Ex-ante Moral Hazard and Repayment Performance under Group Lending

Wei Zhang*

Abstract

This paper aims to investigate compared to individual liability lending, whether group lending has information advantage of overcoming ex-ante moral hazard and efficiency advantage of improving repayment performance. This paper is an attempt to contribute to the ex-ante moral hazard literature by formalizing the dynamic incentive of "non-refinancing threat". A main implication of this paper is that "non-refinancing threat" has much effect on borrower's effort choice and repayment performance under both group lending and individual liability lending. Then the result of the ex-ante moral hazard literature assuming away "non-refinancing threat", to some extent, is misleading. This paper constructs a simple dynamic model in an environment characterized by ex-ante moral hazard and the lack of collateral.[1] The results of the model reveal that: (1) when group members make effort decisions non-cooperatively, the individual equilibrium effort under group lending is lower than that under individual liability lending, hence mere joint liability and "non-refinancing threat" can not mitigate ex-ante moral hazard; (2) when group members coordinate their effort choices the analytical result of the comparison in individual equilibrium effort between group lending and individual liability lending depends on certain conditions; and (3) group lending without peer-cooperation achieves the same repayment performance as individual liability lending; however, group lending with peer-cooperation outperforms individual liability lending in encouraging repayment.

JEL classification: D82; G2; O16

Key Words: Group Lending, Joint Liability, Ex-ante Moral Hazard, Non-refinancing Threat

Introduction:

In the past two and a half decades, group lending or joint liability lending has caught a lot of attention of both practitioners and academic literature. The basic idea of group lending is that borrowers who can not provide conventional collateral are asked to organize themselves into groups in which members are mutually liable for each other's repayments although loans are made to individuals. If anyone of the group is unable or unwilling to repay his debt obligation, the entire group will be denied access to future financing by the lender until other members repay for the defaulter. The attention of development community was drawn to group lending after Grameen Bank of Bangladesh and Banco Solidario (Bancosol) of Bolivia, as well as other similar microcredit institutions, showed the success in "being able

* Graduate School of East Asian Studies, Yamaguchi University, 1677-1, Yishida, Yamaguchi City, Japan

The author is extremely grateful to the editors of this JOURNAL, Prof. Yasuki Abe and Prof. Shigenori Ishida, and two anonymous referees, for their most valuable comments and suggestions, and very kind encouragement. The author would also like to thank Prof. Haifeng Li, Prof. Longtan Shi and Prof. Noriatsu Matsui, for their generous support. Any errors and/or omissions in this paper, of course, are the responsibility of the author.

[1] This paper ignores the adverse selection problem which undoubtedly has an important effect on repayment performance. In another paper "Group Lending with Adverse Selection" (Zhang, 2008), the author addresses the adverse selection problem.

to reach the poor and realizing high repayment performance" (Mehrteab, 2005, Chapter 1, pp.1).[2]

Since Stiglitz (1990), economists have applied theories of information economics and contracts to the study on group lending to advance various explanations for the success of group lending programs in terms of the remarkable repayment performance. Most of the theoretical literature has emphasized that group lending contract/joint liability lending contract which "exploits new contractual structures and organizational forms that reduce the riskiness and costs of making small, uncollateralized loans" (Morduch, 1998, p1) is critical to the success of group-based microcredit programs. The underlying rationale for group lending works in the rural credit contexts of asymmetrical information and limited availability of collateral is that the arrangements of group lending create incentives for group members to screen and monitor each other, as well as apply powerful social sanctions on delinquent members to enforce repayments.[3] By effectively shifting part of the responsibility and cost of screening, monitoring and enforcing loans from the lender to peers, group lending claims to conquer the typical asymmetric information problems and promote repayment rates, even in the absence of collateral requirements.[4] These theoretical explanations can be roughly categorized into:[5]

(1) those dealing with peer selection and adverse selection problem (e.g. Ghatak 1999 and 2000; Van Tassel; 1999; Armendáriz de Aghion and Gollier, 2000; Laffont and N'Guessan 2000);

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[2] In comparison with the subsidized credit programs and other traditional forms of rural credit, the representative group-based microcredit programs have enjoyed well-publicized success reflected by remarkable repayment rates often above 95% (Morduch, 1999).

[3] Social sanctions may involve social isolation or exclusion from the local community, as in Besley and Coate (1995) and Armendáriz de Aghion and Morduch (2000) , social, moral or peer pressure, as in Armendáriz de Aghion (1999) and Armendáriz de Aghion and Morduch (2000), the loss of personal reputation as in van Bastelaer (1999) and Armendáriz de Aghion and Morduch (2000) or the social ostracism/exclusion from access to other goods and services as in Armendáriz de Aghion and Morduch (2000) and Bond and Rei (2003). It is argued that by substituting "social collateral" for missing physical collateral, group lending provides a new approach of enforcing contracts and allows the previously marginalized borrowers to commit to repay (Conning, 2005).

[4] Contrary to the frequent celebrations of the positive aspects of group lending, there are some critical voices. The criticisms are concerned with: the additional costs for borrowers of attending group meetings, monitoring peers and repaying for the defaulting peers; the extensive tension which harms social capital among members, the free-riding of members which intrigues high default rates; the rigid methodology which is poorly adapted to the diverse credit demands of clients (Armendáriz de Aghion and Morduch, 2001; Conning, 2005; Giné and Karlan, 2006). See Conning (1999) and Morduch (2000) for the summaries of debates and disagreements in group lending modality amongst practitioners and policymakers.

[5] The empirical research on group lending can be roughly categorized into: (1) those exploring the relevance of social capital to repayment performance (e.g. Wydick, 1999; Ahlin and Townsend, 2007a; Cassar *et al.*, 2007); Karlan, 2007. Cassar *et al.* (2007) explore this problem by taking a new approach of laboratory experiments); (2) those concerned with the relative merits of group lending versus individual liability lending (e.g. Giné and Karlan, 2006; Ahlin and Townsend, 2007a; Ahlin and Townsend, 2007b; Cull *et al.*, 2007). Giné and Karlan (2006) explore this problem by taking a laboratory experiments approach); and (3) those that have surveyed peer matching and group formation (e.g. Sadoulet and Carpenter, 2001; Lensink and Mehrteab, 2003). See Ghatak and Guinnane (1999), Morduch (1999) and Armendáriz de Aghion and Morduch (2005) for a review of theoretical and empirical literature. Empirical studies that seek to measure the poverty-alleviation impact of microcredit include Khandker, S. R. (1998), Morduch (1998), Pitt, M. M. (1999), Khandker, S. (2001), Khawari (2004), and Montgomery and Weiss (2005).

(2) those concerned with peer monitoring and ex-ante moral hazard problem (e.g. Stiglitz, 1990; Varian, 1990; Banerjee *et al.*, 1994; Laffont and Rey, 2003; Conning, 1996, 1999 and 2005; Ghatak and Guinnane, 1999; Chowdhury, 2004; Guttman, 2006; Aniket, 2007; Cason *et al.*, 2007)[6];

(3) those addressing social sanctions, peer monitoring and ex-post moral hazard problem (e.g. Besley and Coate, 1995; Armendáriz de Aghion, 1999).

This paper is an attempt to contribute to the ex-ante moral hazard literature on group lending. In credit market, ex-ante moral hazard takes place at the investment stage of loan transactions when the lender lacks the abilities either to observe the borrower's privately-taken actions and/or to force the borrower to take requisite actions. A borrower's privately-taken actions which are based on his own interest are not necessary for the best interest of the lender. Then the actions taken by the borrower are not Pareto-Optimal. Collateral requirements play a part in mitigating ex-ante moral hazard because they provide the lender with a way to force the borrower to take requisite actions. However, in many developing countries, "limited wealth, limited property and poorly functioning legal system combine to reduce the possession of collateralizable assets" (Bond and Rai, 2002, pp.1). Therefore, ex-ante moral hazard becomes a major constraint to the development of rural credit market (Stiglitz, 1990). This paper aims to examine relative to traditional individual liability lending contract, whether group lending contract has the information advantage of mitigating ex-ante moral hazard and the efficiency advantage of encouraging repayment.

This paper proceeds as follows: Section 2 surveys the literature and outlines the uniqueness in the present model with respect to the theoretical models that have been developed. Section 3 presents the individual liability lending argument in a context of ex-ante moral hazard and the lack of collateral. Section 4 which is concerned with ex-ante moral hazard in group lending makes a comparison in individual equilibrium effort between individual liability lending and group lending. Section 5 investigates the efficiency advantage of group lending in terms of enhancing repayment rate. Finally, Section 6 concludes and spells out some avenues for future research.

