this version: December 1, 2005

Joint liability contracts without asymmetric information

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Abstract

We construct a dynamic model of self-enforcing consumption smoothing contracts offered by an outside principal to a community of agents. The agents are connected by risk-sharing arrangements that are themselves subject to enforcement problems, as in Kocherlakota (1996). We show that the principal can earn a higher profit if he conditions his repeated interactions with each agent on the history of his interactions with *all* the agents in the group (a joint liability contract), rather than on his history with that agent only (individual liability contracts). This result holds even in the absence of informational asymmetries. The observation driving it is that with individual liability contracts, a joint-welfare maximizing group may prefer to have one or more group members default on their contracts, so that the group can consume a mix of outside funds and the defaulters' stochastic income.

One contribution of our work is to give precise economic content to the concept of "social capital" as the per-agent surplus from group risk sharing over autarky. The group can deter its members from defaulting on their contracts with the principal by threatening to reduce that surplus.

JEL codes: O12, Z13

Keywords: group lending, joint liability, social capital

We thank Susan Athey, Orazio Attanasio, Valerie Bencivenga, Dean Corbae, Scott Freeman, Ken Hendricks, Narayana Kocherlakota, Dirk Krueger, Preston McAfee, David Sibley, Giancarlo Spagnolo, Maxwell Stinchcombe, Steve Tadelis, and Mark Wright for helpful discussions. We also thank for their comments seminar participants at Duke, Texas, Stanford, Texas A&M, UBC, the Dallas Fed, the 2002 SED meetings, the 2003 summer meetings of the Econometric Society, the 2003 summer workshop of the Economic Institute of the Hungarian Academy of Sciences, and the 2004 meeting of the Financial Intermediation Research Society. Paal thanks the Donald D. Harrington Fellows Program at the University of Texas at Austin for financial support.

I. Introduction

We study the contracting problem between a principal and a group of agents in an environment of one-sided commitment, where enforcement technologies are not available to the principal. Agents collude to maximize their joint surplus. The principal must confront the fact that agents, belonging to such a group have better outside options than if they were acting in isolation. We show that, under some circumstances, the principal can do strictly better by conditioning his continued interaction with each agent not only on the past actions of that agent, but on those of every other agent as well.

The contracts that microfinance institutions, such as the Grameen Bank, typically write with their borrowers provide an example of such an environment. [1] The success of microcreditors relative to traditional lenders in maintaining reasonable ex post returns on their loans lies partly in the fact that they manage to overcome enforcement problems by interacting with groups of borrowers instead of individuals. The joint liability contracts that they offer imply negative consequences for each group member (typically in the form of non-refinancing threats) should one group member default. This arrangement creates an incentive for the group to apply their own sanctions against a delinquent borrower. To the extent that such low cost "social sanctions" are available to the community when direct sanctions by the lender are impossible or very costly, group contracts can dominate individual contracts. The phenomenon of lenders inducing groups to enforce contracts for them by applying "social penalties or pressures" is also referred to as collateralizing loans with the "social capital" of the borrower.

Enforcement problems occupy an important role in discussions of sovereign debt as well. An international lender's behavior towards one country in a region (such as the European Union or Latin America) or one state in a federation (such as the United States or Australia) might depend on the history of his interactions with other countries in the same region or federation.

Our theory also applies to the issue of lending to a married couple. Typically, spouses are jointly liable for non-business loans. For example, in the state of Texas, loans to married individuals generally involve joint liability with the partner, unless the lender specifically agrees to only look at the individual's separate property as collateral.

We formulate our problem in an infinite horizon model of a monopolistic outside principal (the "lender") offering additional consumption smoothing to a community of agents (the "group of borrowers") who are connected by informal social insurance arrangements. The members of the community face random income fluctuations and engage in risk sharing with each other in order to smooth their consumption. These risk sharing contracts are themselves subject to limited

[1] Morduch (1999) provides an extensive and interesting review of microfinance institutions.

enforcement and are self-sustaining due to the repeated nature of community interactions. There is aggregate risk, so that there is demand for outside insurance and lending. However, the outside lender also faces the problem of lack of enforcement and must structure contracts in such a way as to overcome these enforcement problems. In this environment we investigate the advantages of contracting with a group rather than dealing with individuals separately.

We use the following definitions. A joint-liability contract conditions the principal's interactions with any single agent on the history of his interactions with *all agents*. By contrast, an individual-liability contract with a given agent conditions the principal's interactions with the agent on the history of his interactions with *only that agent*.

Typically in our environment there will be a multiplicity of subgame perfect equilibria under either type of contract. In fact, the set of subgame perfect equilibrium outcomes is identical under the two types of contracts. We select among equilibria by assuming that the borrowers, faced with any offered contracts, act to maximize their joint surplus.[2] We show that with this additional requirement a contract based on joint liability may give strictly higher profits to the lender than a contract based on individual liability. Thus, joint liability lending may be viable in situations when individual liability lending is not. The intuition behind this result is that the outside lender, by threatening to withhold future funds from the group at large, can compel the group to pressure a defaulting member to repay. This "social pressure" in our model takes the form of threatening the defaulting borrower with a reduced share of the surplus that community risk sharing generates over autarky. By contrast, a lender interacting with individuals separately can only punish default by denying further credit, without being able to manipulate the terms of a defaulter's participation in group risk sharing. In some circumstances, though, the group is actually better off when one or more members default on their contracts, so that the group can share a mixture of outside lending and the defaulters' random income. This difference between outside options drives the result.

Our model environment is deliberately parsimonious. We make assumptions on the preferences and the joint income process of our borrowers. We assume a single, risk-neutral outside lender. Both the borrowers and the outside lender have access to perfect information but no access to any enforcement technology. Our final assumption is that the lender can commit to future actions but the borrowers cannot. Our aim is to isolate the role of economic interactions within a community in creating social capital, and we formulate a model that demonstrates this possibility in a transparent manner.

The stylized nature of our model environment makes our results applicable in multiple contexts, as mentioned earlier. For concreteness, we nevertheless consider it useful to provide some motivation for our modeling choices from the perspective of rural credit markets, a framework in which joint liability contracts have been widely studied. That motivation is what we turn to next.

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[2] Abdulkadiroglu and Chung (2003) use a similar assumption to model tacit collusion by bidders in an auction.

A. Group lending by microfinance institutions

Theoretical work on why group lending outperforms individual lending has focused on how group lending overcomes various frictions that hinder the operation of rural credit markets. These postulated frictions include asymmetric information problems as well as enforcement difficulties. Our purpose in this paper is to further the understanding only of how *enforcement* problems can be ameliorated by group lending practices.[3]

The most important modeling choice we make is to give no informational or enforcement advantage to the borrowers relative to the outside lender. This approach is quite distinct from the standard approach in the literature[4]. Indeed, all theoretical models of joint liability lending that we are aware of feature such an exogenous information or enforcement advantage. By contrast, in our model, information is freely available to everyone and all contracts must be self-enforcing. As a result, we can highlight how social capital is created through repeated community interactions, instead of arising from superior monitoring or punishment technology that the community possesses.

