Informal Insurance Under Individual Liability Loans: Theory and Evidence*

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Abstract

There has been a recent shift from joint liability to group loans with individual liability by some prominent micro lending institutions across the world. Some recent field experiments observed no change in repayment rates with this regime change. This paper investigates the role of informal insurance among group members to explain the success of group lending with individual liability. In our model members of a group face idiosyncratic shocks and realization of output is private information. They can insure each other through informal arrangements in repeated interactions. This paper focuses on a repeated game analysis and we show that with informal insurance individual liability lending can lead to repayment rates as same as joint liability. We also provide supportive evidence for the existence of informal insurance under individual liability group lending based on a primary survey conducted in West Bengal, India.

JEL classification: D81; G21; I38; O12; O16; O17

Keywords: Individual liability; Group lending; Informal insurance

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1. Introduction

It has been well established in economic literature that access to credit can empower the poor. Formal financial intermediaries, such as commercial banks, usually refuse to serve poor households because of the high cost of small transactions and lack of traditional collateral. As a consequence, an enormous pool of potential abilities and talents remain untapped by the society. The Grameen Bank is the world's best known lender to the poor and reaches more poor people than most of the other micro-lending organizations. It reaches to more than 8.35 million borrowers with the total amount of loan disbursement being Tk 684.13 billion (US $ 11.35 billion) since inception.[1] The unique feature of this bank had been the joint liability loans and similar banking models were subsequently adopted by hundreds of organizations around the world.

Under joint liability, a group of borrowers were given individual loans, but held jointly liable for repayment. If any member defaulted, future loans to all the group members would be denied or delayed. The economic literature has focused on this aspect of joint liability as the major factor behind the success of the Grameen Bank. It was believed that joint liability would encourage mutual insurance among group members and generate social pressure on borrowers to repay loans creating a sustainable model of lending.

However, in recent years, there has been a shift from joint liability to individual liability group lending undertaken by some prominent micro lending institutions including the Grameen Bank.[2] Under the new system, access to future credit by an individual borrower solely depends on her own performance and is not conditional on the performance of others in the group. Providing useful insights regarding this regime shift, Giné and Karlan (2011) conducted a field experiment with the Green Bank in Philippines, in which they compared randomly selected branches with joint liability to those without and found no significant change in repayment rates. Their experiment suggests that joint liability may not be the key feature of successful micro lending, which is also consistent with the experience of the Grameen Bank in Bangladesh. Due to the growing dissatisfaction with joint liability lending among its members, the Grameen Bank in 2002, replaced their model of group lending with Grameen II followed by an increase in borrowers from 3 million to 8 million. The natural question that arises at this point is, what leads to the smooth functioning of a micro lending system with individual liability loans?

Much of the previous literature has focused on the fact that under joint liability successful

[1] http://www.grameen-info.org

[2] Other banks who have adopted this model are for e.g. Association for Social Advancement (ASA) in Bangladesh, Bank Rakyat Indonesia (BRI) and BancoSol in Bolivia

group members might help unsuccessful group members repay, hence risk is shared within the group. The theoretical models inspired by Grameen suggest that joint liability clauses are key to efficient lending. In this paper we propose a theoretical framework that helps us understand the role of informal insurance and risk sharing under the individual liability group lending model. One may doubt existence of such insurance mechanisms within groups when liability is individualized. We argue that there are still possibilities of informal insurance and risk sharing under individual liability. Informal insurance may evolve in situations where formal insurance contracts cannot be written. It is based on reciprocity. In the context of group lending we may observe informal and mutual insurance when default by one member due to a bad income shock is paid by other group members with the anticipation that the currently defaulting member will help other defaulting members of the group when the former has a good income shock. The heart of our theory lies in explaining that though liability is individualized, borrowers can informally insure each other in "groups" leading to repayment rates similar to those as under joint liability. In addition, this paper also suggests that benefits of informal insurance are best reaped when individuals are in an optimal "group" size. The bank can increase social welfare by stipulating a "group" size its clients should maintain to obtain a loan. In order to examine whether informal insurance based on reciprocity really plays a role in the context of group lending under individual liability we carried out a small survey with clients of Bandhan Financial Services Pvt. Ltd. (BFSPL) in West Bengal, India. Bandhan delivers loans through the model of Individual liability through group formation and is one of the largest MFIs in India. Using the data obtained from the survey we study the interaction between informal insurance and network structure inside the groups.

Before moving on to discussing this issue in further detail, we must shed light on the institutional features of Grameen II. The new system abandoned one of the most celebrated features of the old format of Grameen lending, "joint liability". It also introduced a much more flexible punishment scheme as opposed to Grameen I which unleashed stricter punishments for defaulters. According to Yunus,

> "There is no reason for a credit institution dedicated to provide financial services to the poor to get uptight because a borrower could not pay back the entire amount of a loan .... Many things can go wrong for a poor person during the loan period..... Since she is paying additional interest for the extra time, where is the problem?"

Despite the shift from "joint liability" to "individual liability" it is still mandatory for individuals to be in a group in order to obtain a loan from the bank. As before individuals should have their groups formally recognized by Grameen staff. There is a clear distinction between "group liability" and "group lending". As Giné and Karlan (2011) pointed out, "group liability" refers to the terms of the actual contract, whereby individuals are both borrowers and simultaneously guarantors of other clients' loans. "Group lending" means there is some group aspect to the process or program, perhaps only logistical, like the sharing of a common meeting time and place to make payments.

Another important feature of Grameen I that has been retained by Grameen II is public repayment meetings. Repayments are made in public meetings where all the borrowers are present. These meetings allow the borrowers to learn about each other which helps in alleviating frictions. As observed by Armendariz and Morduch (2005), when repayments are made in public, "the villagers know who among them is moving forward and who may be running into difficulties".

We build our theoretical model in light of these institutional features. In our model we have N risk-neutral villagers and villagers are connected through links, which are bilateral in nature. Each villager can invest in a project that can be a success with probability p or a failure with probability $1-p$. Villagers can obtain a loan from a microcredit organization to fund this project. Each borrower must pay back the loan along with the interest charged by the bank. A borrower who defaults is punished by the bank and this non-pecuniary cost of punishment is increasing in the amount of default. Unlike extant theoretical literature on micro finance, we use a continuous punishment function to capture a more flexible loan disbursement scheme. A continuous punishment scheme is also more efficient from the bank's perspective as it can prevent strategic defaults when a client can only afford a partial repayment and cannot payback the loan in full. Implementation of such punishment schemes can be achieved through grace periods in loan repayment, adaptable installment schedules, loan renegotiation in the case of an income shock, loan refreshing at some point during the loan cycle etc[3].

Since default is costly, individuals can enter into informal arrangements with people whom they have links with. A contract of value x specifies the amount the successful individual transfers to her unsuccessful counterpart. The links are undirected in nature. When both are successful or unsuccessful, no transfers are made. At every period t, individuals observe their own output levels, but they do not observe others' output levels. Unsuccessful individuals approach their neighbors with whom they have an arrangement in order to repay their loans. Individuals with positive probability learn about their neighbors' outcomes at the public meeting. Once individuals learn about their neighbors' outcomes, they decide on

[3]See Laureti and Hamp

whether to sever links with the neighbors who did not keep their promises.

Each individual has n direct links and each link is characterized by a promise value x. The analysis focuses on the role of number of links on welfare for different punishment schemes. We show that when punishment equals the amount of default, welfare does not depend on the number of links an individual has. However individuals gain from links whenever cost of default is larger than the amount of default. We show for convex costs, individuals' expected utility under risk sharing is non decreasing in the number of neighbors. With a small cost of maintaining each link, there exists an optimal number of links for which an individual's gain from informal insurance are maximized. The result has an important policy implication in the context of group loans with individual liability as the bank can stipulate village specific group sizes that individuals need to maintain in order to get a loan. We also show with convex costs of punishment, the existence informal insurance arrangements that can lead to the same repayments as joint liability even under individual liability lending.

To complement our theoretical analysis, we conducted a survey with the clients of Bandhan Financial Services Pvt. Ltd. (BFSPL) in West Bengal, India. This survey was carried out in the two districts of West Bengal, India. We randomly chose a branch in each district. A total of 113 interviews were conducted. In order to study the interaction between informal insurance and network structure inside the groups we asked for the following information from Bandhan members in our survey. First, in case you need to take money, list up to 5 members in your group whom you would approach. Second, in case others need help, list up to 5 members who you think would approach you. The above questions were asked to capture bilateral directed links among group members that have future possibility of serving as insurance. Specifically, the first question gives us a set of links an individual considers as potential sources of help. The second question, on the other hand, gives us the set of links an individual thinks would seek help from her. We constructed the networks for each of these questions and also calculated network measures like average degree and clustering coefficients for each of the groups. The analysis concludes that there is existence of informal insurance within the group members though less than the full potential. The econometric analysis is also indicative of the fact that there is a degree of reciprocity among group members.

We also asked if Bandhan members would ask for financial help if they are not in a position to pay back their weekly installments. 47% of the members answered they would definitely ask for help from fellow group members. 19% would most likely ask for help, around 3% would probably ask for help and 17% would not ask for help. Almost 21% of the members would not ask for financial help from group members if they were not a part of the group. 42% of the members would still approach these individuals even if they were not a part of the group and almost 9.5% were unsure.

Literature: Much of the earlier literature discusses several institutional features of joint liability which has been summarized by Ghatak and Guinnane (1999). The literature on individual liability lending is still at a nascent stage. In this paper we provide a theoretical framework that emphasizes on the role of informal insurance under a social network in the context of individual liability loans. Our analysis largely relies on the assumption that individuals face internal frictions and cannot enter into arrangements that maximize joint utility.