2. Literature Review

Stiglitz (1990) and Ghatak and Guinnane (1999) are representative efforts to explain the success of group lending in mitigating ex-ante moral hazard involved in lending to those who can not provide collateral. Stiglitz (1990) provides an early treatment of ex-ante moral hazard with respect to project choice and shows how joint liability and peer monitoring can mitigate the ex-ante moral hazard in an environment where borrowers can perfectly and costlessly observe each other's actions, as well as enforce any action-contingent side contracts or cooperation. Under group lending, group members are mutually liable for each other's repayments and a borrower who succeeds in his project has to repay for his partner in case that his partner's project fails. This arrangement creates incentive for group members to monitor each other's investment decisions so as to ensure that the partner chooses safe project and as such avoid repaying for the failed partner. Consequently, if borrowers have information and enforcement advantages over the outside lender, group lending outperforms individual liability lending in mitigating ex-ante moral hazard and enhancing repayment rates. Focusing on ex-ante moral hazard with respect to effort, Ghatak and Guinnane (1999) propose a modification of Stiglitz (1990). The main results of their model reveal

[6] Chowdhury (2004) and Aniket (2007) look at the relative advantage of sequential and simultaneous lending within group with respect to providing the borrowers appropriate incentive to undertaking peer monitoring. Cason *et al.* (2007) examines this problem by taking a laboratory experiments approach.

that when group members decide on their effort level non-cooperatively, the individual equilibrium effort under group lending is the same as that under individual liability lending. But when group members act cooperatively, both the individual equilibrium effort and repayment rate under group lending are higher than those under individual liability lending.

Although Stiglitz (1990) and Ghatak and Guinnane (1999) have identified important mechanisms of group lending, they have ignored the dynamic aspect of group lending which usually takes the form of denial of future credit in case of collective default. "Non-refinancing threat" is a widely-used device in individual liability lending (Aleem, 1990, in Armendáriz de Aghion and Morduch, 2005; Bolton and Scharfestein, 1990) and its essence has translated directly to group lending practice (Armendáriz de Aghion and Morduch, 2000). In group-based microcredit schemes, if borrowers sign a group lending contract with the lender, the entire group will be treated as being in default and will be cut off access to future credit if any member of the group defaults on his repayment, until the defaulter's debt is repaid by his peers. Undoubtedly, the individual's motive to avoid the loss of being denied future credit has much effect on the borrower's behaviour. However, much of the existing literature on group lending has ignored the "non-refinancing threat". Empirical studies do suggest the importance of joint liability (Chowdhury, 2004); nevertheless, joint liability is not the single major mechanism in group lending and there is nothing to suggest that the "non-refinancing threat" is any less important. As a rare exception, Armendáriz de Aghion (1999) has investigated the role of "non-refinancing threat" in mitigating ex-post moral hazard problem and interpreted the "non-refinancing threat" as a punishment imposed on the borrowers who default strategically. The understanding of the role of "non-refinancing threat" in mitigating ex-ante moral hazard will not only allow us to better understand the working of group lending, but also provide guidance for the appropriate design of microcredit programs.

To the author's knowledge, Armendáriz de Aghion and Morduch (2000) and Guttman (2006) are the only few exceptions that have investigated the influence of the "non-refinancing threat" on borrower's ex-ante effort. Armendáriz de Aghion and Morduch (2000) provide a simple outline of the incentive provided by "non-refinancing threat" for a borrower's optimal ex-ante effort under individual liability lending in a "Bolton - Scharfestein" (Bolton and Scharfestein, 1990) framework. Guttman (2006) examines the extent to which "non-refinancing threat" influences the incidence of ex-ante moral hazard with respect to borrower's effort under group lending. Apart from the differences in modelling, the uniqueness with respect to Armendáriz de Aghion and Morduch (2000) and Guttman (2006) in this paper are: (1) this paper develops both individual liability lending model and group lending model and makes a comparative analysis; (2) the main results in Guttman (2006) "can not be established using analytical proofs but only illustrated using numerical simulations " (Guttman, 2006, pp.3), while the theoretical possibilities in this paper are supported by clear-cut analytical proofs; and (3) in Guttman (2006), the individual equilibrium effort under group lending is lower than that under individual liability lending while the repayment rate under group lending is higher than that under individual liability lending. However, this paper finds that: (a) when group members make their effort decisions non-cooperatively, the individual equilibrium effort under group lending is lower than that under individual liability lending, hence mere joint liability and "non-refinancing threat" can not mitigate ex-ante moral hazard; (b) when group members coordinate their effort, the analytical result of the comparison in individual equilibrium effort between group lending and individual liability lending depends on certain conditions; and (c) group lending without peer-cooperation achieves the same repayment performance as individual liability lending; however, group lending with peer-cooperation outperforms individual liability lending in improving repayment performance.

Another famous ex-ante moral hazard model, Banerjee, Besley and Guinnane (1994), has analysed the mechanism of German Credit Cooperatives in the late 1990s and early 2000s. In their model, borrowers are allowed to have assets and only one member is the borrower and the other is the monitor. Hence, the lending is a sequential process within group. Banerjee *et al.* (1994) shows that German Credit Cooperatives create similar incentive structure to group lending which indices monitoring among borrowers. Also, the monitoring member may inflict penalty on the borrowing member in case of default, which is helpful to reduce ex-ante moral hazard.

This paper is an attempt to contribute to the theoretical literature by formalizing the dynamic incentive of "non-refinancing threat". This paper adopts the theoretical frameworks proposed by Stigilitz (1990) and Ghatak and Guinnane (1999) and extends them by constructing a two-period dynamic model which formally characterizes the mechanism of the "non-refinancing threat" that was ignored by Stigilitz (1990), and Ghatak and Guinnane (1999), to investigate whether group lending has advantage of mitigating ex-ante moral hazard and improving repayment performance over individual liability lending. This paper exploits the extent to which joint liability and "non-refinancing threat" mitigate ex-ante moral hazard and makes a comparison in individual equilibrium effort and repayment rate between individual liability lending and group lending.

3 The Individual Liability Lending Model

In order to capture the dynamic incentive of "non-refinancing threat", consider a two-period lending contract with two sets of market participants: a population of borrowers having no initial wealth and saving capacity between periods, and a single outside lender in the community which is referred as a microcredit institution operated by non-government organizations (NGOs, which unusually adopt group-lending in their microcredit schemes).[7] Borrowers have no alternative source of funding except the particular lender. Both borrowers and the lender are risk neutral. Borrowers seek to maximize their expected payoffs and the lender commits to make zero-profit because it represents a non-profit organization.[8] In each period, borrowers are endowed with one unit of labour and a risky production project which requires one unit of labour and one unit of capital to be initiated. Borrowers commit their own labour to their projects and the opportunity cost of the labour is $\hat{u}$. $\hat{u}$ represents the reservation payoff to the borrower and it may be viewed as the return of the borrower's labour from some alternative occupation. At the beginning of each period, a borrower has to borrow one unit of capital with size of L from the lender in order to launch his project and the lender can not require collateral from him. Let ρ denote the lender's opportunity cost of per loan and r denote the exogenously-given gross interest rate (the principal plus net interest) charged by the lender, where $\rho > L$ [9] and $r > L$. Borrowers are assumed to be identical in terms of risk preference, but they can choose their individual effort in undertaking their projecs. With the pre-specified r, a borrower chooses his effort level which we assumed to be equal to $p \in (0,1)$. It is assumed that the borrower's choice of diligence is unobservable to the lender and it is prohibitively costly for the lender to directly monitor the borrower's privately-taken

[7] This two-period game actually is infinitely repeated between the borrowers and the lender.

[8] We assume that the lender commits to make zero-profit so that the incentive for new entry is limited. Ghatak and Gunniane (1999) assume that the lender earns zero profits either by design or by the forces of economic competition. The latter assumption rules out the problems created by monopoly (Armendáriz de Aghion and Morduch, 2005).

[9] The opportunity cost of capital for the lender ρ represents the reservation payoff to the lender and it includes the full cost of raising funds from depositors or other capital-supplying agencies as well as the transaction costs of delivering loans.

actions. The probability of success of a borrower's project is positively determined his effort, p. At the end of each period, a borrower obtains a random project return either $Y > L$ (this outcome is referred as success) with probability p or 0 with probability $(1 - p)$ (this outcome is referred as failure). We assume that Y is positively correlated with the capital invested which is equal to loan size L, i.e. $\frac{\partial Y}{\partial L} > 0$. Exerting effort incurs associated costs. Let $C = \frac{\alpha p^2}{2}$ be the disutility cost of effort, where $\alpha > 0$ is a fixed cost factor. α **measures the marginal cost of effort in undertaking a project.** It is assumed that $Y < \alpha$ because the social surplus $pY - \frac{\alpha p^2}{2}$ is maximized when $p = p^* = \frac{Y}{\alpha}$ (Ghatak and Guinnane, 1999). Assume that all projects are socially productive in terms of expected returns given the opportunity costs of capital and labour, i.e., $pY > \rho + \hat{u}$. Then efficiency requires that all projects should be financed.

Limited liability constraint which arises from the lack of collateral is specified to borrowers: an individual borrower pays his fixed debt obligation r to the lender only when his project succeeds and he pays noting when his project fails. Moreover, the repayment can not exceed the individual's successful realized return of project, i.e., $Y \geq r$. It follows that a successful borrower is always able to repay his debt individual obligation.

At the end of the first period, if a borrower repays his debt obligation, the lender will extend the second-period credit to him (which occurs with probability p). If the borrower fails to repay, the lender will punish him by denying refinancing him (which occurs with probability $1 - p$).