In the literature on group lending and strategic default, it is commonly assumed that society can impose a "social penalty" on an individual who reneges on a group lending contract. This penalty may be an exogenous constant, as in Armendariz de Aghion (1999), or it may be postulated as an exogenous function of the contemporaneous loss suffered by the complying partner and the repayment capacity of the defaulter, as in Besley and Coate (1995). In contrast, we derive

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[3] There are a number of other dimensions along which the practices of microcredit institutions differ from those of traditional lenders. For example, the group structure can be usefully exploited to better screen borrowers, to improve the monitoring of both the appropriate use of funds and the outcomes of projects, to reduce the cost of transacting with many small borrowers, or to provide education and technical assistance. Ultimately, however, any lender must collect repayment. We single out enforcement issues because in environments with extremely weak legal systems and hardly any physical collateral, every lender must confront the possibility of strategic default. A comparison of various models is carried out by Ghatak and Guinnane (1999) and Ahlin and Townsend (2004). Kocherlakota (1996) proposes a test that could discriminate between dynamic limited commitment and dynamic asymmetric information models, but to our knowledge these alternatives have not been contrasted using micro data from rural communities. To our knowledge the only systematic empirical investigation of the relative importance of enforcement problems versus various informational asymmetries is the work of Ahlin and Townsend (2004), comparing four static models of group lending. Their preliminary results, while not conclusive, indicate that data from Thai villages (particularly, the most rural areas) are best fit by the limited enforcement model of Besley and Coate (1995).

[4] For example, Ghatak and Guinnane (1999) emphasize that joint liability lenders outperform conventional lenders by giving incentives to members of a community to either use information about one another or to apply non-financial sanctions against one another. In Rai and Sjostrom (2004), agents report each other's investment return to the lender. In Che (2002), agents' effort choices are observable to other agents but not to the lender.

these penalties endogenously, which allows us to (1) study the incentives of the community to impose such penalties and (2) examine how the economic environment facing the community affects their magnitude and effectiveness.

The feature of our model that allows us to endogenize social penalties is its explicit dynamic nature. In this regard, our work is closest to that of Sadoulet (2000) and of Che (2002). Sadoulet (2000) examines how dynamic incentives to repay differ under individual versus joint liability contracts in an adverse selection environment. However, by assumption, there is no interaction between insurance provision within a group and credit transactions with the outside. In our model, this interaction is an important element in making joint liability loans more profitable. Che (2002) studies a moral hazard environment where agents repeatedly make effort choices. Joint liability contracts turn effort choice into an endogenous punishment device much in the same spirit as the terms of participation in group risk sharing is an endogenous punishment device in our model. Che and Yoo (2001) find a similar role for basing payments to teams of coworkers on their joint performance.

We model group interactions as risk sharing by risk-averse agents who face exogenous stochastic income streams. Our main motivation for using this environment is that the outcomes in this environment, in absence of an outside lender, are well-understood, having been investigated by Kocherlakota (1996) and Ligon, Thomas, and Worrall (2002). [5]

Finally, the assumption of a monopolistic outside lender deserves comment. Most principal/agent models assume a single principal who moves first by making a take-it-or-leave-it offer. The presence of a monopolistic first mover is also consistent with the observed operation of microfinance institutions in developing countries.[6] The microfinance institutions in question, although close to self sustaining, do not generate positive profits, so that incentives for new entry are

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[5] Regarding the nature of interactions within a community, Ligon, Thomas, and Worrall (2002) and Albarran and Attanasio (2002) show that a number of implications of the dynamic limited commitment environment that we assume in our model are supported by data from three Indian villages and from a Mexican welfare program. The work of Townsend (1994, 1995) emphasizes the importance of income risk and the sharing of this risk within poor rural communities. In his classic study of credit arrangements in Northern Nigerian villages, Udry (1994) also demonstrates that repayments on loans are state contingent, and depend on the realizations of shocks to both the borrower's and the lender's incomes. A natural alternative would have been to assume productive opportunities and capital accumulation. Ligon, Thomas, and Worrall (2002) show that extending the model to include stochastic storage leaves the implications with respect to insurance provision qualitatively unaffected.

[6] For example, van Bastelaer (1999) describes a typical segmentation between the roles of NGOs and local moneylenders in providing credit to different subsets of borrowers. He reports that the interest rates on the loans from different sources do not display a strong tendency to converge.

limited. In the alternative case with multiple outside institutions, the nature of self-enforcing contracts would depend on how the interaction between these outside lenders is modeled.[7]

B. Social capital

In this paper we explore how the value created by repeated economic interactions between members of a group can be used as collateral towards the outside. The analysis of our model suggests an *operational definition of social capital* as the surplus that an agent receives by participating in the group risk sharing arrangement instead of living in autarky. It is exactly this surplus, the credit of the individual with the community, that an outside lender can threaten to reduce in case of default. In this sense, the surplus that we call social capital of an individual represents a form of collateral. Of course, the outside lender has no direct way of manipulating this surplus, but he can structure his interactions with the group at large in such a way that the group has incentives to apply the right sanctions for him.

We believe that our definition of the term social capital captures the meaning that has been attributed to this concept in the microfinance literature. (Of course, community interactions besides risk sharing can also contribute to social capital.[8]) We also believe that it is useful to have a formal economic definition, for example to motivate empirical work. We illustrate this by asking whether in our model higher levels of social capital are associated with higher group loan repayment rates. This is an interesting question because the corresponding empirical hypothesis has been investigated with quite mixed results. We show that our model simply does not generate the hypothesis: A plausible measure of loan repayment rates displays a non-monotonic relationship to our measure of social capital.

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We formally describe the model in Section II. Different lending contracts are compared in Section III, where we show that an outside lender can obtain higher profits using group contracts instead of using individual contracts. In Section IV, we relate previous uses of the term social capital to our definition, and show that the empirical hypothesis that more social capital should improve the repayment performance of group loans does not follow from our model. In Section V, we discuss the robustness of our results and contrast them with previous literature, and in the final section we conclude.

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[7] See, for example, Bulow and Rogoff (1989), Krueger and Uhlig (2004), Kletzer and Wright (2000), and Wright (2002).

[8] Spagnolo (1999), for example, describes social capital as the "slack of enforcement power" in a broadly-defined social interaction available to enforce cooperation in production.

II. Model

A. Environment

The environment (which is similar to the one that Coate and Ravallion (1993) and Kocherlakota (1996) study) is as follows: Time is discrete and indexed by $t = 0, 1, 2, \ldots$. There are N infinitely-lived individual agents. The (random) income of individual i in period t is denoted y_t^i; the possible realizations of y_t^i are given by a set $\{y(1), \ldots, y(S)\}$, where $y(1) < y(2) < \ldots < y(S)$. We assume that income is non-negative, so that $y(1) \geq 0$, and that individuals face some uncertainty over income, so that $S \geq 2$. Y_t is the vector of individual incomes in period t. Joint income Y_t is stochastically determined according to the distribution P, which is i.i.d. across time. The distribution P is symmetric and has full support: If income vector Y' is a permutation of Y, then $P(Y') = P(Y)$, and all combinations of individual incomes have positive probability. Symmetry implies that the marginal distributions are identical across agents and can simply be denoted by $p(y)$. We will also find useful the notation $\overline{p}(\overline{y})$ for the distribution of average group income.

Agents have identical preferences. An individual who consumes x_t in period t receives utility $u(x_t)$, where the function u is increasing, strictly concave (individuals are risk averse), and twice-continuously differentiable.[9] Lifetime utility is the discounted sum of per period utility, multiplied by $(1–\delta)$ to put it on the same scale as utility per period:

$$(1-\delta)\sum_{t=0}^{\infty}\delta^{t-1}u(x_t)\,, \qquad \delta \in (0, 1).$$

An individual who consumes his own income in each period, for example, receives expected utility

$$E(1-\delta)\sum_{t=0}^{\infty}\delta^{t-1}u(y_t^i) = Eu(y^i) = \sum_{s=1}^{S} p(y(s))u(y(s))\,.$$

B. Internal risk sharing (no outside lender)

In the absence of outside funds, the risk averse members of the group can increase their welfare by participating in a risk sharing (social insurance) arrangement, as long as individual income realizations are not perfectly correlated. In each period, agents with high incomes can make a transfer to agents with low incomes, in the expectation of receiving similar transfers in the future when their own incomes are low.

[9] Differentiability is not crucial. For example, assuming that agents are risk neutral above some minimum subsistence level of consumption would not substantively affect our results.