The work of Townsend (1994) and Udry (1994) stimulated interest in the internal contractual arrangements of poor villagers which can potentially insure them against idiosyncratic shocks. They look at how good or how bad these informal risk sharing institutions are for the villages in southern India. They point out that the informal arrangements are imperfect, because they typically suffer from various kinds of informational and enforcement problems.

However, enforcement problems may be less severe in informal arrangements which are enforced by social sanctions i.e. which rely on social capital instead of traditional collateral. Besley and Coate (1995) discuss the role of social capital in the context of Grameen I. They provide a game-theoretic analysis of repayment decisions under group lending. The two incentive effects they emphasized on are: first, there is always a possibility that a successful borrower may repay the loan of a partner who obtains a bad return on her project. Second, group lending may be able to harness social collateral. Under an individual lending contract, all that the borrower has to fear, if she defaults, are the penalties that the bank can impose on her. Under group lending, she may also incur the wrath of other group members. Our paper retains both these features in the context of individual liability loans with the help of a social network. A successful individual may still be interested in helping her unsuccessful neighbor with the expectation that her neighbor will help her in bad times. Links are valuable to an individual because they can insure them against idiosyncratic shocks.

Rai and Sjöström (2004) design a lending mechanism that efficiently induces mutual insurance under joint liability lending. The role of bilateral insurance schemes across networks of individuals has been studied by Bloch et al. (2008). They investigate the structure of a self enforcing insurance network where transfers are based on social norms and are publicly observable. Our paper preserves their feature of bilateral insurance schemes across networks of individuals, however in a different context. Our paper also assumes away the observability of transfers across individuals.

Rai and Sjöström (2010), with whom we share some basic modeling similarities, show that in a Coasean world without frictions the village functions as a "composite agent" who minimize the joint expected cost of default. In such a world, the design of the lending contract is rather unimportant and joint liability loans are no better than individual liability loans. However the cost structure they assume is discrete. Punishment is constant for any positive default amount. This cost structure resembles the cost structure of Grameen I which has been too rigid in enforcing repayments. This strict adherence of rigid rules is not desirable, particularly if the credit institution is dedicated to provide financial services to the poor. Many things can go wrong and if these poor people are forced to default they may not find their way back to the credit market. Grameen II allows for more flexible repayments which are structured more in line with the borrower's cash-flows. Our model differs from Rai and Sjöström (2010) by assuming punishment cost to be a continuous and increasing function of default. This indeed is a better reflection of the highly flexible punishment scheme that has been adopted by Grameen II. Also in contrast to their two agent framework we introduce a general N agent model.

Findings of our paper are strongly supported by two recent field experiments. Giné and Karlan (2009) in their field experiment with Green Bank, a Grameen replica in the Philippines, compares randomly selected branches with joint liability to those without and find no change in repayment rates. They also find that those with weaker social networks prior to the conversion are more likely to experience default problems after conversion to individual liability, relative to those who remain under group liability. This phenomenon is captured in one of our results that shows too few neighbors is not welfare maximizing. A neighbor in our model acts as an insurance possibility rather than a monitoring devise. In other words, lack of neighbors means lack of insurance.

Feigenberg et al. (2010) provide an experimental evidence on the economic returns to social interaction in the context of micro finance. Their results also provide a rationale for the current trend among MFIs of maintaining repayment in group meetings despite the transition from group to individual liability contracts. They emphasize on the role of frequent social meetings to facilitate cooperative behavior.

In response to Feigenberg et al. (2011), Quidt de et al. (2012) derive conditions under which more frequent meetings, modeled as an increase in the amount of time borrowers and loan officers must spend in loan repayment meetings, increases borrowers' incentive to invest in social capital. They also show that individual lending with or without groups may be welfare improving as long as borrowers have sufficient social capital to sustain mutual insurance. In their paper each link is characterized by pair-specific social capital which is conceptualized as the net present value of lifetime payoffs in a repeated "social game" played alongside the borrowing relationship. In our paper welfare improvement is driven by pair-specific informal insurance arrangements in regular networks. The value of a link comes from the fact that a link functions as an insurance possibility.To the best of our knowledge our analysis is the first to emphasize the role of informal insurance based on reciprocity in the context of individual liability group lending models. No prior research provides empirical evidence for the existence of informal insurance in groups formed to obtain individual liability loans.

Section 2 describes the game-theoretic model and section 3 carries out the analysis. In section 4 we argue that individuals would not enter into informal arrangements or make promises to her neighbors that they may not be able to keep. Section 5 discusses the case where individuals can enter into punishment sharing arrangements. In section 6 we briefly discuss about moral hazard and adverse selection aspects of the model. In section 7 we provide supportive evidence of informal insurance through an econometric analysis and section 8 concludes.

2. The Model

Suppose there are N villagers, $i \in \{1, 2, ...N\}$. Each villager has an investment opportunity which requires an investment of one dollar. The project can be a "success" or a "failure". Agent i's output is denoted by $y_i = \{0, h\}$. A successful project yields $h > 0$ amount of output. In case of a failure an individual gets 0. The project can be successful with probability p and fail with probability $(1-p)$. Hence the state of the world is a $N-tuple$ $(y_1, y_2, ...y_N) \in Y \equiv \{0, h\}^N$. The random variables $y_1, y_2, ...y_N$ are independent. The villagers are risk-neutral. They have no assets, so neither self -financing nor borrowing from commercial banks is possible as banks require collateral.

Now suppose there is a benevolent not-for-profit microcredit organization who unlike commercial banks provides credit without collateral. It is assumed that h is high enough so that the projects are viable i.e. it is efficient to fund the investment opportunities.

$$h[Np^N + \binom{N}{N-1}p^{N-1}(1-p)(N-1) + ...\binom{N}{1}p(1-p)^{N-1}] > N$$

The bank cannot observe the state of the world. So it cannot observe whether a project succeeds or fails. Each villager needs to repay $(1+r)$. The interest rate charged by the bank, which is exogenously given, is the opportunity cost borne by the bank.

Default is not costless. A borrower who defaults is punished by the bank. It is often argued that villagers may face hard times because of some exogenous shocks and hence may find it difficult to pay back. However for the lender it can be difficult to verify such shocks.

If default is costless, then the borrower has a strategic incentive to default, claiming that for certain exogenous reasons she failed which may be difficult to verify. To prevent such strategic default we introduce that the bank imposes punishment depending by how much an individual defaulted. This non-pecuniary punishment can be interpreted as loans may be given at a higher interest rate.

Let $C(d)$ be the punishment an individual faces when the amount of default is d and $C' > 0$. Punishment is increasing in the amount of default with $C(0) = 0$. Much of the previous literature assumes that a borrower is punished whenever she defaults irrespective of the default amount. The continuous and increasing cost function is a better reflection of the new punishment scheme introduced in Grameen II which is more flexible as opposed to the stricter punishment scheme in the older system. We analyze the model with both linear and convex cost functions later in Section 3.3.

A villager who invests in a project and takes a loan of one dollar from the bank has an expected return

$$p[h - (1 + r)] - (1 - p)C(1 + r)$$

We assume this to be positive so that villagers have an incentive to invest in a project. If h is high enough this is easy to satisfy and hence incentive compatible for a villager to invest in a project.

Agents interact in a social network. Formally, a network g consists of the N villagers as the set of nodes and a graph—a collection of pairs of agents—with the interpretation that the pair ij belongs to g if they are directly linked. In this paper, a bilateral link is given: it comes from two individuals getting to know each other for reasons exogenous to the model. While such links may be destroyed (for instance, due to an unkept promise) no new links can be created.

An individual can enter into informal arrangements with people whom they have direct links with. We refer to them as "neighbors" of the individual. An arrangement of value x specifies the amount a successful individual transfers to her unsuccessful counterpart. When both are successful or unsuccessful, no transfers are made. A contract of value $x = 0$ means that the linked individuals have no informal arrangement. Hence each link is characterized by a value x. Since default is costly and project returns are independent, villagers can benefit from mutual insurance. If an individual fails while her neighbors are successful, then the successful neighbors can help the individual repay her loan reducing the cost of default. In short these arrangements can act as informal insurance.

2.1. Timeline

We consider an infinite horizon framework where agents are infinitely lived. Time is discrete and every period individuals face the same investment opportunity as described earlier. The villagers need to take a loan every period because the amount they save after paying back the interest to the bank can only suffice their sustenance. Given that they are very poor and their savings can only sustain their livelihood, they cannot avoid borrowing from the bank. At every period t, there are four stages. At stage 1, individuals observe only their own output levels, but they do not observe others' output levels. A public meeting is convened by the bank where individuals declare in public whether they have been successful or not. At stage 2, an unsuccessful individual approaches her neighbors with whom she has an agreement, in order to repay her loan. The neighbors respond by keeping or not keeping her promise. An individual will be interested in helping out her neighbor with the expectation that her neighbor will help her in her bad times. At stage 3, individuals repay their loans to the bank official in the public meeting. These meetings are held in each center (kendra) or branch of the bank. We make a simple assumption that the N villagers that we consider belong to the same branch. We rule out the possibility that individuals may have neighbors who belong to other branches of the bank. The public repayment meetings facilitate the borrowers to learn about each other. We assume that an individual's true outcome is revealed with probability $\beta > 0$. At stage 4, individuals decide on which links to sever.

2.2. Constraints , Payoffs and Equilibrium

For an individual i with k links, we assume the following is satisfied

$$\sum_{j=1}^{k} x_{ij} \leq h - (1 + r) \tag{1}$$

where $x_{ij} = x_{ji}$ is the promise value that characterizes the bilateral link between i and j. This implies that when individual i is successful the total amount promised to all her links should not exceed the resource available to her after repayment of her loan. In other words the budget constraint is satisfied. This assumption is relaxed later in Section 3.4 where we argue that individuals do not promise any x that does not satisfy the budget constraint.