Because the borrower has neither alternative source of funding nor saving capability between periods, in the absence of the second period funding from the lender, his second period project will go unfinanced. Let V denote the discounted value that a borrower can derive from being refinanced. Since this model is restricted to two periods, the lender would stop extending new loans after the second period and the borrower will default on his second period debt obligation with certainty because there is no collateral that the lender can seize. Consequently V represents the borrower's net second-period expected payoff evaluated in the first period. V is lost if the borrower defaults on his first-period loan. $V = \delta(p'Y - \frac{\alpha p'^2}{2})$, where $\delta \in (0,1)$ is the discounted factor which "captures the fact the most people weigh payoffs in the future less than payoffs today" (Armendáriz de Aghion and Morduch, 2005, p123). p' is the borrower's effort in the second period and Y' is the return of his second-period project. Y' is positively correlated with the size of second-period loan, i.e., L'. For simplicity, we assume $L = L'$. Then we have $Y = Y'$. In the second period, the borrower's will choose effort p' to maximize his expected payoff, $U = p'Y - \frac{\alpha p'^2}{2}$. From the first order condition, we get the borrower's equilibrium effort in the second period: $p' = \frac{Y}{\alpha}$. Consequently, $V = \delta(p'Y - \frac{\alpha p'^2}{2}) = \frac{\delta Y^2}{2\alpha}$. One can immediately see that V is positively correlated with Y (and consequently the loan size L).

We rule out the borrower's behaviour of defaulting strategically in the first period: given the realization of the successful project return, a borrower is always willing to make his first-period repayment in order to preserve access to second-period financing. The incentive compatibility constraint (IC) requires that the benefit of defaulting in the first period, i.e., the cost of repaying the first-period loan does not exceed the discounted second-period expected payoff. That is: $V \geq r$, which ensures that a successful borrower would not strategically default on his first-period debt obligation.

The present model focuses on the ex-ante moral hazard in the first period. The sequence of the lending is such that: At the beginning of the first period, the lender offers a lending contract with pre-specified interest rate r to a borrower. Then the borrower takes the loan and chooses effort p in production taking r as given. At the end of the first period, the outcome (success or failure) of the borrower's project is realized. If his project succeeds (which occurs with probability p), the borrower repays the loan and he gets the second-period loan (which occurs with probability p). If his project fails, the borrower pays nothing to the lender and he will lose access to second-period loan. The discounted sum of per period expected payoff to the borrower can be expressed as:

$$U = p(Y - r) + pV - \frac{\alpha p^2}{2}.$$

(1)

In words: p is the borrower's effort level and the probability of success of his first-period project. The borrower's expected payoff is equal to the net return of his first period investment $(Y - r)$ (which is obtained with probability p), plus the discounted value of being refinanced in the second period V (which is obtained only when his first-period project succeeds), less the disutility cost of first-period effort $\frac{\alpha p^2}{2}$.

Since the borrower's effort choice is unobservable to the outsider lender and it is prohibitively costly for the lender to directly monitor the borrower's action, the borrower's choice is subjected to moral hazard. The borrower decides his diligence based on his own private interest, but his choice is not necessary for the best interest of the lender. The borrower may either work hard to obtain a successful project return Y with effort p_1 and cost of effort $C_1 = \frac{\alpha p_1^2}{2}$, or instead, exert less effort and obtain return Y with effort p_2 and cost of effort $C_2 = \frac{\alpha p_2^2}{2}$, where $p_1 > p_2$ and $C_1 > C_2$. Exerting less effort enables the borrower to capture a private benefit $(C_1 - C_2)$ from diverting effort to other private activities, but the borrower's probabilities that his project succeeds and he repays the loan will decrease from p_2 to p_1.

The borrower will work hard only if:

$$p_1(Y - r) + p_1V - \frac{\alpha p_1^2}{2} \geq P_2(Y - r) + p_2V - \frac{\alpha p_2^2}{2}, \tag{2}$$

where

$p_1 > p_2$.

$p_1(Y - r) + p_1V - \frac{\alpha p_1^2}{2}$ is the borrower's discounted sum of per period expected payoff when he chooses to be diligent. $P_2(Y - r) + p_2V - \frac{\alpha p_2^2}{2}$ is his discounted sum of per period expected payoff when he exerts less effort.

Solving (2) yields a relation with respect to interest rate r :

$$r \leq Y + V - \frac{\alpha(p_1 + p_2)}{2}. \tag{3}$$

The inequality $r \leq Y + V - \frac{\alpha(p_1 + p_2)}{2}$ is the borrower's incentive compatibility constraint (IC) for ex-ante effort. When $r \le Y + V - \frac{\alpha(p_1 + p_2)}{2}$, the borrower would have no incentive to be diligent. If the lender wants to reduce this risk, it has to cap the interest rate. It is important to note that the equilibrium gross interest rate r^* must satisfy the lender's zero-profit constraint $pr = \rho$. In a perfect situation, the equilibrium gross interest rate would satisfy both the lender's zero-profit constraint $pr = \rho$ and the borrower's incentive constraint for ex-ante effort $r \le Y + V - \frac{\alpha(p_1 + p_2)}{2}$. When r^* satisfies $pr = \rho$, but not $r \le Y + V - \frac{\alpha(p_1 + p_2)}{2}$, the borrower will tend to exert less effort. Since the lender's probability of suffering from the consequence of default is $(1 - p)$ (note p denotes both the probability of success and the probability of repayment), if the borrower does not work hard, the lender will bear higher probability of default. Then the borrower's effort choice will be negative to the best interest of the lender. In this situation, the lender may have to stop lending to the borrower, which is ex-ante inefficient. Suppose the borrower can offer wealth w as collateral. The lender would seize w in the event that the borrower fails in his project and now the effort incentive constraint for the borrower is:

$$p_1(Y - r) + p_1V - \frac{\alpha p_1^2}{2} + (1 - p_1)(-w) \ge p_2(Y - r) + p_2V - \frac{\alpha p_2^2}{2} + (1 - p_2)(-w), \tag{4}$$

where

$p_1 > p_2$

Solving this equation yields a relation with respect to interest rate r :

$$r \le Y + V - \frac{\alpha(p_1+p_2)}{2} + w. \tag{5}$$

The intuition behind $r \le Y + V - \frac{\alpha(p_1+p_2)}{2} + w$ is that if the borrower provides collateral, the lender can charge gross interest rate higher than that when collateral is unavailable. If the collateral $w > \rho$, the lender would be able to charge interest rates high enough without worrying about the behaviour of shirking. The threat of "losing collateral" makes it more "costly" for a borrower to shirk. The ex-ante inefficient situation mentioned above might be avoided since the existence of collateral relaxes the borrower's incentive constraint for ex-ante effort. However, in many developing countries, "limited wealth, limited property and poorly functioning legal system combine to reduce the possession of collateralizable assets" (Bond and Rai, 2002, pp.1). Then the lender has no way to force the borrower to exert requisite effort and it goes into a "negative cycle" (Armendáriz de Aghion and Morduch, 2005)——if it raises interest rate, the borrower may shirk; but if it does not raise interest rate, it may not cover its gross cost. The problem is that the lender can not observe the behaviour (actions or decisions) of a borrower because of the imperfect information[10] and/or the lender can not force the borrower to work hard because of the limited liability (individual loan without collateral). The result is that the lender may suffer higher probability of default.

Now we compute the individual equilibrium effort under individual liability lending. Taking r as

[10] If the lender has perfect information about the borrower's choice of diligence, i.e., $p = p^* = Y/\alpha$, it can set the gross interest rate at $r - (\rho / p^*)$; however, when the lender can not observe the borrower's action, the choice of interest rate r is subject to moral hazard (Ghatak and Guinnane, 1999).

given, a borrower chooses p so as to maximize his private expected payoff:

$$\max_{p} U = p(Y - r) + pV - \frac{\alpha p^2}{2}. \tag{6}$$

From the first order condition with respect to p, we obtain the equilibrium effort level:

$$p = \frac{Y - r + V}{\alpha}. \tag{7}$$

The partial derivative of the equilibrium effort p with respect to the discounted value of accessing to second-period loan is $\frac{\partial p}{\partial V} = \frac{1}{\alpha} > 0$, which implies that the discounted value of accessing second-period loan V (and then loan size L) has positive effect on the borrower's effort. The intuition is simple: the bigger the expected revenue of second-period loan, the bigger the effort the borrower will exert in the first period. Increasing loan size L will increase Y, i.e., the return of the project in second period (if the projects succeeds) and consequently V, and then the borrower's incentive to exert effort.