Formally, in each period the income vector Y_t is realized and is observed by all agents. Agents then have the opportunity to transfer income to some or all of the other agents; denote by R_t the matrix of transfers made by the agents in period t. The history h_t at period t is the sequence of past and present income realizations and past transfers:

$$h_t = (Y_1, R_1, \ldots, Y_{t-1}, R_{t-1}, Y_t).$$

A strategy for each individual is a function from the set of possible histories to a vector of non-negative transfers. Individual i's strategy specifies how much of his income y_t^i goes to each agent after every history, subject to the constraints that none of the transfers be negative and that their sum is no greater than y_t^i. Individual i's consumption, after the transfers are made, is denoted x_t^i.

Let $\bar{y}_t \equiv \sum_{i=1}^{N} y_t^i \big/ N$ be the group mean of individual incomes in period t and let $\bar{p}$ be the induced distribution of $\bar{y}_t$. In a *full risk sharing arrangement*, in any period each individual's consumption x^i depends only on the average income $\bar{y}$, and not on his own income y^i. In a *symmetric full risk sharing arrangement*, each agent consumes the average income $\bar{y}$ in every period. Because individuals are risk averse, and the variance of $\bar{y}$ is less than the variance of y^i, $Eu(\bar{y}) > Eu(y^i)$, so the group members are better off when they share risk. Full risk sharing is sustainable as a subgame perfect equilibrium if the following condition is satisfied:

$$\min_{\hat{y}^i \in \text{supp}(p)} \left\{ (1-\delta)u\left(\tfrac{N-1}{N} y(1) + \tfrac{1}{N}\hat{y}^i\right) + \delta Eu(\bar{y}) - (1-\delta)u(\hat{y}^i) - \delta Eu(y^i) \right\} \geq 0 \qquad \text{(FRS)}$$

Given an income realization, an agent is willing to make his specified transfer if the expected utility that he gets from doing so and remaining in the group exceeds the expected utility that he would receive from consuming his own income today, being cast out of the risk sharing group, and then consuming his own income in every period in the future. (An individual's expected utility in autarky, $Eu(y^i)$, is his minmax payoff, so casting an agent into autarky is the harshest punishment that can be enforced in a subgame perfect equilibrium.) An agent is most tempted not to make his transfer when all the other group members receive the lowest possible income $y(1)$, so if Condition FRS holds, then the arrangement is sustainable.

Increasing the discount factor δ increases the sustainability of full risk sharing, as does increasing the degree of risk aversion. Decreasing the correlation between individual income realizations also increases sustainability, by lowering the variance of $\bar{y}$ and thus increasing the expected utility that it provides. The effect of a larger group size is ambiguous. Increasing the size of the group decreases aggregate risk (holding the degree of individual income correlation fixed) and increases the gain from risk sharing. On the other hand, a larger group size increases the size of the maximum transfer an individual is called upon to make — when one individual receives the highest income $y(S)$ and the other N–1 receive the lowest income $y(1)$ — and thus make sustaining the risk sharing agreement more difficult. (Ligon, Thomas, and Worrall (2002) examine efficient partial risk sharing when full risk sharing is not sustainable, and Kocherlakota (1996) looks at risk sharing between a pair of agents.)

We assume that the agents choose a symmetric equilibrium, and that from the set of symmetric subgame perfect equilibria they play one that is Pareto optimal.

> Assumption 1: The group members maximize their joint surplus, subject to sustainability and symmetry.

Because full risk sharing is efficient, if Condition FRS holds, then Assumption 1 implies that in the absence of outside sources of funds the group will engage in a symmetric full risk sharing arrangement.

C. Monopolistic outside lender

Now consider the problem faced by the single outside principal (the "lender") who approaches a group that engages in internal risk sharing. The lender maximizes

$$E(1-\delta)\sum_{t=0}^{\infty}\delta^t\pi_t$$

where π_t is his profit in period t. We assume that the lender offers individuals contracts of the following type: The lender guarantees a constant level of income, c. At the beginning of each period, an agent's income y_t^i is realized. If y_t^i is less than c, then the lender transfers the difference, $c-y_t^i$, to the agent. In periods when y_t^i exceeds c, the agent turns over the surplus to the lender. In effect, the individual trades his entire stochastic stream of future income to the lender in exchange for a guaranteed level of income.[10] Both realized incomes and transfers are observed by all parties. Let $M \le N$ denote the number of individuals that the lender offers a contract to. Because income is i.i.d. across time, the lender's problem is to maximize a sequence of one-period expected profits. If the contract is honored, the expected per period profit, $E\pi(c)$, can be written as

$$E\pi(c) = M\sum_{s=1}^{S}[P(y(s))y(s)-c] = M\,(Ey^i - c)\,.$$

The lender is able to commit himself *ex ante* to such a contract. That is, the lender may specify in the contract offered to agent i conditions (on the history of the lender's interactions with

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[10] The assumption of a constant income stream offered by the lender is made for the sake of tractability. However, because the lender is risk-neutral and discounts at the same rate as the borrowers, the assumed contract form is likely to be only slightly restrictive relative to the unconstrained optimal contract. For example, if the lender interacts with only a single isolated agent, the unconstrained optimal contract calls for constant consumption after an initial period of varying consumption levels. A similar outcome will occur when multiple, sufficiently patient, agents interact with each other in a closed environment. (See Sargent and Ljungqvist (2000), pp. 402-416.)

all agents) under which the lender will permanently abandon the agreement. In any period where those conditions are not met, the lender is constrained to provide c to agent i.

We define two different contract types. Contracts where the lender's continued participation depends only on the sequence of agent i' s transfers to the lender are *individual liability* contracts. Under *joint liability* contracts, the lender conditions on all borrowers' histories of transfers. Note that individual liability contracts are a special case of joint liability contracts.

The borrowers, on the other hand, cannot commit. They can walk away from the deal at any point at which they find it profitable to do so, because the lender lacks the ability to enforce the terms of the contract. Thus, a strategy for the lender specifies only what contract (if any) will be offered to each agent in period 0. A borrower's strategy specifies which contracts to accept in period 0, and in all subsequent periods specifies a vector of non-negative transfers to each agent and to the lender. As before, the sum of agent i's transfers cannot exceed y_t^i.

Because of the one-sided commitment, the lender must offer *self-enforcing* contracts. A contract is self-enforcing if after every possible history no borrower finds it in his interest to walk away from it. In the absence of a group risk sharing arrangement, an agent who breaks the terms of the loan contract would be denied future credit and would have to return to consuming only his own income. Therefore, the condition for a contract to be self-enforcing would be that

$$u(c) \geq (1-\delta)u(y(S)) + \delta Eu(y^i) \,. \qquad \text{(SE)}$$

That is, even when an agent receives the highest income level, $y(S)$, he prefers consuming c in every period to breaking the contract, consuming $y(S)$ today, and returning to autarky in all future periods. If $c > CE(y^i)$, where $CE(y^i)$ is the certainty equivalent of individual income y^i, then Condition SE is satisfied for high enough δ. Similarly, for a fixed $\delta > 0$, the condition is satisfied when c is large enough.

If, on the other hand, the borrowers are also participating in risk sharing, then the outside option of an agent who walks away from a contract may be higher than in absence of group risk sharing. For example, if an agent is allowed to continue sharing income with the rest of the group even after being denied access to credit from the lender, then his expected payoff after breaking the contract may be greater than the autarky payoff $Eu(y^i)$. In that case, self-enforcement requires a stricter condition than Condition SE: The lender must provide a higher guaranteed consumption level c to induce borrowers not to abandon the contract. Furthermore, if the borrowers can collude to jointly deviate from a contract, then an even higher level of c may be necessary. In the next section, we explore that situation in detail and examine the conditions under which the lender can do better by offering joint liability contracts rather than by dealing with individual borrowers separately.