We make an additional assumption on the parameters of the model,

$$1 + r \geq \frac{h}{2} \tag{2}$$

This assumption in the context of two person joint liability implies that a successful individual alone cannot repay the entire amount they jointly owe to the bank. In the context of our model this is the "no leftover" condition which ensures that even when all neighbors of an unsuccessful individual are successful, the maximum amount of help does not exceed the amount to be repaid.[4]

Given a network g and a state of the world y, the per-period utility of an individual i is given by

$$\begin{aligned} u_i(g, y) &= h - (1 + r) - \sum x \quad \text{if successful} \\ &= -C(d) \qquad\qquad\quad \text{if unsuccessful} \end{aligned}$$

where $\sum x$ is the total amount the successful individual transfers to her unsuccessful neighbors. The sum is over the number of unsuccessful links.

Equilibrium: An equilibrium consists of a network (g, N) and a set of arrangements $[x^1, x^2, ..., x^N]$ where $x^i \in \mathbb{R}_+^{n_i}$ and n_i is the number of links an individual has, satisfying

1. Each individuals' expected welfare is maximized.
2. Promises are kept whenever possible.

3. Analysis

In this paper we assume that each individual has n direct links. Each link is characterized by a specific promise value $x_{ij} = x$, $\forall i$, $\forall j$. The expected utility or welfare of an individual with n neighbors is

$$W = p\left[(h - (1 + r)) - \sum_{k=0}^{n} \binom{n}{k} p^k (1 - p)^{n-k} (n - k)x\right] - (1 - p)\left[\sum_{k=0}^{n} \binom{n}{k} p^k (1 - p)^{n-k} C(1 + r - kx)\right] \tag{3}$$

Individuals choose x to maximize W subject to the budget constraint

$$nx \leq A, \text{ where } A = h - (1 + r) \tag{4}$$

This constraint implies that $x \in [0, \frac{A}{n}]$ i.e. the maximum possible insurance level is bounded above by A/n.

[4] The "no-leftover" condition is a simplifying assumption. If this assumption is violated then situations may arise when an unsuccessful individual can repay her loan in full and still enjoy some surplus. However this does not alter the main results of the paper as discussed in Section 3.3.

We analyze the role of neighbors on an individual's welfare for linear and convex cost functions which are increasing and has the property $C(0) = 0$. This property ensures that an individual who pays back in full is not punished by the bank. We find that networks plays no role when punishment equals the default amount as is explained in Proposition 1. When punishment is greater than the default amount but linear in nature, individuals with informal arrangements are better off than in autarky. However this welfare increment is network size invariant as discussed in Proposition 2. Proposition 3 considers strictly convex cost functions which drive the main result of our paper. With strictly convex cost functions, individual welfare increases with the number of links.

Proposition 1: *If cost of punishment is linear i.e. $C(d) = d$ then network plays no role in increasing welfare from the autarkic level.*

Proof : By replacing the cost function in equation (3) we obtain

$$W = p\left[(h-(1+r)) - (1-p)^n nx - \binom{n}{1}p(1-p)^{n-1}(n-1)x - ... - p^n 0\right] +$$
$$(1-p)\left[-(1-p)^n(1+r) - \binom{n}{1}p(1-p)^{n-1}(1+r-x) - ... - p^n(1+r-nx)\right]$$

Note that, all terms containing x cancels out. This is true because,

$$\binom{n}{r-1}(n-(r-1)) = \binom{n}{r}r$$

Canceling out terms we get,

$$\begin{aligned} W &= p\left[h-(1+r)\right] - (1-p)(1+r) \\ &= ph - (1+r) \end{aligned}$$

which is the same as the autarkic utility.■

This implies that with linear costs the expected benefit is the same as the expected cost of maintaining a link and hence the welfare of an individual is unchanged at the autarkic value. Ex-ante, the amount a successful individual transfers to her unsuccessful neighbors is exactly the amount she gets back from her neighbors when she is unsuccessful. Since cost of default equals the default amount, the gain from links is same as the cost of maintaining links.

Now assume that the cost of default is greater than the default level, $C(d) > d$. This ensures that no individual has an incentive to strategically default. Under this cost structure we would be interested in finding the optimal amount of insurance x^*, which maximizes the expected utility of an individual. We look for the optimal insurance when the budget constraint (1) is satisfied.

Lemma 1: *If* $C' > 1$ *the optimal insurance is the maximum insurance possible i.e.* $x^* = A/n$.

Proof: For a fixed number of links n, we want to find the optimal insurance x that maximizes the expected utility W as in equation (3) subject to the budget constraint (1).

The individual solves the following optimization problem

$$\begin{aligned} & \max_x W \\ st \quad : \quad & nx \leq A \end{aligned}$$

With fixed n, we take the partial derivative of W with respect to x and obtain

$$\frac{\partial W}{\partial x} = -p(1-p)^n n + \binom{n}{1} p^2 (1-p)^{n-1}(n-1) + ... + \binom{n}{n-1} p^n (1-p)$$

$$+(1-p)\left[\binom{n}{1} p(1-p)^{n-1} C'(1+r-x) + 2\binom{n}{2} p^2(1-p)^{n-2} C'(1+r-2x)... + np^n C'(1+r-nx)\right] \tag{5}$$

Now, $\binom{n}{k-1}(n-k+1) = k\binom{n}{k}$.

We can simplify equation (5) and write

$$\frac{\partial W}{\partial x} = p\left[\begin{array}{c} (1-p)^n n\,(C'(1+r-x)-1) + \binom{n}{1} p(1-p)^{n-1}(n-1)\,(C'(1+r-2x)-1) + ... \\ +\binom{n}{n-1} p^n (1-p)\,(C'(1+r-nx)-1) \end{array}\right] \tag{6}$$

Under the assumption $C' > 1$, $\frac{\partial W}{\partial x}$ is increasing in x. Hence the constraint holds with equality implying that the optimal insurance is $x^* = \frac{A}{n}$.$\blacksquare$

This result applies to linear cost functions of the form $C(d) = \alpha d$, $\alpha > 1$ and to cost functions which are strictly convex. The above lemma implies that when cost is convex and is greater than the default amount, individuals always gain from insurance. In fact, under such circumstances individuals opt for the maximum possible insurance. Ex-ante the amount a successful individual transfers to her unsuccessful neighbors is less than her welfare gain when she is unsuccessful. We now analyze the effect of number of links on welfare with linear costs where cost is greater than the default amount.

Proposition 2*: If $C(d) = \alpha d$, $\alpha > 1$, individuals gain from informal insurance and welfare is higher than autarky. However network size does not play a role, that is, welfare is network-size invariant.*

Proof: See Appendix A.

The intuitive explanation is similar to Proposition 1. Like the previous case, ex-ante, the amount a successful individual transfers to her unsuccessful neighbors is exactly the amount she gets back from her neighbors when she is unsuccessful. However the gains from transfers is higher due to the structure of the cost function. Although welfare is higher than the autarkic level, it is independent of the number of links an individual has.

Now we assume that the costs of default is not only strictly increasing but also strictly convex, $C'' > 0$. Under this assumption we obtain that welfare is increasing in network size. In other words individuals are better off with more neighbors.

Proposition 3*: If $C(d) > d$ and $C'' > 0$ then welfare is increasing in n.*

Proof: See Appendix A.

The assumption of convex costs implicitly implies that individuals are risk averse. From Lemma 1, we know that the optimal insurance is the maximum insurance possible. We obtain that the expected utility is increasing in n evaluated at the optimal level of insurance. Each neighbor can be perceived as an insurance possibility and more neighbors can be associated with higher risk diversification. Since individuals are risk averse they gain from bigger neighborhoods through higher risk diversification and better insurance possibility.

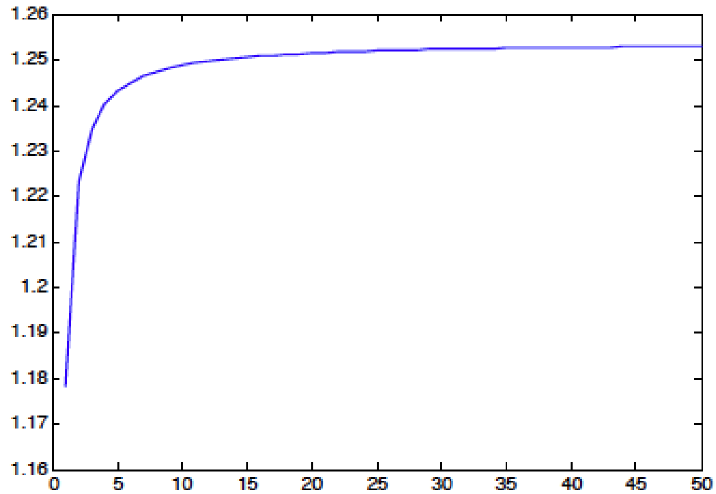
3.1. Example

In light of the above discussion, for a better understanding of the reader we present a simple example with a particular form of the cost function given by $C(d) = e^x - 1$. This cost function satisfies all the properties assumed in our model.

Figure 3.1 depicts the welfare function for the cost function $C(d) = e^x - 1$ with parameter values $h = 3$, $p = 0.9$, $r = 0.6$.

Figure 3.1 : Shape of the example welfare function

This specific example motivates us to find the shape of W for any cost function which is increasing and strictly convex with $C(0) = 0$. We know from Proposition 3, $\sigma^2 = \frac{A^2}{n} p(1-p)$. Thus as $n \to \infty$, $\sigma^2 \to 0$ and hence $\Gamma(n) \to C(1+r) + \mu C'(1+r)$, which is constant. This in turn implies that for large values of n the welfare function is increasing and converges



asymptotically. However we do not know the exact shape of the welfare function. Figure 3.2 depicts a particular form that the welfare function can possibly assume.