Note that the interest rate r that is derived from $p = \frac{Y - r + V}{\alpha}$ is $r = Y + V - \alpha p$. Substituting $r = Y + V - \alpha p$ into the lender's break-even condition $pr = \rho$, we get a quadratic equation in $p : \alpha p^2 - p(Y + V) + \rho = 0$. Solving for p yields two equilibrium values:

$$p_1^* = \frac{Y + V + \sqrt{(Y + V)^2 - 4\alpha\rho}}{2\alpha} \tag{8-1}$$

and

$$p_2^* = \frac{Y + V - \sqrt{(Y + V)^2 - 4\alpha\rho}}{2\alpha}. \tag{8-2}$$

We assume the higher value of p is chosen, since "the lender is different and the borrower is strictly better off' (Ghatak and Guinnane, 1999, p203). Then under individual liability lending, the optimal effort that a borrower will exert is:

$$p^*_{(I)} = \frac{Y + V + \sqrt{(Y + V)^2 - 4\alpha\rho}}{2\alpha}.$$

4. The Group Lending Model

This section develops the group lending model. For simplicity, we restrict the model to group involving two members who are jointly liable for the group loan. The group lending model is built in the environment where the actions taken by the borrower are unobservable to the lender and it is prohibitively costly for the lender to directly monitor the borrower's actions. However, borrowers can "observe each other' actions perfectly and costlessly, as well as enforce any agreement regarding their (effort) levels" (Stiglitz 1990, in Ghatak and Guinnane, 1999, pp.11). A group lending contract is described as (R, A), where R is the gross interest rate and $A \in (0, R]$ is the joint liability payment, i.e., the portion of the debt obligation of the failed member that the successful one is liable for. A is decided by the lender and it measures the degree of joint liability. When one borrower succeeds while his partner fails, the former's debt obligations include the individual liability component R and an additional joint liability component A.

Again, limited liability constraint is specified to borrowers: in case of success, the sum of individual liability payment R and joint liability payment A can not exceed the individual's successful realized return of the project, i.e., $Y \geq R + A$. It follows that a borrower is always able to repay the group debt if his project succeeds.

The lender will withhold the second-period loan from the group in case of collective default in the first period, i.e., in case that the entire first-period group debt is not totally repaid. We rule out borrower's behaviour of defaulting strategically in the first period, i.e., borrowers within a group always prefer to repay the group debt in order to preserve the access to second-period financing. Under group lending contract, the benefit of defaulting is the individual debt obligation (in case that both members succeed) or the individual debt obligation plus joint liability payment (in case that the partner fails). The incentive compatibility constraint (IC) condition is $V \geq R + A$, which ensures that a successful borrower would not default on his first-period debt obligation (in case that the partner succeeds) and the first-period group debt obligation (in case that his partner fails).

4.1. Group lending in a non-cooperative game

First consider the case that the two members act non-cooperatively in their effort decisions, i.e., the two members choose effort levels independently. Suppose one member chooses effort p and the other chooses effort p'. The discounted sum of per period expected payoff to the borrower who chooses p is:

$$U_{pp'}(R, A) = pp'(Y - R) + p(1 - p')(Y - R - A) + [1 - (1 - p)(1 - p')] \times V - \frac{\alpha p^2}{2}$$

$$= p[Y - R - (1 - p') \times A] + [1 - (1 - p)(1 - p')] \times V - \frac{\alpha p^2}{2}. \tag{9}$$

In words, the expected payoff to the borrower who chooses p when his partner chooses p' is equal to the expected return obtained when both of them succeed, $pp'(Y - R)$, plus the expected return obtained when he succeeds while his partner fails, $p(1 - p')(Y - R - A)$, plus the discounted value that he can derive from being refinanced, V, which occurs with probability $[1 - (1 - p)(1 - p')]$,[11] less the disutility cost of his effort, $\frac{\alpha p^2}{2}$.

Given the partner's choice of p', the borrower chooses p so as to maximize his private expected payoff:

$$\max_{p} U_{pp'}(R, A) = p[Y - R - (1 - p') \times A] + [1 - (1 - p)(1 - p')] \times V - \frac{\alpha p^2}{2}. \tag{10}$$

From the first order condition with respect to p, we get his equilibrium effort:

$$p = \frac{Y - R - (1 - p')A + (1 - p')V}{\alpha} = \frac{Y - R}{\alpha} + \frac{(1 - p')(V - A)}{\alpha}. \tag{11}$$

Notice that $p = \frac{Y - R}{\alpha} + \frac{(1 - p')(V - A)}{\alpha}$ is a symmetric Nash equilibrium.[12] We obtain:

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[11] $[1 - (1 - p_{,})(1 - p_{,})]$ implies that at least one project succeeds. Note that the model is restricted to "subgame perfect equilibria where neither of the two borrowers default strategically" (Armendáriz de Aghion, 1999, pp.83).

[12] From the expected payoff of the borrower who chooses p':

$U_{pp'}(R, A) = p[Y - R - (1 - p') \times A] + p[1 - (1 - p)(1 - p')] \times V - \frac{\alpha p^2}{2}$, we can derive the equilibrium effort level p' that maximizes $U_{p'p}(R, A)$:

$$p = p' = \frac{Y - R + V - A}{\alpha + V - A}. \quad (12)$$

Note that $p = \frac{Y - R}{\alpha} + \frac{(1 - p')(V - A)}{\alpha}$ is the borrower's reaction function on his partner's action. From $p = \frac{Y - R}{\alpha} + \frac{(1 - p')(V - A)}{\alpha}$, we can deduce the partial derivative of the borrower's equilibrium effort p with respect to his partner's choice of p':

$$\frac{\partial p}{\partial p'} = \frac{A - V}{\alpha} < 0.$$

(13)

(13) implies that when group members act non-cooperatively in their effort decisions, the less effort his partner exerts, the more effort the borrower will exert. Or, alternatively, the more effort his partner exerts, the less effort the borrower will exert. If the initial effort levels of the two members are not at the equilibrium level, the game of effort choice is not stable and both members will choose another effort level as a reaction taking his partner's action as given. Then a series of reaction and counter-reaction on effort will happen. Finally, the game of reaction and counter-reaction leads to a stable equilibrium.

Now we compute the equilibrium value of individual effort under group lending without peer-cooperation in effort decisions. From $p = \frac{Y - R + V - A}{\alpha + V - A}$, we derive the gross interest rate $R : R = Y + V - A - p(\alpha + V - A)$.

Substituting $R = Y + V - A - p(\alpha + V - A)$ into the lender's zero-profit condition under group lending: $pR + p(1 - p)A = \rho$, we get the quadratic equation in p:

$$(\alpha + V)p^2 - p(Y + V) + \rho = 0.$$

Solving for p yields two equilibrium values:

$$p_1^* = \frac{Y + V + \sqrt{(Y + V)^2 - 4(\alpha + V)\rho}}{2(\alpha + V)} \quad (14\text{-}1)$$

and

$$p_2^* = \frac{Y + V - \sqrt{(Y + V)^2 - 4(\alpha + V)\rho}}{2(\alpha + V)}.$$

(14-2)

$$p' = \frac{Y - R}{\alpha} + \frac{(1 - p)(V - A)}{\alpha} \Leftrightarrow p' - \frac{(1 - p)(V - A)}{\alpha} = \frac{Y - R}{\alpha}.$$

From (11), we get $p - \frac{(1 - p')(V - A)}{\alpha} = \frac{Y - R}{\alpha}$.

Then we get an equation $p' - \frac{(1 - p)(V - A)}{\alpha} = p - \frac{(1 - p')(V - A)}{\alpha}$ from which we can derive:

$$p' - p = \frac{(p - p')(V - A)}{\alpha}.$$

Since $V > \alpha$, we get $p = p'$.

In line with the analysis, we assume $p_1^* = \dfrac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)}$ is chosen.

Then under group lending without peer-cooperation in effort decisions, the borrower's optimal effort is:

$$p^*_{(G-N)} = \frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)}.$$

Comparing $p^*_{(G-N)} = \dfrac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)}$ with the individual equilibrium effort under individual liability lending $p^*_{(I)} = \dfrac{Y+V+\sqrt{(Y+V)^2-4\alpha\rho}}{2\alpha}$, we immediately see that the denominator of the group lending expression is bigger than that of individual liability lending expression, while the numerator of the group lending expression is smaller than that of individual liability lending expression. Then the individual equilibrium effort under group lending without peer-cooperation in effort decisions is lower than that under individual liability lending, i.e., $p^*_{(G-N)} < p^*_{(I)}$.

This result can be explained as that:

In individual liability lending, the borrower's action in effort choice is affected by the "non-refinancing threat", however, in group lending the borrower's action in effort choice is affected by the mix of joint liability payment and "non-refinancing threat". We have known that under individual liability lending, the slope of borrower's reaction function on V is $1/\alpha$. In what follows we will examine the summing effect of joint liability payment A and the discounted value of accessing second-period's loan V (and then the loan size L) on the borrower's equilibrium effort in group lending without peer-cooperation in effort decisions.

Deducing the partial derivative of the individual equilibrium effort p with respect to joint liability payment A from $p = \dfrac{Y-R+V-A}{\alpha+V-A}$ yields:

$$\frac{\partial p}{\partial A} = \frac{\partial\left(\frac{Y-R+V-A}{\alpha+V-A}\right)}{\partial A} = \frac{Y-R-\alpha}{(\alpha+V-A)^2}. \tag{15}$$

Note that as has been assumed, $Y < \alpha$. We have $\dfrac{\partial p}{\partial A} = \dfrac{Y-R-\alpha}{(\alpha+V-A)^2} < 0$.

$\dfrac{\partial p}{\partial A} < 0$ implies that joint liability payment A has negative effect on borrower's equilibrium effort, i.e., increasing A will decrease borrower's equilibrium effort. It follows that joint liability itself has no information advantage of mitigating ex-ante moral hazard; instead, it exacerbates the ex-ante moral hazard problem. The intuition behind this result is: the bigger the joint liability payment, the bigger debt obligation a borrower has to transfer to his partner when he succeeds while his partner fails, i.e., the bigger the joint liability payment, the bigger the expected cost of repaying for his failed partner in case of success of his own project.