D. Insurance vs. lending

Although we have been referring to "borrowers" and "lenders," the contracts described above are more accurately characterized as providing insurance rather than credit. We could, however, replace the stochastic fluctuations in $\bar{y}$ with deterministic cyclical fluctuations – low income in the winter, high in the fall, for example. In that environment, the agents will smooth consumption by borrowing from the lender at the bottom of the cycle and repaying at the top. Our main results will still hold in that environment. Thus, our model can interpreted as a simplified representation of borrowing and lending as well as one of insurance provision.

III. Individual versus joint liability

The goal of the lender is to maximize expected profits $M \cdot E\pi(c)$ (where $M \leq N$ is the number of individuals offered contracts) subject to the constraint that the contract must be self-enforcing. The lender chooses the number M of agents to lend to, the level c of guaranteed income offered, and the structure (joint or individual liability) of the contract's renewal policy. For simplicity, we restrict the lender to offering the same c and the same renewal policy to each borrower, although he may offer contracts to only a subset of the agents. We continue to assume that the group members, given the set of contracts offered, will maximize their joint utility subject to subgame perfection and symmetry. The solution to the lender's problem, then, will be a subgame perfect equilibrium that is coalition-proof (in the sense of Bernheim, Peleg, and Whinston (1987) and Moreno and Wooders (1996)) with respect to the coalition of all agents.

In this section we provide general conditions under which a lender may be able to increase profits by offering joint rather than individual liability contracts to the group members, even when borrowers are arbitrarily patient. First, we derive an upper bound on the lender's profits from any contract. Second, we show in Proposition 1 that there is a joint liability contract that can achieve that upper bound. Third, we demonstrate through an example that in some cases the optimal individual liability contract provides a strictly lower profit, and in Proposition 2 we describe formally the circumstances in which this will occur.

A. An upper bound on the lender's profits

In interacting with a potential borrower who is part of a group risk sharing arrangement, the lender must take that arrangement into account, even if he offers only individual liability contracts. Consider agent i, who has stochastic income y^i. Suppose that the outside lender approaches this agent and offers to provide constant income c forever in exchange for that random income stream. If agent i lived in isolation and simply planned to consume c, then the proposed contract is self-enforcing if Condition SE is satisfied. In the limit as $\delta \to 1$, the lender's profit-maximizing choice of c converges to $CE(y^i)$, the certainty equivalent of agent i's random income. In fact, however, individual i is already involved in a risk sharing arrangement, so that his effective income is not y^i but $\bar{y}$, the group's average income. Thus, maximizing profits subject to Condition SE is not the right problem for the lender to solve, because the borrower has a better outside option.

Assume that the lender offers contracts to $M = N$ agents. In order for all agents to accept this contract, he must provide a guaranteed consumption level c at least as large as $CE(\bar{y})$, the certainty equivalent of the groups' pooled income, or else the agents could do better through internal risk sharing. Furthermore, c must in fact be strictly greater than $CE(\bar{y})$, so that the agents cannot gain by jointly abandoning the contract when they all receive high income realizations. If c were equal to $CE(\bar{y})$, then in any period when $\bar{y}_t > c$, the agents could break the contract, consume $\bar{y}_t$ today, and receive $Eu(\bar{y}) = u(CE(\bar{y}))$ in each future period by reverting to internal risk sharing. By honoring the contract forever, on the other hand, they would consume $c < \bar{y}_t$ today and $c = CE(\bar{y})$ in the future, which gives them strictly lower utility. To be sustainable, c must be at least $CE(\bar{y}) + \varepsilon(\delta)$, where $\varepsilon(\delta)$ is defined as the smallest value satisfying

$$u\left[CE(\bar{y}) + \varepsilon(\delta)\right] \geq (1-\delta)u\left[y(S)\right] + \delta u\left[CE(\bar{y})\right]$$

This limit on c puts an upper bound, equal to the greater of $N\left[Ey^i - CE(\bar{y}) - \varepsilon(\delta)\right]$ and zero, on the lender's expected profit per period in a self-enforcing contract. As the discount factor δ approaches one, $\varepsilon(\delta)$ converges to zero.

Note that for large δ, the assumption that the lender offers contracts to all agents is not restrictive. Suppose that the lender guarantees c to $M < N$ agents. Then the lender could make the same expected profit by guaranteeing $[Mc + (N–M)\, Ey^i] / N$ to all agents. For $\delta \to 1$, if the original contract is sustainable ($c \geq CE(\bar{y})$), then the new contract is also sustainable ($Mc + (N - M)Ey^i \geq CE(\bar{y})$). Since the borrowers consume strictly more under the new contract, they could be made strictly better off without making the lender worse off.

B. Joint liability contracts

The lender can achieve maximum profit with the following strategy, which uses joint liability contracts: If $N \cdot (Ey^i – CE(\bar{y}) - \varepsilon(\delta)) > 0$, the lender offers each group member a contract guaranteeing income $c_J^* \equiv CE(\bar{y}) + \varepsilon(\delta)$ in each period, as long as no agent has failed in any previous period to turn over his realized income y_t^i to the lender (and as long as the lender himself has not deviated). Otherwise, the lender offers no contract. The agents' strategy is to reject any contract with $c \leq y(1)$ and revert to symmetric internal risk-sharing; to accept any contract with $y(1) < c < c_J^*$ and eventually deviate from it;[11] and to accept any contract $c \geq c_J^*$ and not deviate in any period when no prior deviation has occurred. In the third case, if agent i fails to turn over his income, then all group members move to an internal risk sharing equilibrium where agent i's utility is reduced to $Eu(y^i)$, his autarkic utility. If the lender deviates, or if more than one borrower deviates simultaneously, the group reverts to symmetric internal risk sharing. Those strategies constitute a subgame perfect equilibrium that is proof to self-enforcing joint deviations by the agents when δ is high enough, as shown in Proposition 1.

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[11] The optimal time for the group to deviate is the first period in which realized mean income $\bar{y}'$ satisfies the following condition:

$$(1-\delta)u(\bar{y}') + \delta Eu(\bar{y}) > (1-\delta)u(c) + \delta EV(c, \bar{y}),$$

where $V(c, x)$ is given recursively by

$$V(c, x) \equiv \max\{(1-\delta)u(x) + \delta Eu(\bar{y}), (1-\delta)u(c) + \delta EV(c, \bar{y})\}.$$

Proposition 1: Let N, u, and $P(Y)$ be given. Then there exists $\underline{\delta} < 1$ such that for all $\delta \in (\underline{\delta}, 1)$, there is a subgame perfect equilibrium σ featuring joint liability contracts such that

i) σ is proof to self-enforcing joint deviations by the group members, and

ii) σ gives the lender expected profits of $\max\{N(Ey^i - c_J^*), 0\}$ per period.

Proof: The strategies are as given above. First, let δ be at least high enough that Condition FRS and Condition SE are satisfied, and offering contracts to all agents maximizes the lender's expected profit. Then if the lender is patient enough, his strategy is clearly optimal: Given that the borrowers will eventually reject any c less than c_J^*, $\max\{N(Ey^i - c_J^*), 0\}$ is the maximum possible profit.

The group members get higher expected utility from accepting the contracts when $c \geq c_J^*$ than from reverting to internal risk sharing, so it is a best response for them all to accept. Given the punishment strategies, Condition SE guarantees that no borrower can ever gain from consuming his income rather than turning it over to the lender, even when he receives the highest possible income $y(S)$. After a deviation, the lender's strategy is to not interact with the agents, so not interacting with the lender is a best response for the agents. Therefore, the best the agents can do is an efficient (subject to the enforcement constraints) risk sharing arrangement. As in Kocherlakota (1996), there exists such an efficient self-enforcing arrangement that gives agent i expected utility equal to his autarkic utility $Eu(y^i)$ and gives the other agents utility strictly higher than $Eu(\bar{y})$, the expected utility from symmetric risk sharing. Therefore, the punishment path is subgame perfect and proof to self-enforcing joint deviations.