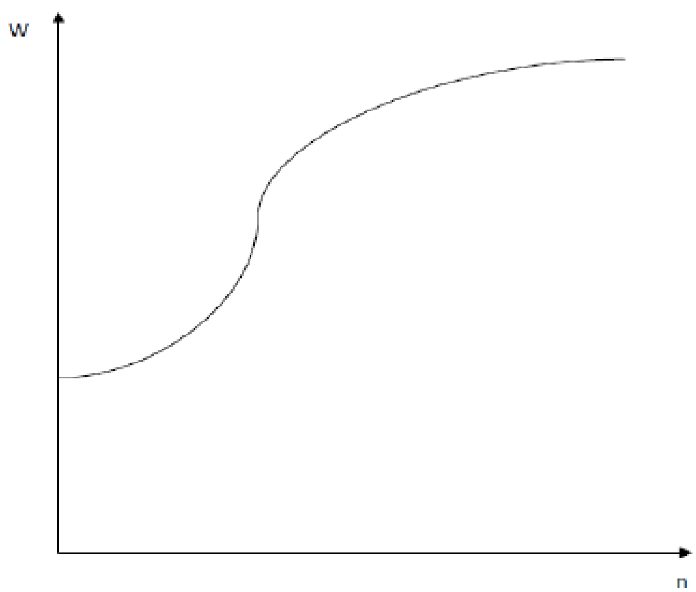
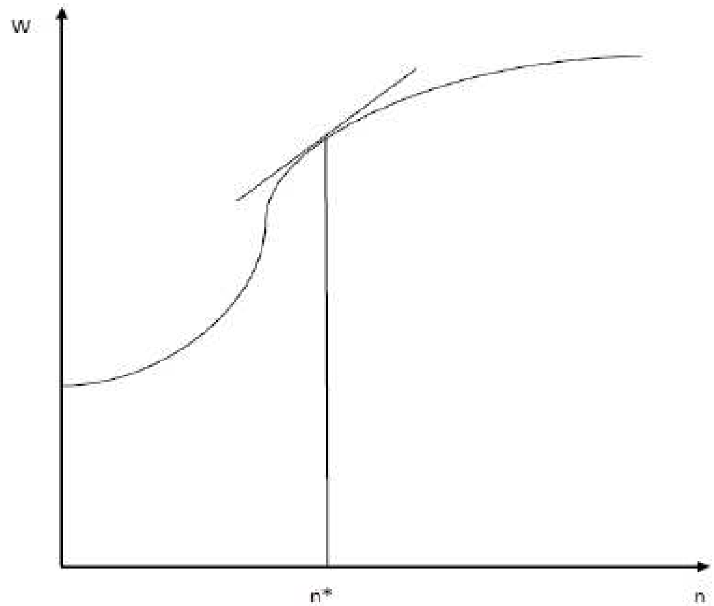


Figure 3.2 : Shape of the welfare function

Now suppose that there is a small cost of maintaining each link. Let θ be the cost of maintaining a link where $\theta > 0$. Hence an individual with n neighbors has to spend $n\theta$ amount of resources to maintain her links. This cost may or may not be non pecuniary in



nature. Pecuniary costs may involve exchanging gifts among neighbors while non-pecuniary costs may come from socializing with them (opportunity cost of labor or compromise on leisure). This motivates us to the next proposition.

Proposition 4: *If $C(d) > d$ and $C'' > 0$ and there is a small cost θ of maintaining each link, then there is an optimal number of links, n^*.*

Proof: We have already established that W increases with n and converges to a constant as $n \to \infty$. Since there is a cost θ for maintaining each link an individual will maintain the number of links where the marginal gain from an additional link is no less than the marginal cost. The optimal number of links is obtained at the point after which the marginal gain of an additional link is less than θ.

Since, $\Gamma(n) \to C(1+r) + \mu C'(1+r)$, there exists a n^* such than for all $n > n^*$, $\Gamma(n+1) - \Gamma(n) < \theta$. In order to obtain the optimal number of links we pick the minimum of such n^*s.■

$Figure\,3.3$: Optimal number of links

Abusing the technical intricacies, figure 3.3 roughly depicts the optimal number of links n^* beyond which the marginal benefit is less than the cost of maintaining an additional link.

Proposition 3 along with Proposition 4 conveys the main results of the paper. The results remain qualitatively unaltered if we relax the "no leftover" condition. Under the assumption $1 + r < h/2$, we redefine the utility function of an individual as

$$\begin{aligned} u_i(g, y) &= h - (1 + r) - \sum x \quad \text{if successful} \\ &= -C(d) + surplus \quad \text{if unsuccessful} \end{aligned}$$

An utility maximizing individual enjoys a surplus of $kx - (1+r)$ when she is unsuccessful, k of her neighbors are successful and $kx > 1 + r$. For punishment costs satisfying $C(d) > d$ and $C' > 1$, the optimal insurance level remains at $x^* = A/n$ as obtained in Lemma 1. The welfare function W is now a concave function with a kink and is no longer strictly concave. It can be easily shown that the lottery z_{n+1} as defined in the proof of Proposition 3, second order stochastically dominates z_n. Hence, individual welfare in equilibrium is non decreasing in n. Moreover individual welfare is bounded above implying that there exists an optimal number of links n^* when there is a small cost of maintaining each link. Though this result holds true for any general regular network, it has an important policy implication in the context of group loans with individual liability. This potentially provides a guidance for an optimal group size that individuals need to maintain in order to get a loan.

4. Relaxing the Budget Constraint

Under assumption 1, the choice of x is restricted to satisfy the budget constraint of an individual. This implies that if an individual is successful and all her neighbors are unsuccessful then the individual is able to keep her promises. Now suppose an individual enters into an arrangement such that her total promise exceeds the budget when some or all of her neighbors are unsuccessful. Individuals may want to promise higher values of x as they can be thought of as better insurance possibilities. However in equilibrium promises must be kept as links are severed as punishment.

Suppose players have a common discount factor $\delta \in (0, 1)$. We argue that if players are patient enough then the budget constraint is satisfied endogenously. This leads us to our next proposition.

Proposition 5: *Suppose $n \leq n^*$. Consider the following strategy. An individual pays $x = A/n$ to her unsuccessful neighbors whenever she is successful. She severs link with her neighbor whenever she finds out that her neighbor has not kept her promise. As $\delta \to 1$, the above strategy constitutes a Nash Equilibrium.*

Proof: See Appendix B.

The argument that supports the above proposition is as follows. Suppose individuals' promises are such that there exist events where promises can not be kept and these events occur with positive probabilities. An individual who can not keep her promise is revealed to be successful with probability β. Given the strategy specified in the above proposition, the neighbors who do not receive the promised value sever links with the individuals who did not keep their promises. Since, links are valuable insurance possibilities, long term gains from a link exceeds short term gains from deviation.

The natural question that arises here is whether the above strategy constitutes a Subgame Perfect Equilibrium (SPE). Once a neighbor does not keep her promise, it is necessary to check whether the link will indeed be severed. Now consider the following strategy. A successful individual keeps her promise, i.e., she pays x to her unsuccessful neighbors whenever she is successful. Whenever an individual finds out that her neighbor did not keep her promise the link in question is severed. An individual severs her link with a neighbor whenever her neighbor is found out to deviate from the actions prescribed above.

For the above strategy to be SPE we need some degree of observability of actions. Links in our model are bilateral in nature and the transfers are private to the links. To implement the punishment strategy we need transactions to be verifiable. If there is a positive probability of information leakage from which one's neighbors can infer if she has deviated from the equilibrium strategy, then the above strategy can be sustained as SPE. However, as discussed in Proposition 5 for Nash Equilibrium to hold we do not require any form of information leakage particular to bilateral transactions.

Consider an individual i whose neighbor j has not kept her promise, i.e. j did not transfer the promised value x even when she was successful and i was not. Now, i's optimal response is to sever the link with j if she finds out that j did not keep her promise. If i instead decides not to sever the link with j, and her neighbors find this out, then all $i's$ neighbors sever their links with i. Losing all the links is costlier than losing a single link. From the point of view of $i's$ neighbors, they will not deviate from the prescribed action as deviation will make them lose all their links. Repeating the argument in Proposition 5, one can show that the strategy prescribed above is indeed a subgame perfect equilibrium.

5. Collusion

In a world with no frictions, if there is a benevolent non-profit microcredit organization providing credit, then resources would be efficiently used so that individuals maximize their joint welfare. However frictions cannot be ignored in the real world. In our model, frictions impede individuals from maximizing joint welfare through punishment sharing. In this section we abstract away from such frictions and look for the first best solution where individuals can collude to share punishment.

Since cost of default is assumed to be a continuous convex function, punishment sharing can be welfare improving. Suppose there are two individuals and we allow for collusion among individuals in the form of punishment sharing. In our earlier setting individuals pay back their entire loan whenever they are successful and the successful individual helps her unsuccessful neighbor with $x^* = [h - (1 + r)]$. Consequently, the successful individual does not face punishment from the bank while her unsuccessful neighbor faces the punishment cost $C(1 + r - x^*)$. However the successful individual can help out her neighbor with some additional $\varepsilon > 0$ for which she faces a punishment $C(\varepsilon)$ and her neighbor's punishment reduces to $C(1 + r - x^* - \varepsilon)$. Since cost is convex, for ε small enough, the reduction in the unsuccessful individual's punishment is larger than the punishment cost faced by the successful individual. Thus individuals can gain by entering into arrangements that allow for punishment sharing.