We further examine the effect of the discounted value of accessing second-period loan V on borrower's equilibrium effort. Deducing the partial derivative of the individual equilibrium effort p with respect to the discounted value of accessing second-period loan V yields:

$$\frac{\partial p}{\partial V} = \frac{\partial\left(\frac{Y - R + V - A}{\alpha + V - A}\right)}{\partial V} = \frac{\alpha - Y + R}{(\alpha + V - A)^2}.$$

(16)

One can see immediately that $\frac{\partial p}{\partial V} > 0$. It follows that the discounted value of accessing second-period loan V (and then loan size L) has positive effect on borrower's equilibrium effort.

Note that the absolute value of the borrower's reaction function with respect to A is $\left|\frac{\partial p}{\partial A}\right| = \frac{\alpha - Y + R}{(\alpha + V - A)^2}$ and the absolute value of the borrower's reaction function with respect to V is $\left|\frac{\partial p}{\partial V}\right| = \frac{\partial p}{\partial V} = \frac{\alpha - Y + R}{(\alpha + V - A)^2}$. Then we have $\frac{\partial p}{\partial V} = -\frac{\partial p}{\partial A}$. The intuition behind $\frac{\partial p}{\partial V} = -\frac{\partial p}{\partial A}$ is that under group lending, joint liability and "non-refinancing threat" work simultaneously on borrower's effort and their effects are offset. However, under individual liability lending, "non-refinancing threat" has positive effect on borrower's effort. Then the individual equilibrium effort under individual liability lending is higher than that under group lending without peer-cooperation in effort decisions. Proposition 1 summarizes the above finding:

PROPOSITION 1: *If the two members act non-cooperatively in their effort decisions, group lending can not mitigate ex-ante moral hazard problem.*

Although Ghatak and Guinnane (1999) claim that when group members decide their effort level non-cooperatively, group lending can not alleviate ex-ante moral hazard; their model shows that the individual equilibrium effort under group lending is the same as that under individual liability lending. Because their static model does not incorporate the dynamic "non-refinancing threat", to some extent, the analytical result of their model is misleading.

Notice that under individual liability lending, the slope of borrower's reaction function on V is $1/\alpha$ and under group lending without peer-cooperation, the slope of borrower's reaction function on V is $\frac{\partial p}{\partial V} = \frac{\alpha - Y + R}{(\alpha + V - A)^2}$, we can establish the following property:

PROPOSITION2. *Given the same increase in discounted value of accessing second-period loan,* V, *individual liability lending induces higher effort than group lending without peer-cooperation in effort decisions.*

PROOF: See Appendix 1

Although the practitioners of group-based microcredit programs have translated directly "non-refinancing threat" from individual liability lending to group lending practice, it should be noted that the "non-refinancing threat" under group lending without peer-cooperation is not as effective as that under individual liability lending.

4.2. Group lending in a cooperative game

Now we present the argument of group lending with peer-cooperation in effort decisions. We assume borrowers can perfectly and costlessly observe each other's actions as well as enforce any sub-contract between them (Stiglitz, 1990). When the two members coordinate their effort decisions, i.e., they choose the same effort level and behave as a single entity to maximize their group surplus, each member's expected payoff is:

$$U_{pp} = p[Y - R - (1-p) \times A] + [1 - (1-p)(1-p)] \times V - \frac{\alpha p^2}{2}. \tag{17}$$

From the first order condition with respect to p, we know that when a borrower chooses:

$$p = \frac{Y - R - A + 2V}{\alpha + 2V - 2A}, \tag{18}$$

his private expected payoff is maximized. Note that the partial derivative of the borrower's equilibrium effort with respect to V is:

$$\frac{\partial p}{\partial V} = \frac{2[(\alpha + 2V - 2A) - (Y - R - A + 2V)]}{(\alpha + 2V - 2A)^2} = \frac{2(\alpha - A - Y + R)}{(\alpha + 2V - 2A)^2} > 0.$$

It follows that "non-refinancing threat" has positive effect on borrower's diligence.

The partial derivative of the borrower's equilibrium effort with respect to A is:

$$\frac{\partial p}{\partial A} = \frac{2Y - 2R + 2V - \alpha}{(\alpha + 2V - 2A)^2} = \frac{2\alpha Y - 2\alpha R + \delta Y^2 - \alpha^2}{\alpha(\alpha + 2V - A)^2}. \quad \text{(Note that } V = \frac{\delta Y^2}{2\alpha}.\text{)}$$

The sign of $\frac{\partial p}{\partial A}$ is ambiguous and it depends on the sign of $2\alpha Y - 2\alpha R + \delta Y^2 - \alpha^2$.

It follows that the borrower's project return Y (and consequently the loan size L), loan term (which affects the discounted factor δ) and the pre-specified interest rate R decide the (positive or negative) effect of the joint liability payment A on the borrower's equilibrium effort. The practical implication of this result is that the lender can pre-specify the appropriate loan size L, interest rate R and loan term, when group members work cooperatively, and such that make $\frac{\partial p}{\partial A} > 0$.

If $2Y - 2R + 2V - \alpha < 0$, we have $\left|\frac{\partial p}{\partial A}\right| = \frac{\alpha + 2R - 2Y - 2V}{(\alpha + 2V - 2A)^2}$.

Notice that $\left|\frac{\partial p}{\partial V}\right| = \frac{2\alpha - 2Y + 2R - 2A}{(\alpha + 2V - 2A)^2}$. We have:

$\frac{\partial p}{\partial V} > \left|\frac{\partial p}{\partial A}\right|$, i.e., $\frac{\partial p}{\partial V} + \frac{\partial p}{\partial A} > 0$.

If $2Y - 2R + 2V - \alpha > 0$, apparently, $\frac{\partial p}{\partial V} + \frac{\partial p}{\partial A} > 0$.

It follows that summing effect of "non-refinancing threat" and joint liability on borrower's effort is positive.

From (18), we can derive the gross interest rate $R = Y - A + 2V - p(\alpha + 2V - 2A)$. Substituting $R = Y - A + 2V - p(\alpha + 2V - 2A)$ into the lender's zero-profit condition $pR + p(1-p)A = \rho$, we get the quadratic equation in p:

$$(\alpha + 2V - A)p^2 - p(Y + 2V) + \rho = 0.$$

Solving for p, we get two equilibrium values of p:

$$p_1^* = \frac{Y + 2V + \sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}}{2(\alpha + 2V - A)} \tag{19-1}$$

and

$$p_2^* = \frac{Y + 2V - \sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}}{2(\alpha + 2V - A)}. \tag{19-2}$$

In line with the analysis, $p_1^* = \frac{Y + 2V + \sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}}{2(\alpha + 2V - A)}$ is chosen.

Then when the two members coordinate their effort, the borrower's optimal effort is:

$$p^*_{(G-C)} = \frac{Y + 2V + \sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}}{2(\alpha + 2V - A)}.$$

We establish the following propositions.

PROPOSITION 3. *The individual equilibrium effort under group lending with peer-cooperation in effort decisions,* $p^*_{(G-C)}$*, is higher than that under group lending without peer-cooperation,* $p^*_{(G-N)}$.

PROOF: See Appendix 2.

This proposition reveals that group lending with peer-cooperation outperforms group lending without peer-cooperation in mitigating ex-ante moral hazard.

PROPOSITION 4. *When the individual equilibrium effort under individual liability lending,* $p^*_{(I)}$*, is lower than* $\frac{\delta Y^2}{2(\delta Y^2 - \alpha A)}$*, the individual equilibrium effort under group lending with peer-cooperation in effort decisions,* $p^*_{(G-C)}$*, is higher than* $p^*_{(I)}$*; when* $p^*_{(I)} > \frac{\delta Y^2}{2(\delta Y^2 - \alpha A)}$, $p^*_{(G-C)} > p^*_{(I)}$*; when* $p^*_{(I)} = \frac{\delta Y^2}{2(\delta Y^2 - \alpha A)}$, $p^*_{(G-C)} = p^*_{(I)}$.

PROOF: See Appendix 3.

It follows that the borrower's project return Y (and then the loan size L), joint liability payment A, the pre-specified interest rate R and the loan term is crucial to the result of the comparison in individual equilibrium effort between individual liability lending and group lending with peer cooperation, and the result of the analysis that relative to individual liability lending, whether group lending has information advantage of mitigating ex-ante moral hazard.

REMARK on proposition 4, as well as the analytical result of $\frac{\partial p}{\partial A}$ under group lending with peer-cooperation:

The practical implication of proposition 4 is that practitioners of group-based microcredit programs can pre-specify the appropriate loan size L, interest rate R and loan term, and such that keep the information advantage of group lending with peer cooperation over individual liability lending in terms of mitigating ex-ante moral hazard. Although the result in this model is established by using analytical proofs, it can be illustrated by using numerical simulations. Numerical simulation is helpful for the practitioners to specify the appropriate values of loan size L, interest rate R and loan term and numerical simulations of the analytical results of this paper can be viewed as one of the avenues for future research.