Thus, the specified strategies constitute a subgame perfect equilibrium that is coalition-proof with respect to the coalition of all agents and that gives the lender expected profits of $\max\{N(Ey^i - c_J^*), 0\}$ per period. *Q.E.D.*

C. Individual liability contracts

The maximum profit that the lender can achieve by offering individual liability contracts, on the other hand, is strictly lower than $N(Ey^i - CE(\bar{y}) - \varepsilon(\delta))$, as long as there is sufficient aggregate risk in the group's pooled income $\bar{y}$. In particular, we show in Proposition 2 that with high aggregate risk individual liability contracts offering $c = c_J^*$ are not self-enforcing. We first provide intuition and an example.

The result is driven by the observation that for $c \in (CE(y^i), Ey^i)$, a group of risk averse agents that shares income fully may prefer to have one member receive random income y^i and the rest get c for sure in each period rather than all of them getting c. That is, it may be that

$$Eu\left(\frac{(N-1)c + y^i}{N}\right) > u(c),$$

even though $u(c) > Eu(y^i)$. The intuition is that replacing the constant income c of one of the group members with random income y^i increases both the mean and the variance of average group income. If the first effect, which raises expected utility, dominates the second effect, which lowers it, then the group is better of "mixing" c and y^i.

More formally, consider the definition of a strictly concave function: If distinct alternatives A and B give the same level of expected utility, then a strict convex combination of the two alternatives is strictly preferred to either. For example, suppose that one alternative is getting constant income $CE(y^i)$, and the other alternative is getting random income y^i. Then the group strictly prefers to have one or more members receiving y^i and sharing it with the rest of the group members, who are getting $CE(y^i)$, rather than to have everyone get $CE(y^i)$. By Jensen's inequality,

$$Eu\left(\frac{(N-1)CE(y^i)+y^i}{N}\right) > E\left(\frac{N-1}{N}u(CE(y^i))+\frac{1}{N}u(y^i)\right)$$

$$=\frac{N-1}{N}u(CE(y^i))+\frac{1}{N}Eu(y^i)$$

$$=u(CE(y^i))$$

By continuity, $CE(y^i)$ can be replaced by some $c > CE(y^i)$ and the inequality maintained as long as the difference between c and $CE(y^i)$ is not too large. For example, if $c = c_J^* = CE(\bar{y}) + \varepsilon(\delta)$, then the inequality still holds as long as $\varepsilon(\delta)$ is small enough and the certainty equivalent of pooled income $\bar{y}$ is not too much greater than the certainty equivalent of individual income y^i — that is, as long as there is sufficient aggregate risk in the group. If the joint income distribution P satisfies that condition, and if the lender has an individual liability contract with every agent (providing $c = c_J^*$), it is certain that at least one agent will eventually break it. To avoid that outcome, the lender must offer a higher c, lend to fewer agents (both of which options reduce expected profits when δ is high), *or* offer only joint liability contracts. If the lender offers credit only as long as all N agents accept and honor their contracts, then the group no longer has the option of mixing c with y^i. As long as c gives greater utility than internal risk sharing (that is, $c > CE(\bar{y})$) and agents are patient enough, then the group does better to honor the lending contracts than to break them and revert to risk sharing. Thus, joint liability contracts can provide higher expected profits than individual lending. The following numerical example demonstrates that possibility, and Proposition 2 formalizes the result.

Example 1: Suppose that $N = 5$ and the income vector is determined as follows: In each period, there are two possible states, G and B, each of which has probability 0.5. Given the state, each agent's income is chosen independently. In state G, an agent's income is $y_H = 300$ with probability $a \geq 0.5$ and $y_L = 100$ with probability $1 - a$. In state B, the probabilities are reversed. The correlation between agents' incomes is increasing in the parameter a. Utility is given by $u(y) = -1/y$, so agents have a constant coefficient of relative risk aversion equal to 2.

First, let the discount factor δ be 0.95. For this value, Figure 1 graphs the utility from c_J^* and the expected utility from $0.8\,c_J^* + 0.2y^i$ against the pairwise correlation of agents' incomes. This figure was constructed by varying a from 0.5 to 1. For high enough levels of correlation (corresponding to high aggregate risk), the expected payoff from having one group member deviate, $Eu\left[0.8c_J^* + 0.2y^i\right]$, is greater than the payoff from the constant consumption provided by the optimal joint liability contract, $u\left[c_J^*\right]$.

Now consider the case of δ converging to 1. Let specifically $a = 0.5$ so that income realizations are independent across individuals, and y_H and y_L occur with equal probability. The expected value of income is 200, and the certainty equivalent of the income $\bar{y}$ from group risk sharing is approximately 189.0264. Under the optimal joint liability contract the outside lender guarantees a constant level of consumption $c_J^* \equiv CE(\bar{y}) = 189.0264$ to all agents and makes expected profits per period of approximately $5(200 - 189.0264) = 54.868$. If the lender offers this same c_J^* in individual liability contracts, at least one agent will certainly walk away from his contract. The reason is that the group gets higher expected utility from sharing $4(189.0264) + y^i$ (such sharing is sustainable since $\delta \to 1$) than from consuming 189.0264 each:

$$0.5\left(\frac{-1}{2(1056.1056)}\right) + 0.5\left(\frac{-1}{2(856.1056)}\right) > \frac{-1}{189.0264}$$

To make the individual liability contracts self-enforcing, the lender must either offer them to fewer agents or provide a larger c. In this example, the lender maximizes expected profits by offering $c_I^* \approx 189.564$ to all five agents, which yields expected profits per period of 52.18. Thus, the profits from individual lending are approximately 4.9 percent lower than group lending profits.

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The following notation will be used in the statement of Proposition 2: Given the discount factor δ, the number of borrowers N, the utility function u, and the joint income distribution $P(Y)$, let $\pi^J(\delta, N, u, P)$ denote the greatest per period profit for the lender in any subgame perfect equilibrium that i) features joint liability contracts, and ii) is proof to self-enforcing joint deviations by the agents. (Proposition 1 demonstrates that for high values of δ, $\pi^J(\delta, N, u, P)$ approaches $N\cdot(Ey^i - CE(\bar{y}))$.) Similarly, let $\pi^I(\delta, N, u, P)$ denote the highest profit when the lender is restricted to offering individual liability contracts.

Proposition 2: Let N, u, and the marginal income distribution $p(y)$ be given. Then

i) for any δ and any joint income distribution $P(Y)$, $\pi^J(\delta, N, u, P) \geq \pi^I(\delta, N, u, P)$, and
ii) there exists an open and non-empty set Ψ of symmetric, full support joint income distributions $P(Y)$ with marginal distribution $p(y)$ with the following property: If

$P(Y) \in \Psi$, then there is a $\underline{\delta} < 1$ such that for all $\delta \in (\underline{\delta}, 1)$, $\pi^J(\delta, N, u, P) > \pi^I(\delta, N, u, P)$ whenever $\pi^J(\delta, N, u, P) > 0$.

