Sequential lending with dynamic joint liability in micro-finance

Chowdhury, Shyamal and Roy Chowdhury, Prabal and Sengupta, Kunal

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Shyamal Chowdhury (University of Sydney)
Prabal Roy Chowdhury (Indian Statistical Institute)
Kunal Sengupta (University of Sydney)

Abstract

This paper develops a theory of *sequential lending in groups* in micro-finance that centers on the notion of dynamic incentives, in particular the simple idea that default incentives should be relatively uniformly distributed across time. In a framework that allows project returns to accrue over time, as well as strategic default, we show that sequential lending can help resolve problems arising out of coordinated default, thus improving project efficiency vis-a-vis individual lending. *Inter alia*, we also provide a justification for the use of frequent repayment schemes, as well as demonstrate that, depending on how it is manifested, social capital has implications for project efficiency and borrower default. We next examine the optimal choices for the MFI and derive conditions for the optimality of the group lending arrangement. Our framework also provides for some plausible hypotheses as to why there has been a recent transition from group to individual lending.

Key words: Collusion; coordinated default; dynamic incentives; frequent repayment; group-lending; MFI competition; micro-finance; sequential financing; social capital; switch to individual lending.

JEL Classification Number: D7, D9, G2, O2.

[*]**Address for Correspondence**: Prabal Roy Chowdhury,
Economics and Planning Unit, Indian Statistical Institute, Delhi Center,
7 - S.J.S. Sansanwal Marg, New Delhi - 110016, INDIA.
E-mail: prabalrc1@gmail.com.
Fax: 91-11-41493981.

1 Introduction

This article seeks to develop a unified theory of two oft-used institutional features in microfinance. In a framework that allows project returns to accrue over time, as well as strategic default, we show that (a) *sequential lending* can help resolve problems arising out of coordinated default, thus improving project efficiency vis-a-vis individual lending, and (b) that *frequent repayment* schemes improve dynamic incentives for repayment. We demonstrate that a socially motivated MFI opts for a higher project size, and lends to a greater number of borrowers under group lending. Finally, we show that this framework provides a rich explanation of the transition from group to individual lending occurring over the last decade or so.

We consider a model where project size is endogenous, and returns are formulated dynamically, as a stream of income accruing over a period of time. There is *ex post moral hazard* in that the borrowers can strategically default at any point of time (see Gine *et al.*, 2011, for evidence on strategic default).

For the benchmark case of individual lending, we show that the optimal repayment scheme involves *immediate and frequent repayment* (IFR for short), with the repayment starting early, and continuing at the maximal feasible rate until the MFI recoups its loan, thereby demonstrating two features that appear to be 'near-universal' (Bauer *et al.*, 2008), namely early and frequent repayment. Further, in the presence of either (a) risk-aversion, or (b) positive discounting, the optimal scheme may be 'gradual' in the sense that it asks for less than the maximal feasible payoff at every instant.

In the presence of a severe moral hazard problem (in a sense made formal later), however, the efficient level of investment may not be attainable, even with IFR schemes. Given this, we then examine whether group-lending with *sequential lending* can help improve efficiency.

Sequential lending, whereby loans to group members are staggered, can trace its origin to ROSCAs (Besley *et al.*, 1993) and has been widely adopted by many microfinance institutions (henceforth MFIs), including Grameen I and its replicators.[1] While over the last decade or so there has been a move towards individual lending (Rai and Sjostrom, 2010), sequential lending continues to be widely used. In India, the Self Help Group (SHG) Linkage Program, with 54 million clients in 2008-09 (Srinivasan, 2009), provides loans in sequence (Aniket, 2006, 2009). Further, BRAC offers canonical Grameen I schemes in a number of African countries such as Liberia, Sierra Leone, Tanzania and Uganda (based on discussions with BRAC International officials, and field visits, in particular to BRAC Uganda). Even some European micro-finance programs follow sequential lending practices (see, Molnar, 2010, and Castri, 2010). It is therefore of interest to examine the reasons as to why it had been so widely used in the recent past, and still continues to be used in many cases.[2] Further, this allows us to develop a framework where one can endogenously solve for whether the MFIs are going to opt for group, or individual lending, in the process throwing some light on the recent move towards individual lending.