Suppose the arrangement between two individuals is given by x which specifies the amount a successful individual transfers to her unsuccessful neighbor. Now the welfare function of an individual is given by

$$W = p\,[h - (1 - p)C(1 + r - h + x)] - (1 - p)\,[(1 - p)C(1 + r) + pC(1 + r - x)]$$

Welfare maximization leads to the optimal arrangement $x^{**} = h/2$. Punishment is shared up to the point where both individuals face the same level of punishment. Notice that when only one individual is successful, the bank collects h in the form of repayments. This is the same amount the bank collects under individual liability loans with no punishment sharing.

The same argument holds when an individual has n neighbors with whom she enters into punishment sharing arrangements. The welfare of an individual with n neighbors is then given by

$$\begin{aligned} W &= p[h - \sum_{k=0}^{n} p^k(1 - p)^{n-k}C(1 + r - h + (n - k)x)] \\ &\quad -(1 - p)[\sum_{k=0}^{n} p^k(1 - p)^{n-k}C(1 + r - kx)] \end{aligned}$$

and the optimal arrangement is given by $x^{**} = h/(n+1)$. When the number of successful individuals is m, the bank collects $m \times h$ which is same as the amount the bank collects under individual liability without punishment sharing.

The optimal punishment sharing arrangement is conceptually equivalent to joint welfare maximization of a group of individuals. In other words, individuals behave as a "composite agent" who minimizes joint expected punishment. Joint welfare maximization is the first best solution that joint liability aims to enforce. Joint liability is sometimes justified as a way to encourage the group members to help each other in bad times by "formalizing" the idea of mutual insurance. However internal frictions often impede this kind of collusive behavior. Our analysis in Section 3.3 provides an alternative model of risk mitigation where internal frictions preclude individuals from punishment sharing. The expost collection of the bank in equilibrium is same as the amount it collects under the first best solution.

6. Discussion

In this section we briefly discuss important issues like moral hazard and adverse selection in the context of our model. The following discussion suggests that stricter punishments are essential to remove moral hazard and sustain the all effort equilibrium where every member of the group exerts high effort. When faced with the adverse selection problem, stricter punishments might help in removing social segregation.

6.1. Moral Hazard

When output depends on the choice of effort, an individual's expected payoff not only depends on her own action but also depends on the action of her neighbors. Since neighbors act as insurance possibilities, neighbors' choice of effort can affect an individual's payoff in two ways. The expected amount a successful individual transfers to her unsuccessful neighbor decreases with the neighbor's effort choice while the expected transfer an unsuccessful individual receives from her successful neighbor increases with the choice of effort. Thus an individual has incentives to take remedial action against a neighbor who does not put effort. However when peer monitoring is prohibitively costly strict punishment schemes may alleviate the moral hazard problem as discussed below.

Suppose there are $n + 1$ individuals. Each individual puts effort $e \in \{0, 1\}$. When an individual puts effort $e = 1$, the probability of success is given by p whereas when $e = 0$, the probability of success is given by q, $p > q$. Let $c > 0$ be the cost of putting effort.

Let γ be the probability of putting effort and $\gamma^* \in [0, 1]$ be the symmetric equilibrium effort choice. Let $p' = \gamma p + (1-\gamma)q$ be the probability of success of an individual putting effort with probability γ.

Given other players play the mixed strategy γ, an individual's gross payoff from putting effort is given by

$$\pi_1(p') = p\,(h-(1+r)) - p * T_{x^*}(p') - (1-p)Z_{x^*}(p')$$

The payoff of the individual from not putting effort is given by

$$\pi_0(p') = q\,(h-(1+r)) - q * T_{x^*}(p') - (1-q)Z_{x^*}(p')$$

where, $T_{x^*}(\cdot)$ is the total expected transfer an individual makes to her unsuccessful neighbors when she is successful given an arrangement x^*. $Z_{x^*}(\cdot)$ is the expected punishment an individual faces when she is unsuccessful under the same arrangement x^*.

Suppose $\gamma^* \in [0,1]$ be the symmetric equilibrium strategy (assuming existence). Now $p^* = \gamma^* p + (1-\gamma^*)q$. Notice that the previous analysis (about optimal insurance and optimal network size) carries over with $p = p^*$ and $x^* = \frac{h-(1+r)}{n}$.

Since we know p^* and x^*, we can compute $T_{x^*}(p^*)$ and $Z_{x^*}(p^*)$. Now

$$\pi_1(p^*) - \pi_0(p^*) = (p-q)\,(h-(1+r)) - (p-q)T_{x^*}(p^*) + (p-q)Z_{x^*}(p^*)$$

Since $h-(1+r)-T_{x^*}(p^*) \geq 0$, $\pi_1(p^*) - \pi_0(p^*) > 0$.

For an individual to be indifferent between $e = 1$ and $e = 0$, we must have

$$\pi_1(p^*) - \pi_0(p^*) = c \tag{7}$$

Observe that $T_{x^*}(\cdot)$ and $Z_{x^*}(\cdot)$ are decreasing functions of γ. This is because as neighbors of an individual put more effort, they are unsuccessful with a lower probability and hence the expected transfer is lower. Similarly a higher γ works as a better insurance possibility. Neighbors putting more effort are successful with higher probability and hence reduces expected punishment of an individual who is unsuccessful. Also $\pi_1(\cdot) - \pi_0(\cdot)$ is decreasing in γ as $Z_{x^*}(\cdot)$ decreases at a higher rate than $T_{x^*}(\cdot)$. This is because transfers are linear and cost of punishment is convex.

Equilibrium Analysis: For $\gamma^* \in [0,1]$ to be a symmetric equilibrium, (7) must be satisfied. It is evident from equation (7) that a symmetric mixed strategy equilibrium will exist only for certain parameter values. For example, if p and q are not significantly different, then an interior solution will exist only for small values of c.

An all effort equilibrium exists if $(p-q)\,(h-(1+r))-(p-q)T_{x^*}(p)+(p-q)Z_{x^*}(p) \geq c$. This condition implies that it is optimal for an individual to put effort with probability one when all her neighbors do the same. All individuals put effort in this symmetric pure strategy Nash equilibrium.

Let $\gamma^* \in (0,1)$ be a symmetric mixed strategy equilibrium, i.e. $\pi_1(p')-\pi_0(p')=c$. Now suppose the cost of default $C(d)$ becomes steeper for all default levels maintaining $C(0)=0$. At γ^*, Z_{x^*} increases making $\pi_1-\pi_0>c$. Since, $\pi_1-\pi_0$ is decreasing in γ the new equilibrium (assuming existence) $\gamma^{**}>\gamma^*$. This implies that steeper punishments lead to higher equilibrium effort.

When peer monitoring is not prohibitively costly and individuals are sufficiently patient a high effort equilibrium can be sustained through a different mechanism. An individual can punish by severing the link with her neighbor who shirks. Suppose the cost of monitoring each neighbor is ϵ which reveals the neighbor's actions with probability ϵ. Using similar argument as in the proof of Proposition 5, high effort equilibrium can be sustained as $\delta \to 1$.

6.2. Segregation

So far our analysis suggests when the economy consists of homogeneous individuals, a larger network corresponds to insurance possibilities no worse than a smaller network. However in reality, the economy may not consist of homogeneous agents and this may lead to different implications in the context of our model. We capture heterogeneity among individuals by introducing differences in productivity. A high productive individual has a higher probability of success than that of a low productive individual.

Our previous analysis relies on an individual's willingness to engage herself in informal insurance arrangements with her neighbor. In a homogeneous population with linear or convex costs of default, individuals are never worse off with more links. In a heterogenous economy, a low productive individual fails to act as an insurance possibility as good as a high productive individual. Since a low productive individual fails more frequently, the high productive individual has to help her low productive neighbor more often than being helped by her neighbor. This may preclude the high productive individuals from entering into arrangements with low productive neighbors leading to social segregation. In a segregated society, individuals end up keeping links only with individuals of similar ability. However as already discussed in Section 3.3, larger number of links imply better insurance possibility, severe punishment schemes adopted by the bank may trigger the need for insurance. This in turn encourages high productive individuals to keep links with low productive neighbors and hence eliminate social segregation.

Suppose a high(low) productive individual is successful with probability $p(q)$, where $p > q$. Also suppose there is one high productive individual and one low productive individual in the economy.

The expected welfare of the high productive individual under autarky is

$$W_A = p\,(h - (1 + r)) - (1 - p)C(1 + r)$$

Expected welfare of the high productive individual when she has a link with the low productive individual

$$W_L = p\,[h - (1 + r) - (1 - q)x] - (1 - p)\,[(1 - q)C(1 + r) + qC(1 + r - x)]$$

Now

$$W_A - W_L = \underbrace{(1 - p)q[C(1 + r - x) - C(1 + r)]}_{(-ve)} + \underbrace{p(1 - q)x}_{(+ve)}$$

Given $p > q$, we have $(1 - p)q < p(1 - q)$. Therefore, $|C(1 + r - x) - C(1 + r)|$ has to be sufficiently higher than x for W_L to be larger than W_A. The strictness of the punishment function is captured by the degree of convexity of $C(\cdot)$. More convex the punishment function higher is the welfare gain from having a link. With linear punishment functions of the form $C(d) = \alpha d$, $\alpha > 1$ social segregation is eliminated for values of α higher than $p(1-q)/q(1-p)$.

7. Empirical Analysis

In this section we provide some supportive evidence for the presence of informal insurance under individual liability loans. In order to conduct a detailed analysis on individual liability lending in groups we carried out a survey with clients of Bandhan Financial Services Pvt. Ltd (BFSPL)[5]in West Bengal. Bandhan delivers loans through the model of individual liability through group formation and is one of the largest MFI in India with its headquarters in Kolkata. Bandhan groups consist of only female members and the average group size is 30.