Proof: Part i) is immediate, since the set of individual liability contracts is a subset of the set of joint liability contracts. To prove part ii), recall that S is the number of elements in the support of the marginal distribution $p(y)$. Then a joint income distribution $P(Y)$ is a vector in the $(S^N–1)$ dimensional simplex. Let $P^*(Y)$ denote the joint distribution where individual incomes are perfectly correlated, so that $y_t^i = y_t^j$ for all t and for all $i, j \in \{1, \ldots, N\}$. Given $P^*(Y)$, the distribution of pooled income $\bar{y}$ is the same as the marginal distribution $p(y)$, so $CE(\bar{y}) = CE(y^i)$. Because u is concave, therefore,

$$Eu\left[\frac{(N-1)CE(\bar{y})+y^i}{N}\right] > Eu\left[CE(\bar{y})\right].$$

Thus, when δ is high enough, the following inequality holds:

$$Eu\left[\frac{(N-1)CE(\bar{y})+y^i}{N}\right] > u\left[c_J^*\right] \qquad \textbf{(CC)}$$

When Conditions CC, FRS, and SE are satisfied, the lender cannot offer individual liability contracts promising income $c_J^* \equiv CE(\bar{y}) + \varepsilon(\delta)$ because, as in Example 1, at least one borrower is sure to break the contract and share his future stream of random income with the other borrowers, who are still receiving c_J^*. Instead, the lender must either provide a higher level of guaranteed income or lend to fewer borrowers. Because c_J^* is continuous as a function of the joint distribution $P(Y)$, if Condition CC holds for $P^*(Y)$ and a given discount factor δ, then it holds in an open neighborhood (with respect to Euclidean distance) of $P^*(Y)$ for any higher discount factor. Further, around any point in that neighborhood, there is an open sub-neighborhood where, for high enough δ, Conditions FRS and SE also hold, and lending to all agents maximizes expected profit, in which case Proposition 1 guarantees that $\pi^J(\delta, N, u, P) = \max\{N(Ey^i - c_J^*), 0\}$. Thus, there is a $\underline{\delta} < 1$ and an open neighborhood around $P^*(Y)$ such that in that neighborhood a profit level of $\max\{N(Ey^i - c_J^*), 0\}$ is attainable with joint liability contracts, but not with individual liability contracts, unless $\max\{N(Ey^i - c_J^*), 0\} = 0$. *Q.E.D.*

IV. Social capital and repayment performance

Above, we present a model in which borrowers enforce joint liability loans on behalf of the lender by threatening to reduce a defaulter's portion of the shared group income. In that way, the surplus from group risk sharing over autarky acts as collateral in the joint liability contracts. This observation leads us to associate this surplus with the concept of social capital as used informally in the microfinance literature.[12] Accordingly, we formally define social capital as the normalized value of the expected surplus from consuming group mean income rather than individual income:

$$\text{social capital} \equiv \frac{Eu(\bar{y})}{Eu(y^i)} - 1.$$

Grootaert and van Bastelaer (2001) provide an in-depth discussion of the term social capital. On a micro level they describe social capital as "those features of social organization such as networks of individuals and households, and the associated norms and values that create an externality for the community as a whole." They also emphasize that social capital is an asset, in the sense that it generates a stream of benefits. Finally, they note that one of the channels through which social capital produces payoffs is "by increasing the benefits of compliance with expected behavior or by increasing the costs of non-compliance." In the context of our model, participating in informal social insurance arrangements creates a surplus that arises from the repeated interactions of a group of agents. This surplus can be used to repeatedly collateralize outside loans even if loans to individuals are not sustainable. The group interactions are not formally sanctioned; instead they are maintained in equilibrium by shared beliefs about expected behavior and how deviations from it would be punished.

The observation that social capital can perform the function of collateral in joint liability loans led to the hypothesis in the empirical literature that increased social capital lowers the default probability on loans. Researchers have not found robust support for this hypothesis, however. One clear reason for the divergent results is the fact that the different studies span a wide range in terms of the quality of their data, the definition of default, and the variables that are used to proxy for social capital. However, our model suggests that the hypothesis is not justified in the first place.[13]

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[12] It is often asserted in the literature that social capital can be used to support credit contracts that would not be supportable in a more market based, anonymous context. Plunkett (1904) (quoted in Guinnane (1994)), writing about credit cooperatives in Ireland, cleverly expresses this idea when he suggests these institutions perform "the apparent miracle of giving solvency to a community of almost entirely insolvent individuals." In our model, agents who may not be creditworthy individually are creditworthy as a group.

[13] Sharma and Zeller (1997) and Ahlin and Townsend (2004) (in preliminary work) find that groups with higher levels of family relations are more likely to default. On the other hand, Karlan (2003), using Peruvian data, finds a

In order to relate it to the level of social capital, we need to construct a measure for repayment performance within the context of the model. We want this measure to be similar to the delinquency rate measures reported by microfinance institutions and used in the empirical literature. The difficulty is that the type of limited enforcement model that we examine has no explicit default (in the sense of a deviation from the prescribed contract) along the equilibrium path. We propose to use, as a proxy for the fraction of non-performing or delinquent loans, the probability that in $D \geq 2$ consecutive periods the realized net transfer flows from the lender to the group. That is, the lender makes a "loan" in one period and does not receive any repayment in the next $(D–1)$ periods.

Consider the case where the outside lender offers the optimal joint liability contract, paying out c_J^* to each agent and receiving $N \cdot \bar{y}_t$ in every period. In this setting the probability that a loan is delinquent can be expressed as

$$\textit{delinquency rate} = \left[F_{\bar{y}}(c_J^*) \right]^D ,$$

where $F_{\bar{y}}$ is the cumulative distribution function of average group income. We continue to assume that Condition FRS holds and therefore social capital can be measured as $Eu(\bar{y}) / Eu(y^i) - 1$.

We investigate the behavior of the probability of the delinquency rate as the correlation between an individual's income and the average income of the rest of the group varies. Social capital is decreasing in this correlation, because raising the correlation increases the variance of the group's average realized income $\bar{y}$ and thus lowers $Eu(\bar{y})$. We show that the delinquency rate, on the other hand, is a non-monotonic function of this correlation. Therefore, there is no presumption that higher social capital must improve loan performance.

The intuition is as follows: The optimal c_J^* is less than the expected value of y^i, which is also the expected value of $\bar{y}$. (Otherwise, the lender could not make positive profits.) Decreasing the correlation between individual incomes reduces the variance of each period's sample average $\bar{y}$. That decrease in variance has two, conflicting effects on the delinquency probability. First, the realization of $\bar{y}$ is more likely to be close to its mean and thus greater than c_J^*. Thus higher social capital leads to a lower delinquency rate. On the other hand, lowering the variance of $\bar{y}$ increases $Eu(\bar{y})$, the value of the group's alternative to borrowing from the outside lender. That change means that the lender must offer a higher c_J^*, which increases the probability that the realization of $\bar{y}$ is less than c_J^*. Thus higher social capital leads to a higher delinquency rate. Which effect dominates varies with the level of correlation. Furthermore, because the distribution of incomes has finite support, the delinquency probability is in fact not continuous with respect to the correlation, as Example 2 demonstrates. The general result is stated in Proposition 3.

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positive relationship between proxies for social capital (such as geographic proximity and cultural similarity) and repayment performance. Wydick (1999) finds a negative link between the likelihood of repaying another group member's loan and physical distance between borrowers.

Example 2: Suppose that $N = 15$ and $\delta = 0.95$. Suppose also, as in Example 1, that utility is given by $u(y) = -1/y$, and that income is determined as follows: In each period, the state is either G or B with equal probability. In state G, an agent's income is $y_H = 300$ with probability $a \geq 0.5$ and $y_L = 100$ with probability $1 - a$, and in state B, the probabilities are reversed; conditional on the state, agents' incomes are independent. The correlation between agents' incomes is increasing in the parameter a. Therefore, the level of social capital and the optimal $c_J^*(a)$ are both decreasing in a. The level of social capital is high enough to sustain full internal risk sharing when $a < 0.959448$. In addition, $c_J^*(a) > Ey^i$ (so that lending is profitable) for all $a > 0.503603$. Let

$$P_n(a) \equiv \sum_{i=0}^{n} 0.5 \frac{15!}{(15-i)!i!}\left[(1-a)^{15-i} a^i + (1-a)^i a^{15-i}\right]$$

denote the probability that at most n agents receive income y_H, so that mean income $\bar{y}$ is no more than $\bar{y}(n)$, defined as $\bar{y}(n) \equiv \frac{1}{15}(300n + 100(15-n))$. When $c_J^*(a)$ is at least $\bar{y}(n)$ and below $\bar{y}(n+1)$, then the c.d.f. $F_{\bar{y}}(c_J^*(a)) = P_n(a)$. For example, the probability jumps, when $c_J^*(a) = \bar{y}(7) = 180$ at $a \approx 0.823327$, from 0.482206 to 0.495567. As $c_J^*(a)$ continues to increase from this level, $P_7(a)$ decreases. When $c_J^*(a)$ reaches $\bar{y}(8) = 580/3$ at $a \approx 0.685313$, the probability jumps again from 0.430194 to 0.5, at which level it stays for all lower values of a.