Under group lending the analysis focusses on the interaction between social sanctions and collusive possibilities. Social sanctions involve the borrowers who are adversely affected because of default, imposing some penalty on the defaulting borrower(s). While such sanctions can help prevent default, whether such sanctions are actually imposed or not, however depend on the

[1] In Bangladesh, examination of the data collected by IFPRI in 1994 and used in Zeller *et al.* (1996) for 128 groups belonging to group-based credit programs of three MFIs (ASA, BRAC and RDRS) shows that sequential lending was common to all three MFIs.

[2] de Quidt *et al.* (2012) report that out of 663 institutions that reported to Microfinance Information Exchange (MIX) in 2009, 12.2% of the lenders offered joint liability loans (JLLs) exclusively, and 57.9% offered some JLLs. Of course, this study does not tell us whether these joint liability contracts also involved sequential lending or not.

extent of collusion among the borrowers. We consider two scenarios, with limited, and complete collusion. In the first case, borrowers cannot make transfers to one another in a bid to avoid social sanctions in case of default. Thus collusion takes a limited form and simply involves *not* invoking the social sanction whenever *all* borrowers benefit from a coordinated default. Under the second case, we allow borrowers to make transfers among one another. Complete collusion is modeled simply as the borrowers taking default decisions jointly, based on maximizing aggregate group payoff. Clearly, in case of a default, the social sanctions are never invoked.

Under the first scenario with limited collusion, we find that sequential lending necessarily improves efficiency vis-a-vis individual lending (as long as social sanctions are not too small). The basic intuition can be explained using a two member group. Let the first recipient default at a time when the second borrower is yet to receive her loan. Such a default adversely affects the second borrower, who obtains no loan, and thus imposes the social sanctions. Next at the instant when the second borrower obtains her loan, the first borrower would have already repaid a substantial amount and thus will be adversely affected if the default by the second borrower as the lender will liquidate both the projects. Consequently the first borrower will then impose the social sanction.

The possibility of limited collusion implies that the second borrower cannot obtain her loan too early in the cycle, otherwise there will be coordinated default by the borrowers. Furthermore, the second loan can not be too delayed either since in that case when the first borrower completes her project, she will not impose the social sanction and this may then lead to defaulting by the second borrower. It is this subtle interaction of dynamic incentives, in particular between sequential lending and IFR, that ensures that a higher project return can be implemented.

We next examine the scenario with complete collusion. Given that social sanctions have no bite we find, somewhat surprisingly, that more efficient projects can be sustained compared to that under individual lending. The intuition has to do with dynamic incentives that arise since default decisions take group payoffs into account. For exposition, we again consider a two member group. At the start of the project, default payoffs involves a single project while the continuation payoff includes the total net income that arises from both these projects and thus defaulting incentives are low. Now, at the time, when the second borrower receives its loan, default can still be costly for the overall group. This is because at this point, the first project has already run its course for some time, and some repayment have already been made, the combined payoff from these two projects could be higher for the group if it did not default on their loans. Consequently, it is possible to support the no default outcome when borrowers can collude and make side transfers to avoid imposition of social sanctions.

The maximal sustainable loan size under complete collusion is however lower than that under limited collusion. There are two countervailing forces at work here. While, the fact that social sanctions have no bite under complete collusion, makes loans harder to recover, the fact that default decisions take group payoffs into account, makes loans easier to recover. Why does the first effect necessarily dominate? This has to do with the fact that under limited collusion group size is taken to be large enough making social penalties an effective threat, whereas social penalties have no bite under complete collusion.

We next consider the optimization problem facing a socially motivated MFI, i.e. one that cares for its borrowers, a natural assumption in this context.[3] Solving for the optimization problem of such an MFI under both lending regimes, we find that both project size, as well as

[3]The United Nations Interagency Committee on Integrated Rural Development for Asia and the Pacific (UNICIRDAP, 1992) mentions six characteristics of an NGO, one of them being 'highly socially motivated and committed'. See Besley and Ghatak (2005, 2006) for studies on incentive provision to socially motivated agents.

the number of borrowers served are higher under group-lending.