This survey was carried out in two districts of West Bengal – Purulia and East Midnapore during the months of November and December 2014. Bandhan operates 7 branches in Purulia

[5]Bandhan emerged as a full -fledged commercial bank from 23rd August 2015. The survey was carried out earlier when its operations were restricted only to microfinance

and 28 branches in East Midnapore. Two branches were randomly chosen - Raghunathpur in Purulia and Kanthi in East Midnapore. The Raghunathpur branch has been in operation for about 7-8 years and Kanthi for 6-7 years at the time of the survey.

In each branch, two groups from Raghunathpur and three groups from Kanthi were randomly selected. The two groups in Raghunathpur were – Barsha and Jyotsna. The three groups that were chosen in Kanthi were – Champa, Diya and Karabi. We had to choose three from Midnapore because we wanted to cover almost equal number of individuals in both the districts. A total of 113 interviews were conducted. 57 interviews were conducted in Purulia and the remaining 56 were interviewed in East Midnapore. The detailed break-up of the group sizes and number of interviews done in each group is given in Table 1 below.

Table 1: Group Name and Number of Members Interviewed

Group Name	Village	District	Number of members interviewed
Barsha	Raghunathpur	Purulia	29
Jyotsna	Arra	Purulia	28
Champa	Srirampur	E. Midnapore	9
Diya	Dhandihi	E. Midnapore	33
Karabi	Srirampur	E. Midnapore	14

We first dicuss the household demographics of the sample followed by a description of loans from Bandhan. Then we present evidence of informal insurance and the regression analysis. At the end we have a discussion about some interesting observations that we draw from the data.

7.1 Demographics and Household Information

We provide a description about the demographics of the individuals interviewed and also contains basic information about their households. The average age of the 113 members interviewed across all the groups is 35.3 years. The three groups interviewed in East Midnapore consisted of all members from the Muslim community whereas the two groups interviewed in Purulia consisted of all members who are Hindus. 50 out of the 56 interviewed in East Midnapore belong to the General category and the rest 6 belong to Other Backward Classes (OBC). In Purulia, 48 out of 57 belong to Scheduled Caste (SC) with the rest 7 belonging to the General Category and 2 to OBC. Around half the sample size, 54 out of 113 were holders of a BPL card.

Out of 112 responses on the question on marital status, 111 were married and only 1 was single. The average year of schooling across the sample is 2.8. The average schooling in East

Midnapore is 4.2 as opposed to Purulia where the average is 1.5 and this is consistent with the fact that Purulia is a more backward state as compared to East Midnapore.

The average family size in the sample is 5.4 while 2.1 is the average number of earning members in the family. Each individual was asked to report their own income as well as their family income. The average own income in the sample is Rs.1461.9 per month while the average family income is Rs.13730.5

When the individuals were asked to report their occupation 56% of the sample (63 out of 112) answered that they were housewives. When these members were asked about the occupation at the time of joining Bandhan, then 64.3% (72 out of 112) reported that they were housewives. So there has not been a drastic change in the occupation pattern of the members after obtaining loans from Bandhan. Though these women who are the members of the Bandhan group, the loans that they take are often used by their husbands in their respective occupation. The natural question that arises at this point is that then why Bandhan doesn't induct the male members of the family who are actually using the loan. There are possibly two reasons – In general women have more self –respect and are more committed towards the family, so they will ensure that the loan is paid back on time so that their family's respect is maintained in the village. Bandhan might take leverage of this fact and possibly has created a monitoring system, which ensures them 99.9% repayments. This is a point worth exploring in the future. Secondly the only channel for the husband to get a loan is through their wives, this might empower the women by increasing her status in the family.

7.2 Loans from Bandhan

Bandhan provides only one loan to an individual at any given point of time. These loans can be either Suchana (Rs.1, 000 –Rs.15, 000) or Sristhi (Rs.16, 000 – Rs.50, 000). These loans are given at an interest rate 22.4%. Individuals were asked to recall the last three loans that they had taken from Bandhan and the purpose of the loan. The average last loan size in the sample is Rs. 6220, the average being higher for East Midnpaore as compared to Purulia.

Individuals make weekly repayments of the loans in a public meeting, which is held at one of the group member's house. Individuals observe each others' repayments and this was confirmed by our survey also. A loan officer from Bandhan leads these meetings. Members are persuaded, if not required, to attend these meetings and most of them comply unless there is some medical or other perceptible emergency.

The weekly repayments start immediately after a week of the loan receipt. This is the traditional model that microfinance institutions have been following across the globe and micro finance practitioners argue that the fiscal discipline imposed by this system is critical to preventing loan default. However this might limit the impact of microfinance on micro enterprise growth and household poverty by discouraging them to take illiquid risky investments. 72% of the respondents reported that they pay the first 3-4 weekly installments to Bandhan out of their present savings or a portion of the loan is kept aside for this purpose. This means in either case the effective loan size is much smaller than the actual loan size.

Bandhan enjoys almost zero default and has a record 99.9% repayment rate. The majority of the clients perceive that repayment is a must. When asked what steps the group members take if they default then almost 43% responses recorded are that the group members shout at the defaulting member. Also 39% responded that the group members cooperate and even try to help the individual to repay back in case of default. These are the features that we expect to see under joint liability but is surprising to find them in this present lending model. The borrowers value repaying on time to a great extent and this might probably be due to the fact that they consider Bandhan as the main potential source of credit available to them and recognize that their access to future loans would be compromised if they defaulted on loan repayment or were sufficiently delinquent.

7.3 Informal Insurance within Groups

In order to study informal insurance and its interaction within groups, the Bandhan members were asked to list up to 5 members in their respective group whom they would approach for help in case they were on the verge of default. Similarly they were also asked to list up to 5 members in their group whom they think would approach them if they were on the verge of default. The above questions were asked to capture bilateral directed links among group members that have future possibility of serving as insurance. Specifically, the first question gives us a set of links an individual considers as potential sources of help. The second question, on the other hand, gives us the set of links an individual thinks would seek help from her.

Table 2 gives us the average degree centrality for each group as well as the average clustering coefficients for the first question. Our measure of average degree or degree centrality is simply the number of nodes one is connected to, divided by total number of nodes. We use degree centrality as our measure of centrality as opposed to other centrality measures such as between-ness centrality, closeness centrality and eigenvector centrality. This is because all group members know each other and monetary transactions are usually bilateral in nature. The other centrality measures are useful in explaining either one's control over the group, or spreading of information in the group, which is not the focus of our analysis.

The average degree for all groups is 1.44. The average degree we believe is a fair representation of the number of insurance possibilities despite the fact that we had restricted the number of insurance possibilities to a maximum of 5. In our sample of 113 individuals, only 4 individuals provided us with names of five insurance possibilities. The rest of the members named less than 5 people as insurance possibilities. After looking at the average number of insurance possibilities within the groups, it seemed interesting to look for presence of sub-groups or cliques within these groups. It is evident that these groups are far from forming complete networks in terms of informal insurance. To look for the presence of cliques we used the measure of average clustering. The clustering coefficient of a network is given by the following formula.

$$Cl = \frac{3 \times number\, of\, triangles\, in\, the\, network}{number\, of\, connected\, triples\, of\, nodes}$$

where a "connected triple" refers to a node with edges to an unordered pair of nodes. We observe that heavy clustering is absent in all the groups. In fact in the group Champa, the average clustering coefficient is even lower than the clustering coefficient of the corresponding random graph.[6]

Table 2: Network Measures

Group Name	Barsha	Jyotsna	Champa	Diya	Karabi
Nodes	30	29	9	33	14
Average Degree	1.5	1.207	2.556	1.061	1.933
Clustering Coefficient	0.083/0.05	0.162/0.042	0.204/0.284	0.143/0.032	0.226/0.129

Table 3 gives us the average degree centrality of each group as well as the average clustering coefficients for the question where we ask the members to name up to 5 members in the group whom they think would approach them if they were on the verge of default. The average degree centrality for all groups is 1.54. Even though we restricted the maximum number of individuals one thinks would ask for help to 5, only 2 out of 113 reported names of 5 individuals they think would ask for help. This makes the average degree measure a fair representation of one's insurance network. Similar to our observations from the first question, we observe that heavy clustering is absent in all the groups. In two groups namely, Barsha and Champa, the average clustering coefficient is even lower than the clustering coefficient of the corresponding random graph.

Table 3: Network Measures

[6]The first component is the clustering coefficient of the network and the second is the clustering coefficient corresponding to the random graph

Group Name	Barsha	Jyotsna	Champa	Diya	Karabi
Nodes	30	29	9	33	14
Average Degree	0.933	1.103	2.222	2.061	2.067
Clustering Coefficient	0.025/0.0311	0.117/0.038	0.191/0.246	0.119/0.062	0.215/0.138

We also present some selected network structures based on the two questions. Figure 4 depicts the network structure for the group Barsha for the first question while figure 5 depicts the network structure for the group Barsha for the second question.

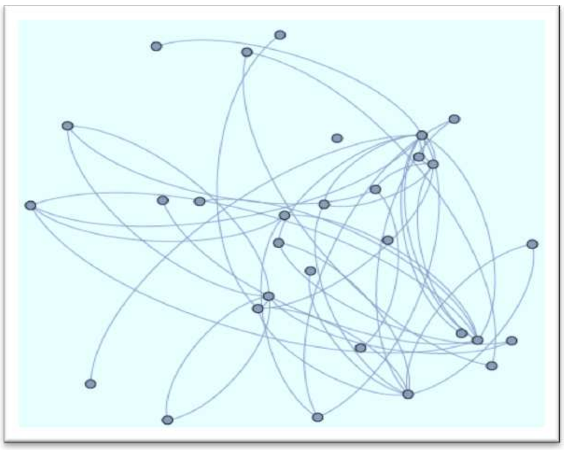
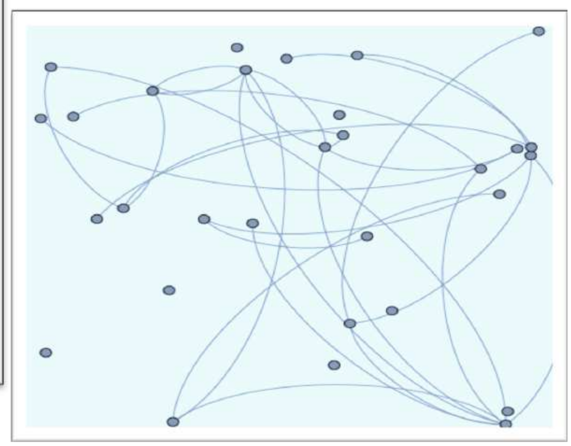


Figure 4



Though dense clustering is absent, individuals do have some degree of linkages which can serve as informal insurance. There are some isolated nodes also as we see in these two graphs. Usually most social networks exhibit high degrees of clustering compared to the clustering coefficient of their corresponding random graphs. However, this is not the case for the networks we constructed. This could be because the nature of financial transactions in networks is different from nature of information flow in social networks.

