shall call “honoring trust,” the probability that the good will be high-quality is 1. If he exerts the low level of effort, which we shall call “cheating,” the probability that the good will be high-quality is  $1 - \epsilon$ , where  $\epsilon \in (0, 1)$ . Thus the seller’s payoff if he honors trust is  $1 - c$ , while his payoff if he cheats is 1. If the buyer decides not to trust the seller, no transaction takes place, and the payoffs of both players are zero.

To simplify the model, it will be assumed that each player plays this trust game twice in each time period, once as a buyer and once as a seller.

It is clear by inspection of Figure 1 that, if the seller is trusted in a one-stage game—and if he maximizes his payoff—he should cheat, thus receiving a payoff of 1 rather than  $1 - c$ . If the buyer nevertheless trusts the seller, her expected net payoff is therefore

$$E\pi_{trust}(cheat) = (1 - \epsilon)u_H + \epsilon u_L - 1 = u_H - \epsilon(u_H - u_L) - 1.$$

It will be assumed that  $\epsilon > (u_H - 1)/(u_H - u_L)$ . The buyer, knowing this, should not trust the seller, thus receiving a payoff of zero rather than  $E\pi_{trust}(cheat)$ , which is negative. Thus the unique, subgame perfect equilibrium in the one-shot trust game with complete information is that the buyer will not trust the seller, and no transaction will take place.

Applying this result to a village in a developing country, where the legal system is very costly to operate and can therefore be ignored for the purposes of our analysis, we would expect no transactions to take place and a very poorly functioning village economy. Taken literally, the result implies that all individuals would be autarkic, producing all goods and services for themselves and trading nothing.<sup>9</sup>

As indicated above, however, the game depicted in Figure 1 is assumed to be repeated  $T$  times, with the value of  $T$  known to both players. Would this repetition of the game lead the buyer to punish the seller for cheating, thus inducing him to honor trust? The answer is negative if the players

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<sup>9</sup>This result bears some resemblance to the situation depicted by Banfield (1958), in his study of a poor village in southern Italy.

have common knowledge of their rationality and complete information of each other's payoffs. Under these assumptions, in the final stage,  $T$ , the game is indeed one-shot, since there will be no further stages in which a cheating seller can be punished. Thus at stage  $T$  the seller will cheat, and therefore the buyer, knowing this, will not trust him. The payoffs of both players will be zero. At stage  $T - 1$ , both players can calculate that in the following stage,  $T$ , the seller will cheat and will not be trusted, whatever happens in the current stage,  $T - 1$ . Given that the outcome in the final stage is independent of the outcome at stage  $T - 1$ , the seller knows that he will not be rewarded in the following stage  $T$  if he honors trust at stage  $T - 1$ . Therefore he has no incentive to honor trust at stage  $T - 1$ . He will cheat, and the rational buyer expects him to cheat. Thus at stage  $T - 1$  the result will again be that the seller is not trusted, and the payoffs of both players again will be zero. But the same argument applies at stage  $T - 2$ . Knowing that the equilibrium in the following stages is that the seller is not trusted regardless of what happens at stage  $T - 2$ , the seller will cheat at stage  $T - 2$  as well, and, knowing this, the buyer will not trust him. And so forth, back to the first stage of the game. The unique equilibrium, therefore, is no trust throughout the game. This is the standard backwards induction argument.

In order to explain how trust nevertheless can emerge, we must therefore relax one of the assumptions stated above. The assumption to be relaxed is *complete information*. Instead of assuming that players know each other's payoffs, we will assume that there are two types of player in the village, and each player's type is his or her private information. One type will be called the *regular* type. The regular type cares only about his or her "material" payoffs, and has no conscience that would cause problems if he or she were to cheat. The other type will be called a *trustworthy* type. This type has a conscience. Therefore, if he cheats as a seller in the trust game, the trustworthy type suffers a psychic cost whose monetary value is  $\psi \in (c, 1)$ . Thus the payoffs of a trustworthy seller are different from those of a regular seller. When the trustworthy seller cheats, his true payoff is  $1 - \psi$  (instead of the material payoff of 1, the payoff to a regular seller), which by assumption

is less than  $1 - c$ . Therefore, the trustworthy seller will honor trust, since his payoff from honoring trust is greater than his payoff from cheating. The trustworthy seller's payoff from cheating is indicated in brackets in Figure 1.

If the buyer knew that the seller was a trustworthy type, she would trust him. Thus a transaction would take place, and both players' payoffs would be positive. But assuming complete information (the buyer can identify the seller's type) would lead to the trivial result that only trustworthy types are trusted. In reality, even in a close-knit community like a village in a developing country, people do not have telltale signs that reveal their type. Individuals' types can be revealed by their behavior, however.

While agents cannot identify their opponent's type, the proportion  $p$  of trustworthy types in the population is assumed to be known to each agent in the village.<sup>10</sup> This parameter will also be employed in the analysis of the microcredit game, the subject of the next subsection.

### 2.3 The microcredit game

In parallel to the trust game outlined in the previous subsection, players are randomly matched to play a finitely repeated "microcredit game." Each group of borrowers consists of two members.

We assume that all observable outcomes in both games immediately become common knowledge of the entire community, so that if a seller sells a defective product in the trust game all his peers in the community immediately know this fact. Similarly, if a borrower defaults in the microcredit game, this fact also immediately becomes known the entire community. In the case of small villages in developing countries, this assumption is eminently realistic. This assumption permits us to allow the random matching of players in the trust game and in the microcredit game to be different.