Figure 1 shows the resulting relationship between social capital and the three-period delinquency probability ($D = 4$). This probability decreases in the level of social capital except for three discrete jumps. The final jump is to $(0.5)^4 = 0.0625$.

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Proposition 3: Suppose that the number of possible income realizations $S = 2$, so that the distribution $\bar{P}$ of average group income $\bar{y}$ depends only on the marginal distribution $p(y)$ of individual income y and the correlation ρ of an individual's income and the mean income of the group.[14] Let the utility function u and the marginal income distribution $p(y)$ be given. Then there exists an integer $\underline{N}$ such that if the number of agents N is greater than $\underline{N}$, the delinquency probability satisfies the following condition: When ρ is below the maximum level at which full risk sharing is sustainable and above the minimum level at which $Ey^i - c_J^* \geq 0$, then as ρ decreases the probability that $\bar{y}_t < c_J^*$ for $D \geq 2$ periods in a row in the optimal joint liability contract varies both non-monotonically and discontinuously. For smaller N, the probability is increasing in ρ.

Proof: Let $\bar{P}(\rho)$ and $F(c; \rho)$: $\mathbb{R} \mapsto [0,1]$ be the distribution and the cumulative distribution function of the average income $\bar{y}$, given ρ. Because $\bar{y}$ takes on values from a finite set $\{\bar{y}(1),$

[14] Because of the symmetry of the joint income distribution, that correlation is the same for all agents.

…, $\bar{y}(S')$ }, $F(c;\rho)$ is a step function. Let $c_J^*(\rho)$ be the optimal level of guaranteed consumption under a joint liability contract, given ρ; $c_J^*(\rho)$ is decreasing in ρ.

For values of c that are not in the support of $F(c;\rho)$ (that is, such that $\bar{y}(s') < c < \bar{y}(s'+1)$ for some s'), the derivative $dF(c;\rho)/dc$ equals 0. Points in the support are where the distribution jumps. Because decreasing the correlation ρ tightens the distribution of $\bar{y}$, the derivative $dF(c;\rho)/d\rho$ is non-negative for $c < E(\bar{y})$. Thus, for values of ρ such that $c_J^*(\rho)$ is not in the support of $F(c;\rho)$, the derivative

$$\begin{aligned} dF(c_J^*(\rho);\rho)\big/d\rho &= dF(c;\rho)/d\rho + dF(c;\rho)\big/dc \cdot dc_J^*(\rho)\big/d\rho \\ &= dF(c;\rho)/d\rho \\ &= 0 \end{aligned}$$

At values of ρ such that $c_J^*(\rho)$ lies in the support of the distribution $\bar{P}(\rho)$, however, a small increase in ρ will decrease $c_J^*(\rho)$ enough that the probability $F(c_J^*(\rho);\rho)$ jumps down to the next step. At such values, increasing ρ infinitesimally results in a discrete drop in $F(c_J^*(\rho);\rho)$.

Thus, as ρ decreases, the probability $F(c_J^*(\rho);\rho)$ that $\bar{y} < c_J^*(\rho)$ is continuously increasing except at a finite number of points, where it falls discontinuously. The probability of delinquency, $\left[F(c_J^*(\rho);\rho)\right]^D$, follows the same pattern. As N grows, holding the marginal distribution $p(y)$ fixed, the number of points near Ey^i in the support of $\bar{P}(\rho)$ increases. If N is large enough, there are points in the support of $\bar{P}(\rho)$ that lie in the range of values that $c_J^*(\rho)$ takes on for ρ between the minimum and maximum. For such N, the probability of non-repayment varies discontinuously and non-monotonically with ρ. Otherwise, the probability is increasing in ρ.

Q.E.D.

The discontinuity result in Proposition 3 relies on the assumption that the support of y^i is finite. Non-monotonicity may result, however, under the assumption of a continuous support as well.

We have used the per period surplus from internal risk sharing relative to autarky, $Eu(\bar{y})/Eu(y^i)-1$, as our measure of social capital. Alternatively, we could define social capital as the present discounted value of the stream of surpluses,

$$\frac{1}{1-\delta}\left(\frac{Eu(\bar{y})}{Eu(y^i)}-1\right).$$

By that definition, the derivative of the delinquency rate with respect to social capital is not well-defined. If social capital increases due to a decrease in the discount factor δ, then the delinquency rate weakly declines, because c_J^* falls while F remains unchanged. On the other hand, if lower aggregate risk is responsible for the increase in social capital, then the effect on the delinquency rate is ambiguous, as explained in Proposition 2. Under this alternative definition of social capital, then, there is again no simple link between repayment performance and the level of social capital.

V. Robustness and comparison to previous literature

In this section, we examine the robustness of our results to variations in modeling, and contrast them with the result of previous work. First, as mentioned in Section II, we note that making income fluctuate deterministically rather than stochastically, so that optimal contracts call for borrowing and lending instead of insurance, will not affect our results.

Second, in our model the lender can condition his continued interaction with the group on each individual's history of transfers. In the equilibrium constructed, that conditioning rules out any incentive for other group members to make a deviating borrower's transfer payment for him. If, on the other hand, the lender conditions only on the total transfer from the group, then agents may want to cover for deviators in order to obtain continued access to outside lending. Imposing such a restriction on the lender's strategy does not affect the results of our model. The only potential difference is in the punishment strategies of the agents. If there is a self-sustaining arrangement where the agents divide $N \cdot c_J^*$ in each period that Pareto dominates (with respect to the borrowers) the punishment equilibrium of Proposition 1, then the group may react to an agent's deviation by making his transfer for him (so that the lender does not abandon the contract) and switching to that new punishment equilibrium.

Another extension is to incorporate moral hazard or asymmetric information. We exclude them from our model not because they are unimportant, but only to show that even when the group members have no exogenous advantage over the lender in terms of monitoring, the lender can still do better by issuing joint rather than individual liability contracts. Intuitively, giving some such monitoring advantage to the agents can only increase the superiority of group lending. However, we believe that an even stronger conclusion holds: The mechanism through which joint liability loans can outperform individual loans in our model is still present when the borrowers have better monitoring ability than the lender. Suppose, for example, that the income distribution depends on the agents' effort levels, and that effort is costly. Spear and Srivastava (1987), among others, study such repeated moral hazard with a single agent. With multiple agents, each of whom can monitor the effort levels of the others and who can jointly (subject to sustainability) collude against the lender, the optimal contract must protect against the outcome where the agents always exert low effort and report that they had all exerted high effort. Although calculating the optimal lending arrangement in such a situation is beyond the scope of the current paper (Laffont (2003), Laffont and Rey (2000), and Rai and Sjostrom (2004) study related problems in static settings with exogenous side-contracting ability), in general the optimal contract entails the agents giving up mean consumption to the risk neutral lender in exchange for lower variance. The basic result of our model, then, still holds: A contract that the agents will accept if the offer is all-or-nothing may not be preferable to a mix of that contract and the status quo that they can achieve through a coordinated deviation by one or more group members. The potential for increasing mean income when a fraction of the agents deviate may be even greater if the optimal contract in the presence of moral hazard specifies a lower effort level than the perfect monitoring outcome. A similar conclusion holds if income does not depend on effort, so that there is no issue of moral hazard, but income realizations are observed only by the agents and not by the lender.