5. The Relative Repayment Performance of Group Lending compared to Individual Liability Lending

Under individual liability lending, the borrower pays his fixed individual debt obligation to the lender only when his project succeeds and he pays noting when his project fails. However, under group lending with joint liability, group members are mutually liable for each other's repayments. Making a comparison in repayment rate between individual liability lending and group lending, we establish proposition 5.

PROPOSITION 5. *Group lending without peer-cooperation in effort decisions achieves the same repayment rate as individual liability lending, but group lending with peer-cooperation outperforms individual liability lending in improving repayment performance.*

PROOF: See Appendix 4.

Although group lending may not have the advantage of overcoming ex-ante moral hazard, it achieves at least the same repayment rate as individual liability lending. The intuition of this efficiency advantage is that group members are mutually responsible for each other's repayments. This efficiency advantage is important for the design of microcredit programs, because the purpose of theorists and practitioners is to find an efficient and sustainable alternative for making productive credit accessible and beneficial to the poor, when they recognized the failure of conventional form of lending to the poor, especially the poor repayment performance of the conventional subsidized credit programs.[13]

REMARK on propositions of 1, 3, 4 and 5:

The repayment rate under group lending is at least the same as that under individual liability lending; even the individual equilibrium effort level under group lending may be lower than that under individual liability lending. Group lending with peer-cooperation in effort decisions is preferable to that without peer-cooperation for its information advantage of mitigating ex-ante moral hazard and efficiency advantage of improving repayment performance, and it outperforms individual liability lending in encouraging repayment.

However, the above analytical results are established on the strong assumption that borrowers can "observe each other' actions perfectly and costlessly, as well as enforce any agreement regarding their (effort) levels" (Stiglitz 1990, in Ghatak and Guinnane, 1999, pp.11). This assumption is away form peer monitoring and peer penalty (Itoh, 1993 and Varian, 1990, in Laffont and Rey 2003). In another paper "Ex-ante Moral hazard, Peer Monitoring and Group Lending" (Zhang, 2008), the author extends the present model to a more realistic scenario inclusive of (costly) peer monitoring and social sanctions. That paper first presents the condition under which the group members will act cooperatively rather than non-cooperatively. It further reveal that a borrower's choice of effort under group lending is affected by a mix of joint liability, "non-refinancing threat", peer monitoring and social sanctions: peer monitoring intensity, "non-refinancing threat" and social sanctions have positive impact on borrower's diligence; while the degree of joint liability has negative impact on borrower's diligence. A borrower's monitoring effort is affected by a mix of joint liability, "non-refinancing threat", peer diligence and social sanctions: "non-refinancing threat", peer diligence and social sanctions have negative impact on

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[13] It was reported that the repayment rates of subsidized credit programs were well below 50% (Braverman and Guasch, 1992, in Armendáriz de Aghion and Morduch, 2005; Murdoch, 1999).

borrower's monitoring effort; while the degree of joint liability has positive impact. When taking account of the lender's objective of maximizing expected repayment revenue subject to its zero-profit constraint, we find that full joint liability is optimal. Given full joint liability to borrowers, there exists an optimal peer monitoring intensity which satisfies the borrower's incentive compatibility constraint that guarantees that borrowers would not deviate from the coordinated decision of diligence, and the borrower's incentive compatibility constraint that guarantees that borrowers would make requisite monitoring effort.

6. Conclusions

This paper is motivated by the group lending literature and the purpose of this paper is to construct a theoretical framework capable of partly explaining the success of group lending with respect to its beautiful repayment performance. Highlighting this point is vital for the development of microcredit programs. The vast majority of the existing literature on group lending has taken the hypothesis that group lending has advantage of mitigating ex-ante moral hazard over individual liability lending. However, most of the literature has ignored the dynamic incentive of "non-refinancing threat". This paper develops a dynamic model formalizing the "non-refinancing threat" and the results of the model reveal that: (1) when group members make effort decisions non-cooperatively, the individual equilibrium effort under group lending is lower than that under individual liability lending, hence mere joint liability and "non-refinancing threat" can not mitigate ex-ante moral hazard problem; (2) when group members coordinate effort, the analytical result of the comparison in the individual equilibrium effort between group lending and individual liability lending depends on certain conditions; and (3) group lending without peer-cooperation achieves the same repayment performance as individual liability lending; however, group lending with peer-cooperation outperforms individual liability lending in encouraging repayment.

This paper has partly explored the advantages of group lending in a dynamic context, which contributes to the group lending literature. But some reservation can be made with respect to the main conclusions and there are many directions to which this analysis can be extended.

Firstly, although maintaining access to future credit is a strong incentive for repayment, the "non-refinancing threat" works only when borrowers value such refinancing. Progressive lending seems to be a possible way of enhancing such incentive since the growing size of loan will increase the value of future credit. But in practice, joint liability imposes a constraint on loan size, since the growing loan size may increase the individual borrower's difficulty in paying the collective debt (Morduch, 1999). Some current policies advocate that microcredit should be made more competitive (Bond and Rai, 2002), but competition will reduce the power of "non-refinancing threat" from the particular lender. Such a problem has been felt by the Bank Rakyat Indonesia and Bancosol, Bolivia (Morduch, 1999). Morduch (1999) also suggests that the dynamic incentive will work better in areas with low mobility to avoid a "debtor run" (Bond and Rai, 2002) and particularly, there should be substantial uncertainty about the end date of the program or "graduation" from one program to the next is well established, since a clear end will give incentive to borrowers to default. In addition, if the threat of cutting off access to future credit is not credibly carried out, most of the incentive power of such mechanism will lose. However, the credible terminating future credit to all members of the group may hurt the benefits of the lender. Moreover, the denial of credit is subject to adverse selection: the lender does not know actually how much a borrower values the access to future credit (Bond and Rai, 2002).

Secondly, this paper shows that compared to individual liability lending contract, group lending contract yields higher repayment rate and thus enhances efficiency. This result holds when all borrowers apply——which allows for adverse selection——and a successful borrower is always able and wiling to repay individual debt obligation as well as joint liability payment in the event that his partner fails. However, loan repayment is also subject to ex-post moral hazard and a substantive theoretical work has addressed this subject (e.g. Besley and Coate, 1995; Armendáriz de Aghion, 1999). In addition, although there is clear evidence that joint liability and "non-refinancing threat" have improved repayment, their effect should not be exaggerated. "Group Lending" is not the only instrument employed by microcredit institutions. "Progress Lending" [14] (Hulme and Mosley, 1996, in Morduch, 1999) or "Step Lending" (ACCION network, in Morduch, 1999), regular repayment schedules, collateral substitutes, sequential lending within group and "targeting on women" are also used to maintain high repayment rates. [15] Some microcredit programs that adopt individual liability lending, such as the Bank Rakyat Indonesia, the Bank Kredit Deas of Indonesia and the village banks started by the Foundation for International Community Assistance (FINCA), have also achieved high repayment rates (Morduch, 1999).

Thirdly, the present model is based on some simplifying assumptions and it is some interest to know the extent to which the results in this paper maintain given more general economic environment——for example, if we allow for variable group size rather than arbitrary group size. We have assumed that a single borrower can repay the collective debt if needed; however, increasing group size will put a limitation on joint liability share. The relative effectiveness of large group size and small joint liability share remains to be formally analyzed. In addition, in this paper the borrower's probability of success is exogenously given. The problem would be more complicated and more interesting if we introduce a more general correlation structure in the outputs of projects across borrowers. Moreover, the availability of outside additional credit is also worth analyzing. Ahlin and Townsend (2007a) have made some pioneering explorations in this subject.

Fourthly, peer monitoring is lively discussed in microcredit literature. Some papers (e.g. Banerjee, Besley and Guinnane, 1994; Ghatak and Guinnane, 1999) argued that lending efficiency is enhanced when borrowers mutually observe each other's actions and impose social sanctions on those who shirk. However, a dilemma arises when the advantage of peer monitoring is counteracted by borrowers' collusion. Although group lending contract can provide monitoring incentives when monitoring partner's effort incurs a cost, it will become ineffective when the cost of monitoring is too high. It is interesting to analyze what will happen if the cost of monitoring rises so high that the borrower's participation constraint is not satisfied.[16]

Finally, despite being an academic-debate concerning, the relative performance of group lending versus individual liability lending has been seldom explored by empirical literature. The reason may be that because in practice most microcredit institutions use only one lending method, e.g., group lending under Grameen bank in Bangladesh and individual liability lending under BRI in Indonesia, the unobserved characteristics in different contexts which influence microcredit institution's choices make it hard to

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[14] The loan transaction begins by lending in small loan size and then loan size will be increased upon satisfactory repayment.

[15] Armendáriz de Aghion and Morduch (2005), Ghatak and Guinnane (1999) and Morduch (1999) have surveyed the functioning of alternative mechanisms except sequential lending within group. Chrowdhury (2004), Aniket (2007) and Cason, *et al.* (2007) have investigated the relative advantage of sequential versus simultaneous lending within group with respect to providing borrowers with appropriate incentive to undertake monitoring effort.