As long as the lender (the microcredit institution) continues to make credit available to the microcredit group, both borrowers can take a loan of

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<sup>10</sup>The parameter  $p$  is treated here as exogenous. For models that make  $p$  endogenous (albeit with variations on the definition of the "good" type), see Guttman (2000, 2001a, 2001b, 2003), as well as the references cited therein.

one unit of capital in each of the first  $T - 1$  stages in their “careers” and undertake to repay the loan with a payment of  $R > 1$  in the immediately following stage. That is,  $R$  includes principal and interest. The size of the loan is limited to one unit, and players cannot save from one period to the next.

For simplicity, we assume that players do not discount future payoffs, and simply maximize the sum of their payoffs in the two games over the  $T$  stages in their career.<sup>11</sup> We abstract from the gradually increasing probability that the current period is the last period in the game that characterizes the real world, as discussed in Section 2.1, and assume that the agents are certain that there will be a subsequent stage until they reach stage  $T$ , when they are certain that the final stage has been reached.

It is also assumed, again for simplicity, that both players’ careers are synchronized so that they reach stage  $T$  at the same stage.

It is assumed, as is standard in microfinance models, that the borrowers have no collateral. If their project succeeds, they receive an income of  $Y$  from the investment. If the project fails, they receive zero income from the project. In this case, given that they have no collateral, they cannot repay their debt.

The success or failure of the project is assumed to depend, as in the trust game, on the effort exerted by the agent. If the agent exerts a high level of effort, which carries a psychic cost  $e$ ,<sup>12</sup> then the project succeeds with certainty. If the agent exerts a low level of effort, whose cost is normalized to zero, then the project succeeds with probability  $1 - \theta$ , where  $\theta \in (0, 1)$ .

The agent undertakes not only to repay his or her own debts, but also to repay the debt of his or her fellow group member if the latter’s project fails. This is the principle of *joint liability*.

While the agent’s effort level is unobservable, the success or failure of

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<sup>11</sup>The assumption that players pay a positive rate of interest on their debts does not contradict this no-discounting assumption, since the size of their loan is fixed exogenously and agents cannot save. Thus there is no possibility of equating their marginal rate of substitution between income in different time periods to  $R$ .

<sup>12</sup>It could also be treated as including the opportunity cost of resources used up in exerting high effort, but this would require a slight modification in the analysis to follow.

her project is observable in the following period. It is assumed that if the agent's own project succeeds, she can be forced to pay her own debt and (if her peer's project fails) the peer's debt as well. In order to make repayment of both members' debts feasible, we assume that  $Y \geq 2R$ . If the project is successful, repayment can be enforced either by the lender or by the other group member, or by a combination of the two.<sup>13</sup> Thus the agent's only decision variable is whether to exert the high or low level of effort in the current project, a decision which is made in all stages except the last stage  $T$ , since no loans are provided at that stage.

The two agent types behave differently with respect to this decision. The regular type, as in the trust game, simply maximizes material payoffs, and therefore exerts herself at the low level of effort unless it is profitable to exert at the high level. The trustworthy type always exerts herself at the high level of effort.

### 3 Analysis of the model

This section solves the model outlined in the previous section. The trust game and the microcredit first will be solved in isolation, in Sections 3.1 and 3.2 respectively. In Section 4, the interaction of the two games will be analyzed.

#### 3.1 Solution of the trust game

Recall that the buyer in the trust game cannot identify the seller's type, but knows the proportion of trustworthy types in the population,  $p$ . Therefore the buyer assigns a prior probability  $p$  to the proposition that the seller is trustworthy.

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<sup>13</sup>Bratton (1986) studied a microcredit program in Zimbabwe in which stop orders were used to enforce repayment from the crops of borrower farmers. A piece of anecdotal evidence on this issue is provided by a report by BRAC, a microcredit institution in Bangladesh (Kahn and Stewart, 1992, quoted by Montgomery, 1996), in which BRAC women told "with pride that they had pulled down a member's house because she did not pay back her housing loan." Besley and Coate (1995) have analyzed the role of social pressure in enforcing loan agreements in microcredit schemes.

The solution concept to be employed throughout the analysis is Perfect Bayesian Equilibrium. Therefore the analysis begins at the end of the game, stage  $T$ .

We begin by noting that if the buyer ever receives a defective product, the seller reveals himself to be a regular type. If this happens, the buyer knows that the seller will cheat at stage  $T$ , and therefore the seller will not be trusted at stage  $T$ , regardless of whether he cheats at stage  $T - 1$ . Thus the seller has no incentive to honor trust at stage  $T - 1$ , and therefore will not be trusted at  $T - 1$  as well. Thus, by backwards induction, we obtain

**Proposition 1** *If the buyer ever receives a defective product, she will not trust the seller in the remaining stages of the game.*

A regular type seller clearly will cheat at stage  $T$ . If  $\epsilon$ , the probability of the product being defective with low seller effort, is small enough, he will optimally cheat at stage  $T - 1$  as well, despite the risk of the product turning out to be defective and thus losing the buyer's trust at  $T$ . (Recall that, since the buyer cannot identify the seller's type, she may trust him at stage  $T$  if his record is clean, since some sellers are trustworthy.) Indeed, if  $\epsilon$  is small enough, he will optimally cheat at stage  $T - 2$  as well, and so forth. If there are sufficiently many stages in the trust game, however, we would expect intuitively that at an early enough stage  $\bar{t}$ , the risk of his product turning out to be defective at *some* future stage may deter him from cheating.