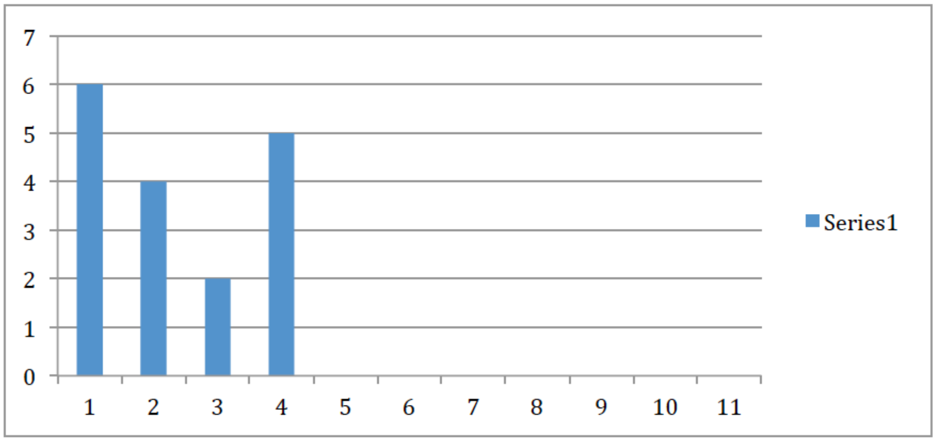
There is evidence of informal insurance within groups, except in the group Jyotsna, based on the percentage of times individuals actually obtained help from group members when they were on the verge of default on a weekly installment. Table 4 gives us the percentage of times individuals actually obtained help from their group members.

Table 4: Evidence of Informal Insurance

Group Name	Barsha	Champa	Diya	Karabi
Informal Insurance	27%	25%	37%	33%

There is another interesting fact that we observe from the data. Individuals were asked to report their sources they received financial help from when they were on the verge of a default. The survey results conclude that when an individual was on the verge of default, 23.8% of the times she obtained help from a fellow group member, which is also the second most used source of help. When on the verge of default, the primary sources of help for these individuals are their husbands. This is not surprising given that about 56% of the respondents were housewives. The results are presented in the frequency table below.

Frequency Table 1:



Summary: Members took help from husband (1), other family members (2), relatives (3) and Bandhan group members (4). They did not take help from Bandhan members outside their group (5).

So on an average we do find evidence of informal insurance in the sample that we have in this survey of limited number of individuals. Over and above individuals do have links to whom they would approach or be approached in case of help. This is less than the full potential of informal insurance as has been pointed out but definitely it shows evidence of informal insurance. The idea of informal insurance is naturally built up in the mechanism of joint liability lending but it is not clearly evident in case of individual liability lending and this study can be a first step in showing that informal insurance may still exist in individual liability lending and hence needs to be studied in greater details.

7.4 Regression

We will now analyze the factors that influence the degree of linkages or the informal insurance arrangements an individual has in a particular group. Based on the question on listing up to 5 members from whom an individual would ask for help in the group when on the verge of default, we calculate the in-degree and out-degree of each individual. The variables in the analysis are labeled as $indegree61$ and $outdegree61$. Indegree is defined the number of edges directed into a vertex in a directed graph whereas out-degree is defined as the number of edges directed out of a vertex in a directed graph. Similarly we also calculate the in-degree and out-degree measures for each individual in the group for the question on listing up to 5 members whom an individual thinks would approach her for help when on the verge of default. These variables are labeled as $indegree62$ and $outdegree62$ in the analysis. At this point we should note that individual i may name or perceive individual j as an insurance possibility but it is always not necessary for person j to think of i as an insurance possibility where $i \neq j$. This is very common in these kind of datasets.

The dependent variable in our regression analysis is indegree_61. An individual probably may be approached by many for help in a group if she has a high family income or wealth in terms of asset possession or both. Also a person may be more approached if she is self employed so that she may have her own savings/income as opposed to a housewife. A bunch of factors may influence indegree_61 and hence our reduced form regression specification is given by

$$Prob[Y = y_i|X_i] = \frac{exp(-\lambda_i)\lambda_i^{y_i}}{\Gamma(1+y_i)}$$

$$\lambda_i = exp(\alpha + X_i'\beta), \quad y_i = 0, 1, 2...N$$

where Y = indegree_61 and X is the set of independent variables. We use the negative binomial model. The reason behind using this regression model is that we have count data which is over dispersed. Thus we write

$$E[y_i|X_i, \epsilon_i] = exp(\alpha + X_i'\beta + \epsilon_i) = \lambda_i h_i,$$

where $h_i = exp(\epsilon_i)$ is assumed to have a one parameter gamma distribution, $G(\theta, \theta)$ with mean 1 and variance $1/\theta$. The marginal negative binomial (NB) distribution is given by

$$Prob[Y = y_i|x_i] = \frac{\Gamma(\theta + y_i)r_i^{\theta}(1-r_i)^{y_i}}{\Gamma(1+y_i)\Gamma(\theta)},$$

$$y_i = 0, 1, 2, ..., \ \theta > 0, \quad r_i = \theta/(\theta + \lambda_i).$$

The result is of the NB model is given below

	(1) indegree_61	(2) indegree_61	(3) indegree_61
indegree_61			
ownprofess~e	-0.228	-0.202	-0.226
	(0.202)	(0.202)	(0.205)
earninghus~n	-0.0000106	-0.00000904	-0.0000107
	(0.0000154)	(0.0000154)	(0.0000157)
indegree_62	0.252***	0.253***	0.244***
	(0.0499)	(0.0496)	(0.0503)
landowners~p		-0.0343	-0.0368
		(0.0367)	(0.0365)
educations~s			0.0202
			(0.0317)
_cons	0.257	0.284	0.271
	(0.195)	(0.194)	(0.194)
lnalpha			
_cons	-0.908*	-0.956*	-0.980**
	(0.357)	(0.373)	(0.380)
N	109	109	109

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

The results that we obtain are very interesting. In all the three model specifications above, the only significant variable is $indegree62$ and its coefficients are positive. The other independent variables are $ownprofession$ which is a dummy and takes a value 0 if an individual is a housewife by profession and 1 if she is employed. Then we have $earninghusband$ which measures the earning of the husband and is a measure for household income. Then we have $landownership$ which measures the amount of land owned by the household and is a proxy for assets and $educationstatus$ measures the average years of schooling of a borrower. All these independent variables except $indegree62$ have no impact on the dependent variable. Now $indegree61$ measures the number of borrowers who consider an individual i as an asset in the group while $indegree62$ measures the number of borrowers who consider individual i as a liability in that same group. The positive and significant coefficient of $indegree62$ leads to a possible explanation that if an individual is helpful to many in the group when members are on the verge of default then many in the group are also ready to help that individual when she is in trouble. Thus this factor is indicative of the presence of reciprocity which seems to be the only important factor in determining the informal arrangements one has. The results are unchanged even if we introduce group dummies in the regression.

Similar results are obtained if we consider *outdegree*61 as the independent variable and we have *outdegree*62 as one of the independent variables in addition to the variables that we have mentioned earlier. *outdegree*61 measures the number of individuals a borrower i consider to be an asset in the group while *outdegree*62 measures the number of individuals a borrower i consider to be liability. The results are shown in the regression table below. All other variables have an insignificant impact on the dependent variable while *outdegree*62 has a positive and significant impact on the dependent variable. Both these regression results point to the fact that reciprocity might be the key driver in explaining the informal arrangements that individuals have within a group. The results are unaltered even if we introduce group dummies.

	(1)	(2)	(3)
	outdegree_61	outdegree_61	outdegree_61
outdegree_61			
ownprofess~e	-0.00410	-0.00323	-0.00218
	(0.145)	(0.147)	(0.148)
earninghus~n	-0.0000104	-0.0000104	-0.0000103
	(0.0000103)	(0.0000104)	(0.0000105)
outdegree_62	0.367***	0.367***	0.368***
	(0.0473)	(0.0481)	(0.0495)
landowners~p		-0.000915	-0.000788
		(0.0213)	(0.0215)
educations~s			-0.00102
			(0.0218)
_cons	-0.0303	-0.0303	-0.0298
	(0.169)	(0.169)	(0.170)
lnalpha			
_cons	-17.13	-17.34	-17.16
	(468.6)	(607.0)	(639.8)
N	109	109	109

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

7.5 Other Observations

We provide a brief overview of some of the interesting observations that are obtained from the data in term of peer monitoring within groups. In our survey of 113 Bandhan clients, we observe that 55% of the respondents had an idea about the financial background of all or most of the members in the group. The members in many cases know about other members' reasons for obtaining a loan. 49.5% reported that they know the reason for which the loan is taken for of all or most of the members in their group. A significantly high percentage of individuals, 76.3% reported that other members in the group knew about her family's financial situation at the time of joining Bandhan. These figures suggest that the members have significant information about others though that varies across groups. This presence of peer monitoring can facilitate informal insurance among the group members which in turn contributes to the high repayments that are observed by Bandhan.