[16] Some recent papers have argued that sequential lending within group can be an instrument to resolve the problem of borrowers' collusion in monitoring (See Chowdury, 2004; Cason, *et al.*, 2007).

conduct cross-section study (Giné and Karlan, 2006). Although there are few exceptions (e.g. Giné and Karlan, 2006; Ahlin and Townsend, 2007a and 2007b), for most of the part, only particular programs are studied. Theoretical propositions are needed to be examined by empirical regularities rather than particular programs.

Appendix

Appendix 1: Proof for Proposition 2

We build a function $F(x) = \frac{1}{\alpha} - \frac{\alpha - Y + R}{(\alpha + V - x)^2}$, where $0 < x < V$.

The partial derivative of $F(x)$ with respect to x is $\frac{\partial F(x)}{\partial x} = \frac{-2(\alpha - Y + R)}{(\alpha + V - x)^3} < 0$.

Then $F(x) = \frac{1}{\alpha} - \frac{\alpha - Y + R}{(\alpha + V - x)^2}$ is decreasing with x.

Suppose that $F(x) = \frac{1}{\alpha} - \frac{\alpha - Y + R}{(\alpha + V - x)^2} = 0$. The particular value of x which satisfies:

$\frac{1}{\alpha} - \frac{\alpha - Y + R}{(\alpha + V - x)^2} = 0$ is $x^* = \alpha + V - \sqrt{\alpha(\alpha - Y + R)}$.

(Note that:

$\frac{1}{\alpha} - \frac{\alpha - Y + R}{(\alpha + V - x)^2} = 0 \Leftrightarrow (\alpha + V - x) = \sqrt{\alpha(\alpha - Y + R)}$ (note $\alpha + V - x > 0$)

$\Leftrightarrow (\alpha + V - x) = \sqrt{\alpha(\alpha - Y + R)}$, i.e., $x^* = (\alpha + V - \sqrt{\alpha(\alpha - Y + R)}$.)

Suppose that $R < \alpha + V - \sqrt{\alpha(\alpha - Y + R)}$, i.e., $\sqrt{\alpha(\alpha - Y + R)} < \alpha + V - R$.

$\sqrt{\alpha(\alpha - Y + R)} < \alpha + V - R$ can be re-arranged into $(\alpha + V - R)^2 > \alpha(\alpha - Y + R)$.

To prove $R < \alpha + V - \sqrt{\alpha(\alpha - Y + R)}$, we need to prove $(\alpha + V - R)^2 > \alpha(\alpha - Y + R)$.

Notice that $V \geq R + A$ and $Y > R + A$. We have:
$(\alpha + V - R) > \alpha$ and $(\alpha + V - R) > (\alpha - Y + R)$.
Then $(\alpha + V - R)^2 > \alpha(\alpha - Y + R)$.

It follows that $R < \alpha + V - \sqrt{\alpha(\alpha - Y + R)}$ is proven.

Notice that $F(x) = \frac{1}{\alpha} - \frac{\alpha - Y + R}{(\alpha + V - x)^2}$ is decreasing with x. We have:

$F(A) > F(x^*)$, where $A \in (0, R]$ and $x^* = \alpha + V - \sqrt{\alpha(\alpha - Y + R)}$ (note $R < x^*$).

Since $F(x^*) = F[\alpha + V - \sqrt{\alpha(\alpha - Y + R)}] = 0$, we have $F(A) > 0$, i.e.,

$$\frac{1}{\alpha}-\frac{\alpha-Y+R}{(\alpha+V-A)^2}>0 \Leftrightarrow \frac{1}{\alpha}>\frac{\alpha-Y+R}{(\alpha+V-A)^2}.$$

Note that $\frac{1}{\alpha}$ ($\frac{1}{\alpha}>0$) is the slope of borrower's reaction function on V under individual liability lending and $\frac{\alpha-Y+R}{(\alpha+V-A)^2}$ ($\frac{\alpha-Y+R}{(\alpha+V-A)^2}>0$) is borrower's reaction function on V under group lending without peer-cooperation in effort decisions. The implication of $\frac{1}{\alpha}>\frac{\alpha-Y+R}{(\alpha+V-A)^2}$ is that the same increase in V induces higher borrower's effort under individual liability lending than under group lending without peer-cooperation in effort decisions. The reason for this result is that joint liability payment A has negative effect on the borrower's equilibrium effort.

Appendix 2: Proof for Proposition 3

We build a new function:

$$p(x)=\frac{Y+x+\sqrt{(Y+x)^2-4(\alpha+x)\rho}}{2(\alpha+x)}, \text{ where } x\in[0,2V].$$

The partial derivative of $p(x)$ with respect to x is:

$$\frac{\partial p(x)}{\partial x}=\frac{(\alpha+x)\sqrt{(Y+x)^2-4(\alpha+x)\rho}+(\alpha+x)(Y+x-2\rho)}{2(\alpha+x)^2\sqrt{(Y+x)^2-4(\alpha+x)\rho}}$$

$$-\frac{(Y+x)\sqrt{(Y+x)^2-4(\alpha+x)\rho}+(Y+x)^2-4(\alpha+x)\rho}{2(\alpha+x)^2\sqrt{(Y+x)^2-4(\alpha+x)\rho}}.$$

Notice that:

$$(\alpha+x)\sqrt{(Y+x)^2-4(\alpha+x)\rho}+(\alpha+x)(Y+x-2\rho),$$

$$-(Y+x)\sqrt{(Y+x)^2-4(\alpha+x)\rho}-(Y+x)^2+4(\alpha+x)\rho$$

$$=(\alpha-Y)\sqrt{(Y+x)^2-4(\alpha+x)\rho}+(\alpha-Y)(Y+x)+2(\alpha+x)\rho>0.$$

We have $\frac{\partial p(x)}{\partial x}>0$. Then the value of $p(x)$ is increasing with x. Consequently we have $p(2V)>p(V)$.

$$p(V)=\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)}=p^{*}_{(G-N)}$$

$$p(2V)=\frac{Y+2V+\sqrt{(Y+2V)^2-4(\alpha+2V)\rho}}{2(\alpha+2V)}.$$

Notice that:

$$p^{*}_{(G-C)}=\frac{Y+2V+\sqrt{(Y+2V)^2-4(\alpha+2V-A)\rho}}{2(\alpha+2V-A)}$$

$$> \frac{Y + 2V + \sqrt{(Y + 2V)^2 - 4(\alpha + 2V)\rho}}{2(\alpha + 2V)} = p(2V).$$

We have $p^*_{(G-C)} > p^*_{(G-N)}$, i.e., the borrower's equilibrium effort under group lending with peer-cooperation in effort decisions is higher than that under group lending without peer-cooperation in effort decisions.

Appendix 3: Proof for Proposition 4

$$p^*_{(G-C)} = \frac{Y + 2V + \sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}}{2(\alpha + 2V - A)},$$

$$p^*_{(I)} = \frac{Y + V + \sqrt{(Y + V)^2 - 4\alpha\rho}}{2\alpha}.$$

$$\frac{p^*_{(I)}}{p^*_{(G-C)}} = \frac{Y + 2V - \sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}}{Y + V - \sqrt{(Y + V)^2 - 4\alpha\rho}}$$

$$= 1 + \frac{V + \sqrt{(Y + V)^2 - 4\alpha\rho} - \sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}}{Y + V - \sqrt{(Y + V)^2 - 4\alpha\rho}}.$$

We have the following propositions:

(1) if $[V + \sqrt{(Y + V)^2 - 4\alpha\rho}] - [\sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}] < 0$, we have: $p^*_{(I)} < p^*_{(G-C)}$;

(2) if $[V + \sqrt{(Y + V)^2 - 4\alpha\rho}] - [\sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}] > 0$, we have: $p^*_{(I)} > p^*_{(G-C)}$;

(2) if $[V + \sqrt{(Y + V)^2 - 4\alpha\rho}] - [\sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}] = 0$, we have: $p^*_{(I)} = p^*_{(G-C)}$.

In order to get the analytical result of:

$$[V + \sqrt{(Y + V)^2 - 4\alpha\rho}] - [\sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}],$$

we go to calculate the result of the mathematical expression of:

$$[V + \sqrt{(Y + V)^2 - 4\alpha\rho}]^2 - [\sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}]^2.$$

$$[V + \sqrt{(Y + V)^2 - 4\alpha\rho}]^2 - [\sqrt{(Y + 2V)^2 - 4(\alpha + 2V - A)\rho}]^2$$

$$= 4(2V - A)\rho - 2V[Y + V - \sqrt{(Y + V)^2 - 4\alpha\rho}]$$

$$= \frac{4(2V - A)\rho \times [Y + V + \sqrt{(Y + V)^2 - 4\alpha\rho}] - 4\alpha\rho \times 2V}{[Y + V + \sqrt{(Y + V)^2 - 4\alpha\rho}]}$$

$$= \frac{(2V - A) \times [Y + V + \sqrt{(Y + V)^2 - 4\alpha\rho}] - 2\alpha V}{[Y + V + \sqrt{(Y + V)^2 - 4\alpha\rho}]}$$