Thus we would conjecture that the time pattern of the seller's optimal strategy would have the form  $H, H, H, H, \dots, L, L, L, L$  where  $H$  denotes "high effort" and  $L$  denotes "low effort." Table 1 illustrates the reasoning underlying this conjecture. The table shows three arrangements of two stages in which the seller might cheat, over the course of four stages. In the first configuration, two stages of honoring trust appear *between* two stages of cheating. In the second configuration, two stages of honoring trust appear *before* two stages of cheating. The first configuration yields a lower total payoff, because after the first stage of cheating, at stage 1, all future expected stage payoffs are multiplied by  $1 - \epsilon$ , the probability that the first stage of cheating did not cause a defective product to be produced. In the

second configuration, the two stages of honoring trust each yield a payoff of  $1 - c$ , without being multiplied by  $1 - \epsilon$ , since they are not preceded by a stage of cheating. The third configuration yields a still lower payoff than the first two, since two stages of cheating precede two stages of honoring trust. Therefore the payoffs of  $1 - c$  in stages 3 and 4 are multiplied by  $(1 - \epsilon)^2$ .

Table 1

1	2	3	4
<i>L</i>	<i>H</i>	<i>H</i>	<i>L</i>
1	$(1 - c)(1 - \epsilon)$	$(1 - c)(1 - \epsilon)$	$1 - \epsilon$
<i>H</i>	<i>H</i>	<i>L</i>	<i>L</i>
$1 - c$	$1 - c$	1	$1 - \epsilon$
<i>L</i>	<i>L</i>	<i>H</i>	<i>H</i>
1	$1 - \epsilon$	$(1 - c)(1 - \epsilon)^2$	$(1 - c)(1 - \epsilon)^2$

Suppose that, at stage  $T$ , the seller has a “clean record”: he has never sold a defective product. Let us further suppose, in line with the above conjecture, that the regular type seller’s strategy is to exert the high level of effort for the first  $\bar{t}$  stages of the game and then exert the low level of effort in the remaining stages. The probability that a regular type’s record will be clean at the beginning of stage  $T$ , given this strategy, is  $(1 - \epsilon)^{T - \bar{t} - 1}$ . We shall simplify this expression slightly by denoting the number of stages in which the seller cheats at the end of the game as  $k$ . (The seller’s optimal  $k$  will be derived below.) Recall that the buyer’s prior probability that the seller is trustworthy is  $p$ . Using Bayes’ theorem, the buyer’s posterior probability, at stage  $T$ , that the seller is a trustworthy type then would be

$$\Pr(\text{trustworthy} \mid \text{clean record}) = \frac{p}{p + (1 - p)(1 - \epsilon)^{k-1}}. \quad (1)$$

At stage  $T - k + 1$ , the regular seller will cheat with certainty, while the trustworthy seller will honor trust with certainty. If the buyer trusts the

seller, her expected payoff at this stage is

$$E\pi(\text{trust}) = p(u_H - 1) + (1 - p)[u_H - \epsilon(u_H - u_L) - 1].$$

Since the buyer's payoff if she does not trust is zero, she will trust if  $E\pi(\text{trust})$  is non-negative.<sup>14</sup> Therefore the buyer will trust the seller at stage  $T - k + 1$  if and only if

$$p \geq 1 - \frac{u_H - 1}{\epsilon(u_H - u_L)}. \quad (2)$$

Let us denote the r.h.s. of (2)  $p_{\min}(\text{trust})$ .<sup>15</sup>

If  $p < p_{\min}(\text{trust})$ , the buyer will not trust the seller at stage  $T - k + 1$  and at all subsequent stages. In this case, the seller therefore has no incentive to honor trust at stage  $T - k$ . Since the buyer knows this, she will not trust the seller at stage  $T - k$  as well. It follows, by backwards induction, that the seller will not be trusted at stage  $T - k - 1$ ,  $T - k - 2$ , etc., back to stage 1.

We now assume that  $p \geq p_{\min}(\text{trust})$ , which allows trust to be developed, since the backwards induction argument of the preceding paragraph does not apply. Our purpose is to derive the optimal number of stages  $k$  in which a regular type seller will cheat. Clearly, a regular type seller will cheat at stage  $T$ . Will it be optimal to cheat at stage  $T - 1$  as well? By cheating at stage  $T - 1$  as well, the seller saves  $c$ , the cost of the high effort level. But he reduces his expected payoff at stage  $T$  from 1 to  $1 - \epsilon$ . Thus it will

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<sup>14</sup>In the case of indifference, we assume that she trusts.

<sup>15</sup>Recall that

$$u_H - \epsilon(u_H - u_L) - 1 < 0$$

is the buyer's expected payoff if the seller cheats. This implies that

$$\epsilon(u_H - u_L) > u_H - 1,$$

ensuring that the second term on the r.h.s. of (2) is less than unity.