Finally, we use this framework to analyze a phenomenon that is not very well understood, namely the transition from group to individual lending discussed earlier. We argue that this shift can be attributed to the increase in MFI competition that was happening around the same time, in particular to several possible effects of such increased competition, including (i) increased competition for donor funds, resulting in a higher opportunity cost of fund for the MFIs, (ii) mission-drift, i.e. the MFIs becoming more profit-oriented, (iii) increased reservation utility of borrowers, and (iv) reduced social capital. We show that all of these tend to make group-lending relatively less attractive, thus providing a possible explanation.

The next section provides a brief review of the literature, whereas Section 3 describes the model and analyzes the case of individual lending. Section 4 then examines a scenario with both IFR, as well as sequential lending, under limited, as well as complete collusion. Section 5 analyzes a scenario where the MFIs optimally decide on projects sizes, etc. Section 6 then uses this framework to analyze some questions of policy interest. Section 7 concludes.

2 Related Literature

We organize our literature review around three themes that this paper relates to.

2.1 Immediate and Frequent Repayment (IFR)

In Jain and Mansuri (2003), early repayment forces borrowers to borrow from friends/local moneylenders, thus tapping into the information possessed by these agents regarding the borrowers' credit worthiness.

In recent contributions, Fischer and Ghatak (2010, 2011) show that the presence of (i) a net continuation value in case of repayment (which may arise either because of contingent renewal, or from avoiding future punishment), and (ii) either present-biased preferences, or strict risk aversion by the borrowers (in the absence of savings instruments), tighten the incentive constraints at the earlier stages, thus providing an explanation for frequent instalments. Moreover, as in the present paper, they also argue that smaller amounts may be less prone to diversion.

This paper and Fischer and Ghatak (2010, 2011) offer complementary insights though, being applicable under different scenarios. The present paper, for example, provides a theory that does not require either a positive net continuation value in case of repayment, or the borrowers to have either present-biased preferences, or strict risk aversion. Fischer and Ghatak (2010, 2011) on the other hand provide a theory that applies even when full repayment is possible in the very first period, a scenario that is not allowed for in the present paper.[4]

Albuquerque and Hopenhayn (2004) consider a repeated game theoretic model of lending with endogenous borrowing constraints, finding that the equilibrium contract involves paying no dividend in the initial years. While reminiscent of our IFR result, it is driven by a different intuition, namely that doing so allows a firm to build up equity as quickly as possible, thus relaxing the borrowing constraint. Relatedly Shapiro (2012) examines dynamic incentives in the presence of asymmetric information, but no enforcement problems. He shows that in all equilibria but one, even the most patient borrowers default with probability one.

Among empirical papers, Field and Pande (2008) argue that a shift from weekly to monthly repayment leads to no significant difference in either delay, or default. Field *et al.* (2011) however find that allowing for a grace period before repayment starts, increases default. Seen

[4] We would like to thank Maitreesh Ghatak and Dilip Mookherjee for encouraging us to clarify these issues.

through the lens of the present paper, such grace periods would necessitate greater repayment later, thus pushing up the incentive to default later on. Feijenberg *et al.* (2013) use an experimental approach to argue that more frequent meetings lead to lower default, possibly because of improved informal risk-sharing arising out of greater social interactions.

The present paper is thus complementary to the literature in that it provides an explanation of IFR that is not based on any of (i) asymmetric information, or (ii) a net continuation value in case of repayment and either present-biased preferences, or strict risk aversion by the borrowers, or (iii) social interactions.

2.2 Sequential Lending

The literature on sequential lending goes back to Varian (1990), who demonstrates that it provides incentives to high productivity borrowers to school low productivity types. Roy Chowdhury (2005) argues that sequential lending can encourage a high level of monitoring by the downstream borrowers. Aniket (2006) examines this issue using a framework with endogenously determined interest rates. Roy Chowdhury (2007) shows that in the presence of contingent renewal there is positive assortative matching, and, consequently, sequential lending allows the lender to test for the composition of a group relatively cheaply. Finally, while Aniket (2009) shows that sequential lending may widen access to less profitable projects, Sinn (2013) examines the role of sequential lending in the presence of *ex post* moral hazard problems. Related papers include Conning (2005) and Ahlin and Waters (2011).