8. Conclusion

This study is primarily motivated by the success of Grameen II, individual liability loans in particular. Although joint liability facilitated mutual insurance by formalizing it to a great extent, it is reasonable to think that informal insurance plays a significant role under individual liability lending as well. Individuals help each other in bad times and informal insurance is facilitated by repeated interactions among individuals.

We investigate the role of informal insurance when individuals are not able to enter into contracts which maximize joint welfare for reasons exogenous to the model. We show that informal arrangements play an important role in protecting individuals from idiosyncratic shocks. When the punishment cost is greater than the default amount and is convex, individuals opt for maximum possible insurance. This in equilibrium leads to the same repayment rates as would be observed if individuals could share punishments and maximize joint welfare.

This paper not only provides an alternative explanation for the success of individual liability loans, it also takes up an important policy question that has not been addressed by the existing literature. In an attempt to provide an alternative explanation of Grameen II we emphasize on the importance of bilateral arrangements in groups.

It has been observed in Grameen II and its various replicas that individuals are encouraged to maintain an implicit group structure among themselves even under individual liability. A natural question to ask is if there is an optimal group size that maximizes individual's welfare. Since under convex costs insurance possibility increases with the number of links an individual has, should the entire village act a single group? Does it really take a village to maximize individual's welfare? The answer is "no". Marginal welfare declines as the number of links increases, and if there is a small cost of maintaining each link, only a finite number of neighbors maximize welfare.

The analysis in this paper thus potentially provides a guidance for the optimal group size that needs to be implicitly maintained by the villagers. In accordance with the punishment scheme adopted by the bank a social planner can adopt policies to encourage villagers to maintain the optimum group size. Our results however remains true for any regular network and finding the optimal group size is one mere application of a more general result.

This paper also provides supportive evidence for informal insurance among group members in individual liability loans in a group lending model. This paper provides a first step in better understanding this new lending model as opposed to the traditional group liability lending model.

Appendix A

Proof of Proposition 2: Given this cost structure we can write the welfare of an individual as

$$\begin{aligned}
W &= -p\left[-(h-(1+r))+(1-p)^n nx+\binom{n}{1}p(1-p)^{n-1}(n-1)x+...+p^n 0\right] \\
&\quad -(1-p)\left[(1-p)^n\alpha(1+r)+\binom{n}{1}p(1-p)^{n-1}\alpha(1+r-x)+...+p^n\alpha(1+r-nx)\right] \\
&= -p\left[-(h-(1+r))+(1-p)^n nx+\binom{n}{1}p(1-p)^{n-1}(n-1)x+...+p^n 0\right] \\
&\quad -(1-p)\alpha(1+r)+(1-p)\left[\binom{n}{1}p(1-p)^{n-1}\alpha x+...+p^n\alpha nx\right]
\end{aligned}$$

From Lemma 1 we know that the optimal level of insurance will be $x^* = \frac{A}{n}$. We now evaluate the welfare of an individual at this level of insurance

Let $\alpha = 1+\gamma$ where $\gamma > 0$.

Thus,

$$\begin{aligned}
W &= p[h-(1+r)]-(1-p)\alpha(1+r)+(1-p)\gamma\left[\binom{n}{1}p(1-p)^{n-1}+...+p^n n\right]\frac{A}{n} \\
&= p[h-(1+r)]-(1-p)\alpha(1+r)+(1-p)\gamma\left[\sum_{r=0}^{n}\binom{n}{r}p^r(1-p)^{n-r}r\right]\frac{A}{n} \\
&= p[h-(1+r)]-(1-p)\alpha(1+r)+(1-p)\gamma np\frac{A}{n} \\
&= p[h-(1+r)]-(1-p)\alpha(1+r)+(1-p)\gamma pA
\end{aligned}$$

So the welfare is greater than autarky by the amount $(1-p)\gamma pA$ which is positive. Moreover the welfare level is independent of n i.e. the size of the network.■

Proof of Proposition 3: The welfare function is given by

$$\begin{aligned}
W &= -p\left[-(h-(1+r))+(1-p)^n nx+\binom{n}{1}p(1-p)^{n-1}(n-1)x+...+p^n 0\right] \\
&\quad -(1-p)\left[(1-p)^n C(1+r)+\binom{n}{1}p(1-p)^{n-1}C(1+r-x)+...+p^n C(1+r-nx)\right] \\
&= p[h-(1+r)]-(1-p)\left[\sum_{k=0}^{n}\binom{n}{k}p^k(1-p)^{n-k}\left(C(1+r-kx)+kx\right)\right]
\end{aligned}$$

Substituting the optimal value of x in the welfare function from Lemma 1 we get,

$$\begin{aligned} W &= p[h-(1+r)]-(1-p)\left[\sum_{k=0}^{n}\binom{n}{k}p^k(1-p)^{n-k}\left(C(1+r-k\frac{A}{n})+k\frac{A}{n}\right)\right] \\ &= p[h-(1+r)]-(1-p)\sum_{k=0}^{n}\binom{n}{k}p^k(1-p)^{n-k}C(1+r-k\frac{A}{n})-(1-p)\sum_{k=0}^{n}\binom{n}{k}p^k(1-p)^{n-k}k\frac{A}{n} \end{aligned}$$

$$W = p[h-(1+r)]-(1-p)pA-(1-p)\sum_{k=0}^{n}\binom{n}{k}p^k(1-p)^{n-k}C(1+r-k\frac{A}{n}) \qquad \text{(A1)}$$

Now we want to show that in equation (A1) the last term is decreasing in n.

Let

$$\Gamma(n) = \sum_{k=0}^{n}\binom{n}{k}p^k(1-p)^{n-k}C(1+r-k\frac{A}{n}). \qquad (*)$$

Define z_n to be a lottery with outcomes $\{0, \frac{A}{n}, \frac{2A}{n}, ..., A\}$ following binomial distribution with parameters n and p. Given an individual has n neighbors, the $(k+1)^{th}$ outcome of z_n which equals $\frac{kA}{n}$, represents the amount an unsuccessful individual receives when k of her neighbors are successful.

Hence, we can rewrite $(*)$ as $\Gamma(n) = EC\left((1+r)+z_n\right).$

Taking second order Taylor series expansion of C around $(1+r)$ we get,

$$\begin{aligned} \Gamma(n) &= EC\left((1+r)+z_n\right) \\ &\approx E\left[C(1+r)+C'(1+r)z_n+\frac{1}{2}C''(1+r)z_n^2\right] \\ &= E[C(1+r)]+C'(1+r)E(z_n)+\frac{1}{2}C''(1+r)E(z_n^2) \\ &= C(1+r)+\mu C'(1+r)+\frac{1}{2}(\mu^2+\sigma^2)C''(1+r) \end{aligned}$$

where, $\mu = Ap$ and $\sigma^2 = \frac{A^2}{n}p(1-p)$.

As n increases the mean of the lotteries remain unchanged while the variance decreases. Since $C'' > 0$, the expected cost $\Gamma(n)$ decreases. Hence welfare increases as n increases. ■

Appendix B

Proof of Proposition 5: We know that if the budget constraint is satisfied then the optimal insurance is A/n. Now we want to see if two individuals have incentives to enter into an arrangement $(A/n + \epsilon)$ where $\epsilon > 0$. This means under certain events which occur with positive probability at least one link is severed.

Let E_ϵ denote the set of events where no link is severed under the arrangement $(A/n+\epsilon)$. Let $E_\epsilon^{'}$ denote the set of events where a link is severed i.e. an individual fails to keep her promise when she is successful and her true type is revealed. $E_\epsilon^{'}$ may correspond to situations where all neighbors of an individual is not successful and the individual is successful. In such a situation the successful individual fails to keep her promise to at least one of her neighbors and her true state is revealed with probability β. It also includes situations where the individual is unsuccessful, her neighbor is successful and all her neighbor's neighbors are unsuccessful.

Let γ be the probability that E_ϵ' occurs and $(1-\gamma)$ be the probability that E_ϵ occurs.

Let V_ϵ be the normalized expected discounted payoff under the arrangement $(A/n + \epsilon)$ and $\overline{V}$ be the normalized expected discounted payoff under the arrangement A/n.

Let V_0 be the normalized expected discounted payoff when a link is severed. Also let $\overline{z}$ and $\overline{x}$ be the one period payoffs under $(A/n + \epsilon)$ and A/n respectively.

Suppose $\overline{z} > \overline{x}$, i.e. one period deviation is profitable. Notice that, $\overline{V} = \overline{x} > V_0$. This follows from the assumption $n \leq n^*$.

Now,

$$\begin{aligned} V_\epsilon &= (1-\delta)\overline{z} + \delta\gamma V_0 + \delta(1-\gamma)V_\epsilon \\ V_\epsilon &= \frac{1-\delta}{1-\delta(1-\gamma)}\overline{z} + \frac{\delta\gamma}{1-\delta(1-\gamma)}V_0 \end{aligned}$$

Subtracting $\overline{V}$ from V_ϵ,

$$V_\epsilon - \overline{V} = \frac{1-\delta}{1-\delta(1-\gamma)}(\overline{z}-\overline{x}) + \frac{\delta\gamma}{1-\delta(1-\gamma)}(V_0 - \overline{x})$$

As $\delta \to 1$, $1-\delta(1-\gamma) \to \gamma$ implying $\frac{1-\delta}{1-\delta(1-\gamma)} \to 0$ and $\frac{\delta\gamma}{1-\delta(1-\gamma)} \to 1$. Therefore, in the limit $V_\epsilon - \overline{V} < 0$.

This proves our proposition.■

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