At stage  $T$  the buyer's posterior probability that a seller with a clean record is trustworthy is

$$\frac{(1 - \epsilon)^{k-1}[1 + \epsilon(u_H - u_L) - u_H]}{(1 - \epsilon)^{k-1}[1 + \epsilon(u_H - u_L) - u_H] + u_H - 1}.$$

be optimal to cheat at  $T - 1$  as well if and only if  $c > \epsilon$ . Suppose that this condition holds. In general, the total expected payoff of  $k$  adjacent stages of cheating at the end of the game, preceded by a stage of honoring cooperation at stage  $T - k$ , is

$$E\pi(k) = 1 - c + \sum_{i=0}^{k-1} (1 - \epsilon)^i.$$

If, at stage  $T - k$ , the seller cheats instead of honoring trust, the expected payoff over the same  $k + 1$  stages<sup>16</sup> will be  $\sum_{i=0}^k (1 - \epsilon)^i$ . Thus the increase in expected payoff due to cheating over  $k + 1$  stages instead of  $k$  stages at the end of the game is

$$\Delta E\pi(k) = c - 1 + (1 - \epsilon)^k$$

Since  $\epsilon \in (0, 1)$ ,  $\Delta E\pi$  decreases monotonically as  $k$  increases. The  $k$  which makes  $\Delta E\pi(k) = 0$  is

$$\bar{k} = \frac{\ln(1 - c)}{\ln(1 - \epsilon)}. \quad (3)$$

Thus the optimal  $k$ , to be denoted  $k^*$ , is the largest integer less than or equal to  $\bar{k}$ . In symbols,  $k^* \equiv \lfloor \bar{k} \rfloor$ .

Summarizing, we have

**Proposition 2** *In the trust game, there is a Perfect Bayesian Equilibrium with the following properties: The seller will be trusted in equilibrium if and only if  $p \geq p_{\min}(\text{trust})$ . If this condition holds, regular type sellers will honor trust up to and including stage  $T - k^*$ . Trustworthy types will honor trust throughout the game.*

### 3.2 Solution of the microcredit game

As we did in the analysis of the trust game, we begin the analysis at stage  $T - 1$ , which is the last stage at which the players decide whether to exert themselves at the low or the high effort level. As stated in section 2.3, the

<sup>16</sup>In the previous stages, the seller honors trust under both strategies, so that the previous stages can be ignored in deriving  $\Delta E\pi$ .

trustworthy player is assumed to exert the high effort level at all stages. Let us assume momentarily that the players can identify each other's type, i.e., there is complete information. This assumption will be relaxed after analyzing the game depicted in Matrix 1. Matrix 1 shows the payoff matrix for two regular types at stage  $T - 1$ , with complete information.

Matrix 1

	High	Low
High	$Y - R - e, Y - R - e$	$Y - (1 + \theta)R - e, (1 - \theta)(Y - R)$
Low	$(1 - \theta)(Y - R), Y - (1 + \theta)R - e$	$(1 - \theta)[Y - (1 + \theta)R], (1 - \theta)[Y - (1 + \theta)R]$

This matrix takes account of the player's cost at stage  $T - 1$  from exerting high or low effort, and her payoff in the following stage, stage  $T$ , from the returns on this effort and the cost of repaying the loan. The entries in the matrix are calculated as follows:

- If both players exert the high level of effort, their projects both succeed, yielding a net payoff of  $Y - R$  from the loan and costing  $e$  because of the high effort.
- If one player exerts the high level of effort and her partner exerts the low level of effort, only the first player's project succeeds with certainty. She then must repay not only her own loan but also her partner's loan (with probability  $\theta$ ), yielding  $Y - (1 + \theta)R - e$ . The other player exerts only the low level of effort, costing nothing, and yielding a net expected income of  $(1 - \theta)(Y - R)$  from the loan, since she must repay only if her project succeeds, which has probability  $1 - \theta$ .
- If both players exert the low level of effort, both players receive a net expected income of  $(1 - \theta)(Y - R)$ , but in the case that the partner's project fails, which has probability  $\theta$ , the player must repay her partner's debt, thus giving a net expected payoff of  $(1 - \theta)[Y - (1 + \theta)R]$ .

We now relax the assumption of complete information, and take account of the fact that neither player can identify her partner's type. This implies

that there is a probability  $p$  that the other player is trustworthy and therefore exerts the high level of effort.

Matrix 2 shows the modified payoff matrix that takes account of this incomplete information. For example, when the “row” player chooses to exert the high level of effort, and her partner (if she is a regular type) also exerts the high level of effort, then both players receive a certain payoff of  $Y - R - e$ . But if her partner (if she is a regular type) exerts the low level of effort, then the row player’s *expected payoff* is  $Y - R[1 + (1 - p)\theta] - e$ , which takes account of the probability  $(1 - p)$  that the partner is a regular type and, since she exerts the low effort level, the row player must pay her partner’s debt if the partner’s project fails, which has probability  $\theta$ . In order to simplify the entries in the matrix, we define  $\phi \equiv (1 - p)\theta$ .