Our results are not robust to weakening the assumption of risk averse borrowers. The mechanism through which joint liability loans outperform individual liability loans in our model (by preventing the group members from consuming a mix of outside funds and their own stochastic income) relies on strict risk aversion on the part of the borrowers. Many papers on joint lending[15] consider risk neutral agents, so in those environments our result disappears.

Our result also fails to hold if borrowers *require* outside financing, in the sense that the only source of income is the return on projects that the borrowers lack the capital to undertake on their own. In that case, clearly, the group cannot gain from having some members refuse outside lending.[16] We believe that that assumption explains the contrast between our results and those of Ghatak and Guinnane (1999), who find in their section on enforcement problems that borrower behavior is identical under joint and individual liability contracts when the group of borrowers acts cooperatively.

Finally, if we drop the assumption of constrained efficiency on the part of the group members, and require only subgame perfection rather than subgame perfection plus proofness to the coalition of the group of borrowers, then individual liability contracts can provide the same profits as joint liability contracts. The intuition is that the punishment strategies used against a borrower who defaults on a joint liability contract can also be used in a subgame perfect equilibrium against a defaulter with individual liability contracts; that equilibrium is susceptible to a self-sustaining joint deviation, but not to any unilateral deviation. Without the requirement of limited coalition-proofness, individual loans can achieve the same outcome as joint liability ones. We suspect that in other models where borrowers can impose costless punishments on behalf of the lender the same equivalence holds, although Besley and Coate (1995) address the issue by directly assuming that borrowers cannot punish anyone who, like a defaulter on an individual loan, does not directly harm them.

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[15] Besley and Coate (1995), Conning (1996, 2000), Andersen and Nina (1998), Armendariz de Aghion (1999), Laffont and N'Guessan (2000), Sadoulet (2000), Rai and Sjostrom (2001), and Che (2002), for example.

[16] Papers such as Besley and Coate (1995), Armendariz de Aghion (1999), Madajewicz (1999), Rai and Sjostrom (2001), and Che (2002), for example, make such an assumption.

VI. Conclusion

We have presented a model of the interaction between a risk-neutral principal and a group of risk averse agents in an environment where only the principal can commit to future actions. Agents seek to smooth their consumption through engaging in internal risk sharing and/or by contracting with the principal. We make two contributions. First, we select among the multiplicity of subgame perfect equilibria by requiring limited coalition-proofness, in the sense that the equilibrium must not be vulnerable to a self-enforcing joint deviation by the borrowers. We show that the lender can earn a higher profit by offering joint liability rather than individual liability contracts, although profit per borrower is still lower than in the absence of the risk sharing arrangement. Second, , we endogenize the level of social capital, defining it as the surplus of internal risk sharing over autarky in a dynamic setting. Then we use this definition to show that there is a non-monotonic relationship between the level of social capital and an appropriately defined loan delinquency rate. This result may help explain the contradictory empirical results trying to link the two in the microfinance literature.

Besides the context of microcredit, our model applies in situations where enforcement problems are pervasive and a group of agents can collude when faced with a common principal. Examples of such situations include sovereign lending to a group of countries or to states within a federation, or supplying credit to married couples. More generally, we believe the framework of agents facing stochastic income who act to maximize joint surplus given the constraint of self-enforceability may provide a natural way of endogenizing the side-contracting ability of agents seeking to collude against a principal, a common issue in mechanism design.

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VIII. Figures

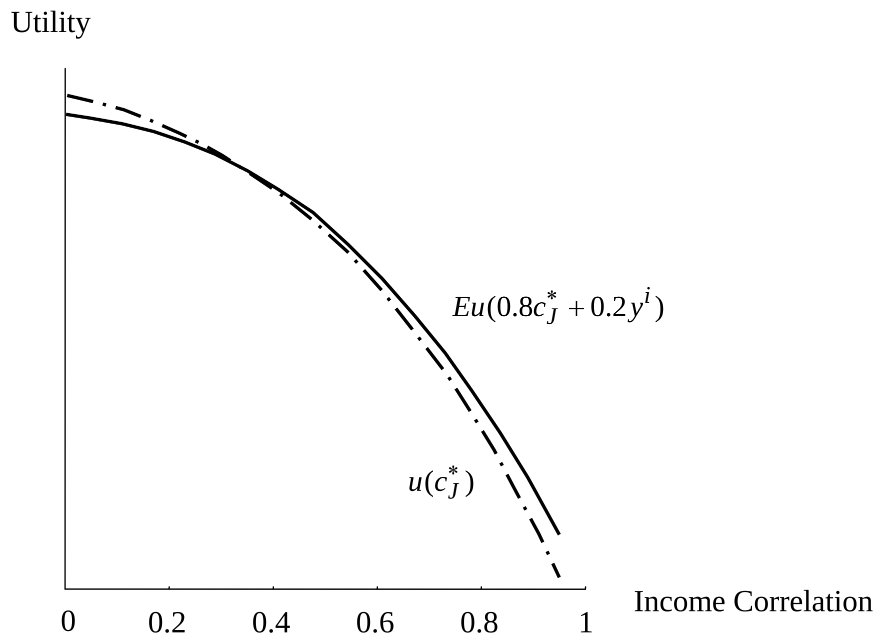

Figure 1: The utility from c_J^* versus the expected utility from $0.8c_J^* + 0.2y^i$ as income correlation varies in Example 1.

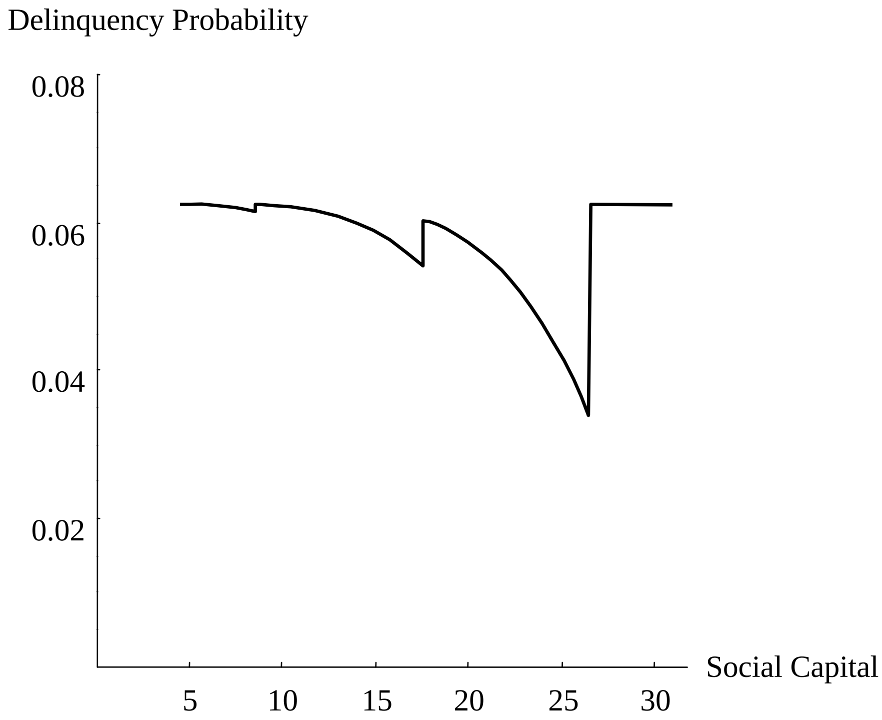

Figure 2: Delinquency probability (D = 4) as a function of social capital in Example 3.