In contrast to this literature, the present paper does not rely on either borrower monitoring, or testing for group composition, neither does it focus on borrowers' access to loans. Instead this paper unearths a role for sequential lending in preventing collusion, either limited, or complete. Further, it examines the *interaction* between sequential lending and frequent repayment, in particular showing that there is a strong synergy between the two.

2.3 Social Capital

Besley and Coate (1995) analyze the implications of social sanctions in a group-lending context. They find that depending on the magnitude of social capital, group-lending may, or may not lead to greater repayment vis-a-vis individual lending. Laffont and Rey (2003) find that even with collusion, group-lending does better vis-a-vis individual lending. Other papers examining the issue include Aghion (1999), Bhole and Ogden (2010), Paal and Wiseman (2011) and de Quidt *et al.* (2012). The empirical evidence on the efficacy of social capital in ensuring timely repayment is mixed. In a lab experiment Abbink *et al.* (2006) find that groups consisting of strangers do as well as self-selected groups. In a similar vein, Wydick (1999) using group lending data from Guatemala finds that friends do not make better group members. In contrast, Karlan (2007), finds that social capital is correlated with positive repayment performances.

In contrast to Besley and Coate (1995) and Aghion (1999), we explicitly allow for borrower collusion. Also, in contrast to Laffont and Rey (2003), Bhole and Ogden (2010), Paal and Wiseman (2011), and de Quidt *et al.* (2012) we analyze sequential, rather than simultaneous lending schemes. Further, unlike Bhole and Ogden (2010) and Paal and Wiseman (2011), (i) we do not allow for repeated interactions but instead analyze a dynamic one-off interaction, and (ii) the magnitude of social sanctions is norm driven in our framework. We add to this literature by analyzing how social capital interacts with sequential lending, in particular how the *nature* of collusion affects repayment performance. In so doing this paper, along with Paal and Wiseman (2011), takes a step in reconciling the mixed results found in the empirical literature.

3 The Model

The framework is populated by a lender, namely an MFI, and a set of potential borrowers of size n. Each borrower has a project that requires a start-up capital of k, where k is a choice variable and can take any non-negative value. Project returns accrue over time, starting at time 0 (say), so that a project of size k yields a return of $F(k)$ at every $t \in [0,1]$. $F(k)$ is increasing, strictly concave and once differentiable in k, with $F(0) = 0$. Moreover, $F(k)$ satisfies a version of the Inada condition, with $\lim_{k\to\infty} F'(k) < 1$. Project returns are observed by the lender.

We assume that neither the MFI, nor the borrowers discount the future and that all have linear utility functions defined over money. Denoting the opportunity cost of 1 unit of fund for the lender by $(1+c)$, where $c \geq 0$, the 'efficient' project size $k^*(c)$ is then obtained by maximizing $F(k) - k(1+c)$. Given strict concavity of $F(k)$, it follows that there exists a unique value of $k^*(c)$ that maximizes $F(k) - k(1+c)$. Since $F(0) = 0$, it follows that $k^*(c) > 0$ if and only if $F'(0) > 1 + c$, with $F'(k^*(c)) = 1 + c$ under this condition. We maintain this assumption throughout this paper. We also note that strict concavity of $F(k)$ implies that $F(k) - k(1+c) > 0$ for all $0 < k \leq k^*(c)$.

The borrowers have no investible fund. Thus, to implement a project of size k, they must borrow the amount k from the MFI and agree to repay the lender according to some repayment schedule. In what follows, we assume that the lender charges an interest rate r for her loan, $r \geq 0$, so that for any project of size k, the aggregate repayment must equal $k(1+r)$.