Matrix 2

	High	Low
High	$Y - R - e, Y - R - e$	$Y - (1 + \phi)R - e, (1 - \theta)(Y - R)$
Low	$(1 - \theta)(Y - R), Y - (1 + \phi)R - e$	$(1 - \theta)[Y - (1 + \phi)R], (1 - \theta)[Y - (1 + \phi)R]$

The calculation of the matrix entries is as follows:

- If regular type player 1 exerts the high effort level, and player 2 (if regular) also exerts the high effort level, the result will be that both players’ projects succeed, whether or not the other player is trustworthy. Thus the regular player’s payoff remains  $Y - R - e$ .
- If a regular type player 1 exerts the high effort level and the opponent (if regular) exerts the low effort level, then player 1 receives an expected payoff of  $Y - (1 + \theta)R - e$  if player 2 is also regular, since player 2’s project fails with probability  $\theta$  and, in this case, player 1 must pay the debts of both players. But if player 2 is trustworthy (which has probability  $p$ ), she also exerts the high effort level and therefore both projects succeed, giving player 1 a payoff of  $Y - R - e$ . Weighting these payoffs by their probabilities, we obtain an expected payoff of

$Y - (1 + \phi)R - e$ . Player 2's project succeeds with probability  $1 - \theta$ , in which case her net income is  $Y - R$ , so that her expected payoff is  $(1 - \theta)(Y - R)$ .

- If both players exert the low effort level, they receive an expected net income of  $(1 - \theta)(Y - R)$  from their projects. There is, however, a probability  $(1 - p)\theta \equiv \phi$  that the partner is a regular type *and* her project fails, implying that the player must pay her partner's debt, so that each player's expected payoff is  $(1 - \theta)[Y - (1 + \phi)R]$ .

There are three cases to consider in the analysis of Matrix 2:

1. If  $e \leq \theta[Y - (1 + \phi)R]$ , each player has an (at least weakly) dominant strategy to exert the high level of effort.
2. If  $\theta[Y - (1 + \phi)R] < e \leq \theta(Y - R)$ , the game is a like the well-known "stag hunt."<sup>17</sup> There are two pure-strategy Nash equilibria, one in which both players exert the high effort level, and the other in which both players exert the low effort level. There is also a mixed-strategy equilibrium where each regular player exerts the high level of effort with probability

$$q^* = 1 - \frac{(Y - R)\theta - e}{R\theta\phi}.$$

3. If  $e > \theta(Y - R)$ , both players have a strictly dominant strategy to exert the low effort level.

Note that there is a critical value of  $p$ , to be denoted  $\bar{p}$ , which delineates between Cases 1 and 2. This value of  $p$  is

$$\bar{p} = \frac{e - \theta[Y - (1 + \theta)R]}{R\theta^2}. \quad (4)$$

Conditional on  $e \leq \theta(Y - R)$ , if  $p \geq \bar{p}$ , then the relevant case is Case 1, while if  $p < \bar{p}$ , then the relevant case is Case 2. We now analyze Cases 1, 2 and 3 in turn.

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<sup>17</sup>Throughout, in the case of indifference, we assume that the agent exerts the high effort level.

### 3.2.1 Case 1: $e \leq \theta[Y - (1 + \phi)R]$

In this case, as noted above, each regular type player has an (at least) weakly dominant strategy to exert the high level of effort. The trustworthy type exerts the high effort level in all cases. Thus we obtain

**Proposition 3** *If  $e \leq \theta[Y - (1 + \phi)R]$ , both players will exert the high level of effort, in equilibrium, throughout the game, regardless of their type.*

### 3.2.2 Case 2: $\theta[Y - (1 + \phi)R] < e \leq \theta(Y - R)$

In this case, as noted above, there are three Nash equilibria in the stage game. We focus on the two pure-strategy equilibria,<sup>18</sup> and analyze this case under the two possible assumptions that one can make regarding the selection of equilibrium:

- *Assumption A.* In the case of two pure strategy equilibria—(High, High) and (Low, Low)—the (High, High) equilibrium is selected.
- *Assumption B.* In the case of two pure strategy equilibria—(High, High) and (Low, Low)—the (Low, Low) equilibrium is selected.

The (High, High) equilibrium is risk dominant if  $e < \theta[Y - \left(1 + \frac{\phi}{2}\right)R]$ . Under this condition, Assumption A is the more reasonable assumption according to the approach of evolutionary game theory [Kandori, Mailath and Rob (1993) and Young (1993)]. If, in addition,  $e < \theta[Y - (1 + \phi)R] + \phi R$ , then the (High, High) equilibrium is payoff (or Pareto) dominant, and Assumption A is the more reasonable assumption according to the rational choice equilibrium selection theory of Harsanyi and Selten (1988). In this case, the players presumably will exert the high level of effort in equilibrium, as in Case 1.

If, on the other hand,  $e > \theta[Y - \left(1 + \frac{\phi}{2}\right)R]$ , the (Low, Low) equilibrium is risk dominant. If  $e > \theta[Y - (1 + \phi)R] + \phi R$ , the same equilibrium is

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<sup>18</sup>The mixed strategy equilibrium is excluded from the analysis for technical reasons, namely that it is evolutionarily unstable and also is unstable in the sense of players revising their strategies in response to prior strategy choices of their opponents.

also Pareto dominant. Thus Assumption B might be the more appropriate assumption. It is conceivable, however, that even if the two players start at the (Low, Low) equilibrium, they may eventually move to the (High, High) equilibrium. If the latter equilibrium gives a higher expected payoff to both players (which requires that  $e < \theta[Y - (1 + \phi)R] + \phi R$ ), one or both of the players in the initial (Low, Low) equilibrium may deviate from this equilibrium in the hope of inducing her partner to deviate as well. Such a deviation would incur a short-run cost if the deviation is unilateral. In the long run, however, after the partner has inferred that the deviation has taken place, the partner would optimally shift to the high effort level as well, particularly if she infers that the deviating agent is a trustworthy type.