The sign of $[V+\sqrt{(Y+V)^2-4\alpha\rho}\,]^2-[\sqrt{(Y+2V)^2-4(\alpha+2V-A)\rho}\,]^2$ depends on the sign of:

$$(2V-A)\times[(Y+V)+\sqrt{(Y+V)^2-4\alpha\rho}\,]-2\alpha V\text{, i.e.,}$$

$$\frac{[(Y+V)+\sqrt{(Y+V)^2-4\alpha\rho}\,]}{2\alpha}-\frac{V}{2V-A}\text{, i.e.,}$$

$$p^*_{(I)}-\frac{\delta Y^2}{2(\delta Y^2-\alpha A)}.$$

Then we have the following analytical results:

(1) if $p^*_{(I)}<\frac{\delta Y^2}{2(\delta Y^2-\alpha A)}$. we have:

$p^*_{(I)}<p^*_{(G-C)}$; (In this case, $p^*_{(G-C)}>\frac{\delta Y^2}{2(\delta Y^2-\alpha A)}$)

(2) if $p^*_{(I)}>\frac{V}{2V-A}$, we have:

$p^*_{(I)}>p^*_{(G-C)}$; (In this case, $p^*_{(G-C)}<\frac{\delta Y^2}{2(\delta Y^2-\alpha A)}$)

(3) if $p^*_{(I)}=\frac{V}{2V-A}$, we have:

$p^*_{(I)}=p^*_{(G-C)}$. (In this case, $p^*_{(G-C)}=\frac{\delta Y^2}{2(\delta Y^2-\alpha A)}$)

Appendix 4: Proof for Proposition 5

1. Under individual liability lending, the repayment rate is:

$$\tilde{p}_{(I)}=p^*_{(I)}=\frac{Y+V+\sqrt{(Y+V)^2-4\alpha\rho}}{2\alpha}.$$

Under group lending without peer-cooperation in effort decisions, the repayment rate is

$$\tilde{p}_{(H-G-N)}=1-[1-p^*_{(G-N)}]^2=2p^*_{(G-N)}-p^2_{(G-N)}$$

$$\tilde{p}_{(H-G-N)}-\tilde{p}_{(I)}$$

$$=2p^*_{(G-N)}-p^{*2}_{(G-N)}-p^*_{(I)}$$

$$=p^*_{(G-N)}(2-p^*_{(G-N)}-\frac{p^*_{(I)}}{p^*_{(G-N)}})$$

The sign of $\tilde{p}_{(H-G-N)}-\tilde{p}_{(I)}$ depends on the sign of $(2-p^*_{(G-N)}-\frac{p^*_{(I)}}{p^*_{(G-N)}})$.

$$2-p^*_{(G-N)}-\frac{p^*_{(I)}}{p^*_{(G-N)}}$$

$$=2-p^*_{(G-N)}-\frac{Y+V-\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{Y+V-\sqrt{(Y+V)^2-4\alpha\rho}}$$

$$= \frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}-2\sqrt{(Y+V)^2-4\alpha\rho}}{Y+V-\sqrt{(Y+V)^2-4\alpha\rho}}$$

$$-\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)\rho}$$

If $\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}-2\sqrt{(Y+V)^2-4\alpha\rho}}{Y+V-\sqrt{(Y+V)^2-4\alpha\rho}}$

$$\div\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)} > 1$$

We have:

$$\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}-2\sqrt{(Y+V)^2-4\alpha\rho}}{Y+V-\sqrt{(Y+V)^2-4\alpha\rho}}$$

$> \frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)\rho}$ i.e.,

$$\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}-2\sqrt{(Y+V)^2-4\alpha\rho}}{Y+V-\sqrt{(Y+V)^2-4\alpha\rho}}$$

$-\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)\rho} > 0$, i.e.,

$\tilde{p}_{(H-G-N)} > \tilde{p}_{(I)}$.

$$\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}-2\sqrt{(Y+V)^2-4\alpha\rho}}{Y+V-\sqrt{(Y+V)^2-4\alpha\rho}}$$

$$\div\frac{Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}}{2(\alpha+V)}$$

$$= \frac{2(\alpha+V)}{Y+V-\sqrt{(Y+V)^2-4\alpha\rho}}$$

$$-\frac{4(\alpha+V)\times\sqrt{(Y+V)^2-4\alpha\rho}\,]}{[Y+V-\sqrt{(Y+V)^2-4\alpha\rho}\,]\times[Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}\,]}$$

$$= \frac{2(\alpha+V)[Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}-2\sqrt{(Y+V)^2-4\alpha\rho}\,]}{[Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}\,]\times[Y+V-\sqrt{(Y+V)^2-4\alpha\rho}\,]}$$

$$= \frac{1}{p^{*}_{(G-N)}}\times\frac{[Y+V+\sqrt{(Y+V)^2-4(\alpha+V)\rho}-2\sqrt{(Y+V)^2-4\alpha\rho}\,]}{[Y+V-\sqrt{(Y+V)^2-4\alpha\rho}\,]}$$

$$= \frac{1}{p^{*}_{(G-N)}} \times \{1 - \frac{[\sqrt{(Y+V)^2 - 4\alpha\rho} - \sqrt{(Y+V)^2 - 4(\alpha+V)\rho}]}{[Y+V-\sqrt{(Y+V)^2 - 4\alpha\rho}]}\}$$

We have the following findings:

(1) If $\frac{1}{p^{*}_{(G-N)}} \times \{1 - \frac{[\sqrt{(Y+V)^2 - 4\alpha\rho} - \sqrt{(Y+V)^2 - 4(\alpha+V)\rho}]}{[Y+V-\sqrt{(Y+V)^2 - 4\alpha\rho}]}\} > 1$, i.e.,

$$p^{*}_{(G-N)} < \{1 - \frac{[\sqrt{(Y+V)^2 - 4\alpha\rho} - \sqrt{(Y+V)^2 - 4(\alpha+V)\rho}]}{[Y+V-\sqrt{(Y+V)^2 - 4\alpha\rho}]}\},$$

we have $\tilde{p}_{(II-G-N)} > \tilde{p}_{(I)}$;

(2) If $\frac{1}{p^{*}_{(G-N)}} \times \{1 - \frac{[\sqrt{(Y+V)^2 - 4\alpha\rho} - \sqrt{(Y+V)^2 - 4(\alpha+V)\rho}]}{[Y+V-\sqrt{(Y+V)^2 - 4\alpha\rho}]}\} < 1$,

$$p^{*}_{(G-N)} > \{1 - \frac{[\sqrt{(Y+V)^2 - 4\alpha\rho} - \sqrt{(Y+V)^2 - 4(\alpha+V)\rho}]}{[Y+V-\sqrt{(Y+V)^2 - 4\alpha\rho}]}\}, \text{ i.e.,}$$

we have $\tilde{p}_{(II-G-N)} < \tilde{p}_{(I)}$;

(3) If $\frac{1}{p^{*}_{(G-N)}} \times \{1 - \frac{[\sqrt{(Y+V)^2 - 4\alpha\rho} - \sqrt{(Y+V)^2 - 4(\alpha+V)\rho}]}{[Y+V-\sqrt{(Y+V)^2 - 4\alpha\rho}]}\} = 1$, i.e.,

$$p^{*}_{(G-N)} = \{1 - \frac{[\sqrt{(Y+V)^2 - 4\alpha\rho} - \sqrt{(Y+V)^2 - 4(\alpha+V)\rho}]}{[Y+V-\sqrt{(Y+V)^2 - 4\alpha\rho}]}\},$$

we have $\tilde{p}_{(II-G-N)} = \tilde{p}_{(I)}$.

Obviously, the analytical results of (1) and (2) are against the common knowledge, so the only result is:

$\tilde{p}_{(II-G-N)} = \tilde{p}_{(I)}$.

2. Under group lending without peer-cooperation in effort decisions, the repayment rate is

$$\tilde{p}_{(II-G-N)} = 1 - [1 - p^{*}_{(G-N)}]^2 = 2p^{*}_{(G-N)} - p^{*2}_{(G-N)}$$

Under group lending with peer-cooperation in effort decisions, the repayment rate is

$$\tilde{p}_{(II-G-C)} = 1 - [1 - p^{*}_{(G-C)}]^2 = 2p^{*}_{(G-C)} - p^{*2}_{(G-C)}$$

$$\tilde{p}_{(II-G-C)} - \tilde{p}_{(II-G-N)} = 2p^{*}_{(G-C)} - p^{*2}_{(G-C)} - 2p^{*}_{(G-N)} + p^{*2}_{(G-N)}$$

$$= 2(p^{*}_{(G-C)} - p^{*}_{(G-N)}) - (p^{*}_{(G-C)} + p^{*}_{(G-N)})(p^{*}_{(G-C)} - p^{*}_{(G-N)})$$

$$= (2 - p^{*}_{(G-C)} - p^{*}_{(G-N)}) \times (p^{*}_{(G-C)} - p^{*}_{(G-N)}) > 0.$$

(Note that $p^{*}_{(G-C)} < 1$, $p^{*}_{(G-N)} < 1$ and $p^{*}_{(G-C)} > p^{*}_{(G-N)}$.)

Then we have $\tilde{p}_{(II-G-C)} > \tilde{p}_{(II-G-N)}$.

It follows that $\tilde{p}_{(II-G-C)} > \tilde{p}_{(I)}$. (Note that $\tilde{p}_{(II-G-N)} = \tilde{p}_{(I)}$.)

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