As in Besley and Coate (1995), a borrower is allowed to strategically default on her repayment obligation at any date t.[5] In the event of such strategic default, the project is 'liquidated' with the borrower obtaining a private benefit of $(1-t)b(k)$ and the lender obtaining $(1-t)z(k)$, where $b(k), z(k) \geq 0$. Throughout, we maintain the following assumption.

A.1.

(i) $b(k)$ is increasing and once differentiable in k, with $b(0) = 0$. Furthermore, for every $k > 0$

$$F(k) > b(k) + z(k).$$

(ii) For all $k \geq 0$, $\frac{b(k)}{F(k)}$ is non-decreasing in k.

A.1(i) implies that 'liquidation' is *ex post inefficient*. Our interest given A.1(i) will be to characterize outcomes that do not involve strategic default and liquidation. As will be clear shortly, the actual magnitude of $z(k)$ plays no role in the ensuing analysis and henceforth, we normalize its value to zero. A.1(ii) captures the intuitive notion that default incentives are non-decreasing in the project size k, and will be satisfied quite generally. In particular, since $F(k)$ is strictly concave, $\frac{b(k)}{F(k)}$ will be decreasing in k if $b(k)$ is (weakly) convex. Moreover, if $b(k) = \gamma F(k)$, where $0 < \gamma < 1$, then $\frac{b(k)}{F(k)}$ is a constant function of k and A.1(ii) is satisfied.

We note that the formulation of the default payoff adopted in this paper is quite general and encompasses many different scenarios.

One interpretation is that the default payoff $b(k)(1-t)$ is closely tied to the physical liquidation of the project, arising either directly out of liquidation by the MFI itself, or as the benefit that the borrower can garner for herself by overusing the asset just prior to defaulting at t (with subsequent liquidation by the lender yielding a residual benefit of $(1-t)z(k)$ to the lender).

[5] There is also a large literature on *ex ante* moral hazard, e.g. Banerjee*et al.* (1994), Bond and Rai (2009), and Ghatak and Guinnane (1999), as well as adverse selection in micro-finance, e.g. Ghatak (1999, 2000), Laffont and Rey (2003), Sadoulet (2000), and Rai and Sjostorm (2004), among many others.

The default payoff however need not necessarily involve physical liquidation of assets, and can be interpreted more broadly.[6] For instance, one can assume that if the borrower wants to default, she can hide the return $F(k)$ from the lender. In order to do this however, the borrower needs to incur a cost which is some fraction $1-\gamma$ of the actual output $F(k)$. Given this interpretation, the default payoff to the borrower can then be written as $\gamma F(k)(1-t)$.[7]

Another possible interpretation is that, following a default, the MFI imposes some one-shot penalty on the borrower, say $p > 0$. Such one shot penalties arise quite naturally, for example, in case the MFI's punishment strategies involve some form of social shaming. The borrower however continues to use the project technology without any further loss of efficiency, so that the default payoff is given by $F(k)(1-t)-p$.[8] Default may also lead to denial of future loans, or a defaulting borrower's credit her tory being wiped out. While such additional penalties would make default less attractive, and some implications of allowing for such default payoffs are analyzed in Fischer and Ghatak (2010, 2011), a full analysis is beyond the scope of this paper. In the rest of the paper, we thus use liquidation as a portmanteau term that allows for all the different interpretations that can be represented via the default function $b(k)(1-t)$.

3.1 Individual Lending

The case of individual lending forms a benchmark for the later analysis. It is also of independent interest since, as discussed earlier, some MFIs are either moving away from group loans, or do not impose any form of joint liability even though the loans may involve a group structure (ASA, for example, has some group loans without group guarantees, ASA (2008)).

We visualize the following scenario: at $t = 0$, the MFI enters into a contract with a borrower that specifies the amount borrowed k, and a payment scheme $y(t, k), t \in [0, 1]$, where $y(t, k)$ is the instantaneous non-negative payment at date t. Let $Y(t, k) = \int_0^t y(\tau, k)d\tau$ denote the aggregate payment that the borrower makes in the time interval $[0, t]$. Throughout, we assume that borrowers are protected by limited liability so that at each date t, the maximum payment that can be made to the lender is no more than the aggregate returns that accrue till date t, i.e. $Y(t, k) \leq tF(k)$ for every t. If the borrower accepts the contract, she immediately invests k in the project and has to make payments according to the repayment schedule. If the borrower fails to meet her payment obligations at any date t, the project is liquidated.