Recall that if the player exerts the high effort level, her project succeeds with certainty, while if she exerts the low effort level, her project succeeds only with probability  $1 - \theta$ . Using Bayes' theorem, the player's posterior probability that her partner is a trustworthy type, upon observing  $n$  consecutive successes of her partner's projects when Assumption B applies, is

$$\Pr(\text{trustworthy} | n \text{ consecutive successes}) = \frac{p}{p + (1 - p)(1 - \theta)^n} \quad (5)$$

This posterior probability should be substituted for the player's prior probability  $p$  that her partner is trustworthy, in Matrix 2 [recall that  $p$  enters into the matrix through the parameter  $\phi \equiv (1 - p)\theta$ ]. When this posterior probability is sufficiently high,  $\phi$  becomes sufficiently small to shift the parameter constellation into Case 1, in which the (at least weakly) dominant strategy for a regular player is to exert the high effort level.

Equating the posterior probability in (5) to the critical probability  $\bar{p}$  defined by (4), we obtain the minimum number of consecutive successes, to be denoted  $n_{\min}$ , required to make the high effort level the (at least weakly) dominant strategy for a regular type player:

$$n_{\min} = \left\lceil \frac{\ln\left(\frac{1 - \bar{p}}{1 - p}\right) + \ln\left(\frac{p}{\bar{p}}\right)}{\ln(1 - \theta)} \right\rceil. \quad (6)$$

The delimiters around the fraction on the right-hand side indicate that  $n_{\min}$  is the smallest integer that is at least equal to the fraction shown.

If  $n_{\min} < T$ , a regular type *may* have an incentive to deviate from the (Low, Low) equilibrium in order to be identified as a trustworthy type. Such a deviation, however, is only optimal if the expected costs of the deviation (the decrease in expected payoff in each of the  $n_{\min}$  stages in which the agent has unilaterally deviated from the equilibrium) are lower than the benefits (the increase in expected payoff when both agents have moved to the high-effort equilibrium). If these conditions are fulfilled, the low-effort equilibrium could be eliminated by the “intuitive criterion” of Cho and Kreps (1987).

If  $\theta$  is relatively small, however, the player’s posterior probability that her partner is trustworthy will increase relatively slowly. Thus, for relatively small  $T$  and  $\theta$ , we could have  $n_{\min} > T$ , and two regular type players can be “trapped” in the low-effort equilibrium in Case 2, under Assumption B.

Summarizing, we have

**Proposition 4** *If  $\theta[Y - (1 + \phi)R] < e \leq \theta(Y - R)$ , under Assumption A the two players will exert the high level of effort, in equilibrium, throughout the game, regardless of their type. Under Assumption B, the two players may exert the low level of effort throughout the game, particularly if  $\theta$  and  $T$  are relatively small.*

### 3.2.3 Case 3: $e > \theta(Y - R)$

In this case, the regular type player has a dominant strategy to exert the low level of effort. Therefore the only agents who will exert the high effort level, in equilibrium, will be the trustworthy types. We thus obtain

**Proposition 5** *If  $e > \theta(Y - R)$ , only trustworthy types will exert the high effort level in equilibrium.*

## 4 Interaction of the two games

As emphasized in the Introduction, there is a presumption in the literature that there is a positive “synergy” between microcredit programs and social

capital. On the one hand, the success of microcredit programs is enhanced by the stock of social capital, while on the other hand, the existence of a microcredit program can increase the stock of social capital in a community. This section discusses two channels through which this synergy might work, in the framework of the two games analyzed in Section 3.

#### 4.1 Channel 1

The first channel works simply by changing the payoffs to exerting the high effort level in the trust game and in the microcredit game. Suppose, for example, that  $p_{\min}(\text{trust}) < p < \bar{p}$ . Thus the proportion of trustworthy types in the community is high enough to support an equilibrium in the trust game in which buyers trust sellers, and sellers honor trust, up to and including stage  $T - k^*$ , where  $k^*$  is the largest integer less than or equal to  $\bar{k}$  as defined in (3), and is assumed to be less than  $T$ . Since  $p < \bar{p}$ , the microcredit game is either in Case 2 or Case 3. Therefore the groups in the village are liable to fail (in Case 2, if Assumption B applies, or in Case 3, since the only equilibrium is that both group members exert the low effort level, by Propositions 4 and 5). The equilibrium in the trust game, however, changes the incentives in the microcredit game by increasing the payoff to the high effort level in the latter game. The seller in the trust game gains  $1 - c$  in each stage in which he is trusted, and he will be trusted only as long as his investment project in the microcredit game succeeds (since trustworthy types exert the high effort level and therefore their projects always succeed). Thus Matrix 2 changes to Matrix 3. (To save space, and given that the game is symmetric, only the payoffs to the row player are shown. In Matrix 3,  $t$  denotes the current stage, as will be explained below.)

Matrix 3

	High	Low
High	$Y - R - e + (1 - c)(T - k^* - t)$	$Y - (1 + \phi)R - e + (1 - c)(T - k^* - t)$
Low	$(1 - \theta)[Y - R + (1 - c)(T - k^* - t)]$	$(1 - \theta)[Y - (1 + \phi)R + (1 - c)(T - k^* - t)]$

The entries in Matrix 3 show both the payoff in stage  $t + 1$  from the success or failure of the player's project,<sup>19</sup> and the sum of the payoffs in the trust game from stage  $t + 1$  up to and including stage  $T - k^*$ , provided that the regular type player does not reveal his type through the failure of his project. The payoffs shown in Matrix 3 assume that in future stages (up to and including stage  $T - k^*$ ) the player exerts the high effort level, so that the differences in the payoffs between the high and low effort levels represent payoffs from a one-time deviation from an equilibrium in which the player exerts the high effort level.