A repayment schedule $y(t, k)$ is said to satisfy the *no default (ND)* condition if, for every $t \in [0, 1]$,

$$F(k)(1-t) - \int_t^1 y(\tau, k)d\tau \geq b(k)(1-t). \tag{1}$$

Given k, and $y(t, k)$ for which the ND condition holds, the aggregate repayment received by the lender is given by $\int_0^1 y(t, k)dt$.

For any r, a lending scheme $< k, y(t, k) >$ is said to be *r-feasible* if it satisfies the ND condition and

$$\int_0^1 y(t, k)dt = k(1 + r). \tag{2}$$

[6] We are thankful to several anonymous commentators who suggested these alternative interpretations.

[7] A default payoff of $\gamma F(k)(1-t)$ can also arise in case the default penalty leads to some loss of efficiency, though not physical liquidation of the assets. Such loss of efficiency can arise in case (a) default leads to some loss of social capital following some form of public shaming, for example, public disclosure of such default, and (b) the project payoff is itself dependent on social capital.

[8] While this interpretation fits less obviously into the present framework, we shall later discuss the implications of adopting this alternative formulation of the default function under individual lending.

Note that if $r \geq c$, then equation (2) also ensures that the MFI makes non-negative profits on its loans.

Our plan in this section, as well as the following one, is to characterize the set of r-feasible project sizes k, taking the interest rate r as given.[9] Towards that end, we first define a simple class of contracts, where the loan amount is repaid in the shortest possible time.

DEFINITION 1. *An immediate and frequent repayment scheme (henceforth IFR) corresponding to a project size k and an interest rate r is defined as*

$$y(t,k) = \begin{cases} F(k), & \text{if } 0 < t \leq \frac{(1+r)k}{F(k)}, \\ 0, & \text{otherwise.} \end{cases} \tag{3}$$

Our next result, Lemma 1, is analytically extremely convenient as it shows that, in the presence of risk neutrality and in the absence of discounting, one can, without loss of generality, restrict attention to such IFR contracts.

LEMMA 1. *Under an individual lending arrangement, if a lending scheme $< k, y(t,k) >$ is r-feasible, then the IFR scheme corresponding to the project size k is also r-feasible.*

Proof. We first observe that since the scheme $< k, y(t,k) >$ is *r-feasible*, it must satisfy the ND condition at $t = 0$. But at $t = 0$, the ND condition for any scheme is given simply by

$$F(k) - k(1+r) \geq b(k). \tag{4}$$

Next we consider the IFR scheme given k and r. Under this scheme, the entire loan is repaid by $\tilde{t}$, where $\tilde{t} = \frac{k(1+r)}{F(k)}$. Consider $t < \tilde{t}$. Since, at any such date $\int_t^1 y(\tau,k)d\tau = k(1+r) - F(k)t$, the ND constraint under an IFR can be re-written, using equation (1), as

$$F(k) - k(1+r) \geq b(k)(1-t). \tag{5}$$

Clearly, under an IFR, the default incentives are decreasing over time. Thus, the ND constraints are satisfied for all t, if and only if the ND constraint at $t = 0$, i.e. $F(k) - k(1+r) \geq b(k)$, is satisfied, which is true given (4). □

The intuition as to why one can restrict attention to IFR schemes is simple. With a frequent repayment scheme, the installments are staggered, so that the amount to be repaid does not become very large at any one point, in particular as the project nears completion. While default incentives are largest at the very start of the project, i.e. at $t = 0$, at this point continuation payoffs are also correspondingly higher. With any other repayment scheme, the net continuation payoff of the borrower will be strictly lower at some point in time in the future, making default alternative more attractive to the borrower.

We observe that Lemma 1 is consistent with Field *et al* (2011). It is also in line with Kurosaki and Khan (2009), who find that while, in Pakistan, several group-lending schemes failed in the late 1990s, there was a drastic decrease in default rates from early 2005, when contract designs were changed and involved more frequent repayment installments (and improved enforcement of contingent renewal).

For any k which is r-feasible, let the payoff of a borrower be denoted $\pi(k,r) = F(k) - k(1+r)$. Further, given $r \geq 0$, let $k^0(r) > 0$ solve $\pi(k^0(r), r) = 0$. Given our assumption that

[9] In Section 5, we study the optimization problem for the MFI.

$\lim_{k\to\infty} F'(k) < 1$, for any $r \geq 0$, $k^0(r)$ is uniquely defined. Moreover, $\pi(k,r) > 0$, if and only if $k < k^0(r)$.

We now introduce a notion that plays an important role in the development of our results.

Definition 2. *For any (k,r), with $\pi(k,r) > 0$, define the average net default incentive,*

$$\phi(k,r) = \frac{b(k) - \pi(k,r)}{\pi(k,r)} = \frac{b(k)}{\pi(k,r)} - 1. \tag{6}$$

Note that $b(k) - \pi(k,r)$ represents the net gain from defaulting at $t = 0$. Thus $\phi(k,r)$ measures the net default incentive as a proportion of the net return, $\pi(k,r)$ at $t = 0$. Clearly if the average net default incentive $\phi(k,r)$ is positive, a borrower with loan size k will strictly prefer to default at $t = 0$ and thus a loan of size of k that promises the MFI an aggregate repayment of $k(1+r)$ cannot be sustained.

In Chowdhury *et al.* (2014) we prove Lemma 2 which shows that for any k_1, k_2, such that $0 < k_2 < k_1 < k^0(r)$, we have $\phi(k_2,r) < \phi(k_1,r)$. Given Lemma 2, it follows that if a project of size $k > 0$ is r-feasible, then a project of size $k' < k$ is also r-feasible. The following proposition fully characterizes the set of project sizes that are r-feasible under individual lending.

Let $k^I(r) > 0$ satisfy

$$\phi(k^I(r), r) = 0.$$

Note that $\phi(k,r) \to \infty$ as $k \to k^0(r)$. Since $\phi(k,r)$ is an increasing function of k (Lemma 2), $k^I(r) > 0$ exists if and only if $\lim_{k\to 0} \phi(k,r) < 0$.[10] Furthermore, Lemma 2 also ensures that $k^I(r)$ is uniquely defined.

Proposition 1. *A project of positive size k is r-feasible if and only k is not too large, i.e. $0 < k \leq k^I(r)$.*

Proof. Now at $t = 0$, under an IFR, the ND constraint is satisfied if and only if $k \leq k^I(r)$. Since the net default payoff from the IFR contract is decreasing in time (see the proof of Lemma 1), it then follows that for a project size k to be r-feasible, it must be the case that $k \leq k^I(r)$. □

Proposition 1 thus shows that given r, $k^I(r)$ is the maximum project size that is r-feasible.

Remark 1. *A.1(ii) plays an important role in Proposition 1 as it ensures that $\phi(k,r)$ is an increasing function of k. This, in turn, ensures that the set of r-feasible project choices k is a convex set, namely the interval $[0, k^I(r)]$. In the absence of A.1(ii), $k^I(r)$ needs to be defined as the supremum of all k such that $\phi(k^I(r), r) = 0$. Moreover, in such a case, it will not be true that if k is r-feasible, then any $k' < k$ is also r-feasible.*

Remark 2. *It might be of interest to note that in this set up, an IFR scheme does strictly better than an one shot repayment scheme in which the borrower repays the loan in a single installment. To see this, let $k^I_{OSR}(r)$ be the supremum of project sizes that is feasible under a one shot contract. Let t_{OSR} be the date the repayment is made when the project size is $k^I_{OSR}(r)$. Since the borrower prefers not to default at t_{OSR}, we have $(1-t_{OSR})b(k^I_{OSR}) + t_{OSR}F(k^I_{OSR}) \leq \pi(k^I_{OSR}, r)$. By A.1(i), we have $F(k^I_{OSR}) > b(k^I_{OSR})$ and thus $\pi(k^I_{OSR}, r) > b(k^I_{OSR})$. This gives us $\phi(k^I_{OSR}, r) < 0 = \phi(k^I(r), r)$. From Lemma 2, we then have $k^I_{OSR} < k^I(r)$.*