Given the modifications to Matrix 2, it is not surprising that the three cases analyzed in Section 3.2 are now defined differently. They are:

1.  $e \leq \theta[Y - (1 + \phi)R + (1 - c)(T - k^* - t)]$ . In this case, the regular type player has an (at least weakly) dominant strategy to exert the high effort level.
2.  $\theta[Y - (1 + \phi)R + (1 - c)(T - k^* - t)] < e \leq \theta[Y - R + (1 - c)(T - k^* - t)]$ . In this case, the stage game in the microcredit game has two pure strategy Nash equilibria, (High, High) and (Low, Low).
3.  $e > \theta[Y - R + (1 - c)(T - k^* - t)]$ . In this case, the regular type player has a strictly dominant strategy to exert the low effort level.

Since the right-hand side (r.h.s.) of the weak inequality in Case 1 has increased by  $\theta(1 - c)(T - k^* - t)$  as compared to the corresponding r.h.s. in Case 1 in Section 3.2, there is a corresponding *increase in the space of parameter values for which Case 1 applies*. Similarly, since the r.h.s. of the inequality in Case 3 has increased by the same amount, there is a corresponding *decrease in the space of parameter values for which Case 3 applies*. Therefore the *mere existence of the trust game* in parallel to the microcredit game, for the “intermediate” value of  $p$  defined by  $p \in (p_{\min}(\text{trust}), \bar{p})$ , increases the likelihood that agents will exert the high effort level in the microcredit game. Moreover, this increase of  $\theta(1 - c)(T - k^* - t)$

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<sup>19</sup>Recall that the success or failure of the project is observed only at stage  $t + 1$ .

in the r.h.s. of the inequalities defining Cases 1 and 3 will be larger, the smaller is  $t$ . Thus the “positive externality” of the trust game on the success of microcredit groups will be relatively large in the earlier stages of the agents’ careers, and will disappear at stage  $T - k^*$ .

The positive externality of one game on the other can also work in the opposite direction, although the conditions in this case are more restrictive. Suppose that the relative sizes of  $p_{\min}(\text{trust})$  and  $\bar{p}$  were reversed so that  $p_{\min}(\text{trust}) > \bar{p}$ , and  $p \in (\bar{p}, p_{\min}(\text{trust}))$ . In this case,  $p$  is too small to support trust in the trust game, but is large enough to put the microcredit game in Case 1, in which regular types have an (at least) weakly dominant strategy to exert the high effort level. But if their type were revealed by supplying a defective product in the trust game, the relevant payoff matrix would be Matrix 1, in which the condition for Case 1 is more stringent, namely  $e \leq \theta[Y - (1 + \theta)R]$  instead of  $e \leq \theta[Y - (1 + \phi)R]$ . If the former weak inequality is not satisfied, then once the regular type player’s type is revealed, the microcredit game would shift to the (Low, Low) equilibrium in Case 2 if Assumption B applies. This, in turn, would imply that a regular type seller whose type is revealed in the trust game would lose in expected payoff, in each stage of the microcredit game [the difference in expected payoff between the (High, High) and the (Low, Low) equilibrium in Matrix 1], by the amount

$$(Y - R - e) - (1 - \theta)[Y - (1 + \theta)R] = \theta(Y - R) + (1 - \theta)\theta R - e,$$

which will be positive if

$$e < \theta(Y - R) + (1 - \theta)\theta R.$$

This loss may provide a sufficient incentive for a regular type seller to honor trust in the trust game, even though in the trust game played in isolation, he would not honor trust. And if it is optimal for the regular type to honor trust, he will be trusted.

Summarizing, we obtain

**Proposition 6** (a) Suppose that  $p_{\min}(\text{trust}) < \bar{p}$ . If  $p \in (p_{\min}(\text{trust}), \bar{p})$  and  $k^* < T$ , the existence of the trust game will increase the space of parameter values for which agents will exert the high effort level in at least one equilibrium in the microcredit game. This increase will be larger at the earlier stages of the agents' careers, and will disappear at stage  $T - k^*$ . (b) Similarly, suppose that  $p_{\min}(\text{trust}) > \bar{p}$  and  $p \in (\bar{p}, p_{\min}(\text{trust}))$ . If, in addition, (i) Assumption B applies in Case 2 of the microcredit game and (ii)  $\theta(Y - R) + (1 - \theta)\theta R > e > \theta[Y - (1 + \theta)R]$ , the existence of the microcredit game may induce regular type sellers to honor trust in the trust game.

## 4.2 Channel 2

The second channel, unlike the first channel, works in only one direction. Suppose that  $p$  is smaller than both  $p_{\min}(\text{trust})$  and  $\bar{p}$ . In words, the proportion of trustworthy types is too small to support trust in the trust game, and also is too small to put the microcredit game in Case 1, in which both group members (even if they are regular types) exert the high level of effort. Instead, we assume that the relevant case in the microcredit game is either Case 2, in which case we assume that Assumption B applies, or Case 3. In either case, in equilibrium the two group members exert the low level of effort, if they are regular types.

The operation of the second channel is much more complicated than that of the first channel. Therefore the discussion in this subsection will be less formal than that of the previous subsection.

In Section 3.2.2, we noted that if a player  $i$  exerts the high effort level in the microcredit game when, in equilibrium, regular types exert the low effort level, then it is reasonable to expect that player  $i$ 's partner will interpret this deviation as implying that player  $i$  is a trustworthy type. The only proviso is that it takes time before this deviation is observed by player  $i$ 's partner, since player  $i$ 's effort level is not directly observable. Equation (5) gives the partner's posterior probability that player  $i$  is a trustworthy type, after observing  $n$  consecutive successes of player  $i$ 's projects. Equating the r.h.s. of (5) to  $p_{\min}(\text{trust})$ , we can calculate the number of stages in which

player  $i$  must deviate from the equilibrium in the microcredit game in order to make his partner in the trust game believe that he is trustworthy (with sufficiently high probability), which we denote  $n_{\min}(trust)$ :

$$n_{\min}(trust) = \left\lceil \frac{\ln\left(\frac{1 - p_{\min}(trust)}{1 - p}\right) + \ln\left(\frac{p}{p_{\min}(trust)}\right)}{\ln(1 - \theta)} \right\rceil.$$

Player  $i$  loses  $e - \theta[Y - (1 + \phi)R]$  in each stage that he deviates from the (Low, Low) equilibrium by exerting the high effort level, but once  $n_{\min}(trust)$  stages have passed, he is trusted in the trust game, allowing him to gain  $1 - c$  per stage, and also to cheat in the last stages, giving him a payoff of 1 per stage. Upon reaching stage  $n_{\min}(trust)$ , he need not exert the high effort level in each of the remaining stages in the microcredit game, since there is a probability  $1 - \theta$  that his project will succeed even if he exerts the low effort level. Thus player  $i$  may optimally revert to the low effort level before stage  $T$ , just as he will revert to the low effort level in the trust game before stage  $T$ , as explained in Section 3.2.1.

This deviation of player  $i$  from the low effort level equilibrium in the microcredit game will also shift that equilibrium in that game to the (High, High) equilibrium, if the game was initially in Case 2 with Assumption B applying. As shown in Section 3.2.2,  $n_{\min}$  stages of consecutive project successes are required to make player  $i$ 's partner believe with sufficiently high probability that player  $i$  is a trustworthy type, in order to induce the partner to shift to the high effort level. Thus, in Case 2 under Assumption B, the player  $i$ 's expected payoff from deviating to the high effort level includes the benefits of shifting the equilibrium to the (High, High) equilibrium, provided that this equilibrium is Pareto dominant. If these "long run" expected benefits exceed the "short run" expected costs of deviating from the (Low, Low) equilibrium, then the latter equilibrium can be eliminated by the intuitive criterion.

This is not quite the end of the story, however. If it is optimal for one

regular type player to deviate from the (Low, Low) equilibrium, then seemingly it will be optimal for all of them to do so. But if they all deviate, then the deviation cannot be interpreted as evidence that they are trustworthy types. Thus, in Case 2 under Assumption B and in Case 3, one obtains a mixed strategy equilibrium in which some regular types exert the high effort level and some exert the low effort level. In this equilibrium, when a buyer in the trust game observes repeated successes in the seller’s investment projects, she updates her prior probability that the seller is trustworthy to a level that makes her just indifferent between trusting and not trusting. She then trusts with a probability that makes the regular type players in the microcredit game indifferent between exerting the high and low effort level, thus supporting the mixed strategy equilibrium.

Summarizing, we obtain

**Proposition 7** *If  $p < p_{\min}(\text{trust})$  and  $p < \bar{p}$ , and if  $n_{\min}(\text{trust}) < T$ , then if the microcredit game is in Case 2 with Assumption B applying or in Case 3, there may be a mixed strategy equilibrium in which a positive proportion of the regular types exert the high level of effort in the microcredit game and honor trust in the trust game, and in which buyers trust sellers in the trust game with positive probability.*

## 5 Concluding remarks

We have found that it is possible to formulate the widely held presumption of a synergy between microcredit programs and social capital, in the context of a rigorous game theoretic model. In this model, there are two types of players: regular and trustworthy. Player types are private information, but in a repeated game framework, reputations can be developed which support trust in a bilateral “trust game” and repayment in a microcredit game, when the two games are played in parallel. There are conditions under which trust in the trust game is the equilibrium outcome independently of the outcome in the repayment game and vice versa. But there are also conditions under which the development of trust in the trust game (an aspect

of social capital) will enhance repayment performance in the microcredit game. Similarly, there are conditions under which the threat of group default in the microcredit game, induced by the revelation of cheating in the trust game, may provide an incentive to sellers in the trust game to honor trust even though they would cheat if the trust game were played in isolation. Here the existence of a microcredit program may increase the stock of social capital in a community.

The model developed in this paper can be extended in a number of potentially fruitful directions. The fact that microcredit groups usually have more than two members could be incorporated in the model. Continuous rather than dichotomous strategy sets could be introduced as well. Similarly, the assumptions that with a high effort level the high-quality good is produced with certainty in the trust game, and the borrower's investment project succeeds with certainty in the microcredit game, can be relaxed. All of these extensions would improve the usefulness of the model in guiding policy in the development of microfinance institutions. It is hoped, however, that the present model provides some useful insights despite the simplicity of its assumptions.

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