[10] If $F'(0)$ is finite, then $\lim_{k\to 0} \phi(k,r) < 0$ iff $b'(0) < F'(0) - 1 - r$, and when $F'(0)$ is infinite, the condition is $lim_{k\to 0} \frac{b'(k)}{F'(k)} < 1$.

Remark 3. *It is easy to extend the present formulation to allow for any possible dynamic incentive considerations that may arise if, in case of default, a borrower is denied loans in the future. Letting V denote the utility loss to the borrower arising out of this possibility, it is straightforward to see that the no default condition in such a case can be written as $b(k,r) - V \leq \pi(k,r)$ and the maximum project size k will then satisfy $\phi(k,r) = \frac{V}{\pi(k,r)}$. As is clear, the presence of such considerations will reduce the net benefit of default and will allow larger project sizes to be r-feasible.*

Remark 4. *How does $k^I(r)$ compare with the efficient project size $k^*(c)$? It is easy to check that a necessary and sufficient condition for $k^I(r)$ to be strictly less than $k^*(c)$ is that $\phi(k^*(c), r) > 0$. This condition is likely to hold, (a) higher the value of $b(k)$, (b) lower the value of $\pi(k,r)$ and (c) higher the interest rate r (thus if $\phi(k^*(c), 0) > 0$ then $k^I(r) < k^*(c)$ for all r).*

Proposition 1 essentially establishes two properties of feasible repayment schedules, namely that they involve (a) immediate and frequent repayment, as well as (b) front-loaded repayments. At this point it may be in order to examine how these two results hold up under alternative model specifications.

First, consider a scenario where the borrowers have strictly concave utility functions or have positive time discount factors. Under such a scenario, an IFR scheme, in general, will fail to be optimal. This is because alternative repayment schemes that shift some of the repayments to later instants (while keeping aggregate repayment unchanged) will be preferred by a borrower with diminishing marginal utility of income or who discounts the future. However, even in such a scenario, an optimal scheme must necessarily be characterized by 'gradual' repayments in that payments are made 'a little at a time' (Jain and Mansuri, 2003).

Next we consider the alternative default payoff function discussed earlier, where in case of default, there is a one shot penalty of $p > 0$, but the borrower can continue her project without loss of efficiency. It is possible to show that the incentive to default is decreasing over time even under this specification. It is thus sufficient to consider default incentives at $t = 0$. This gives the result that a project size of k can be sustained if and only if $p \geq k(1 + r)$, so that an analogue of Proposition 1 will hold.

Proposition 1 tells us that if at $r = c$, $k^I(c) < k^*(c)$, then the efficient project size of $k^*(c)$ is not feasible under individual lending even when the lender makes zero profit. *Strategic default* considerations thus have serious efficiency implications. It is then natural to ask whether group contracts allows us to implement more 'efficient' project sizes. To this, we now turn.

4 Group Lending and Social Capital

We will consider group lending in the presence of dynamic joint liability. Under dynamic joint liability, the entire group is held responsible (and penalized) in case of default: first, if some borrowers default, then all existing projects are necessarily dissolved, and second, group members who are yet to receive their loans are denied any future loans.

One important objective in examining group lending is to study the complex role played by social capital in ensuring repayment (Aghion and Morduch, 2005, pp. 123-125). Without being too formal about it, let social capital capture the strength of the social ties present among the borrowers.[11] We argue that while such social ties may help sustain sanctions against defaulting

[11]Townsend (1994), Udry (1990) and Fafchamps and Lund (2003), among others, discuss various aspects of mutual insurance, risk pooling, gift giving and receiving, etc.

borrowers,[12] thus improving incentives for repayment, these can also encourage default in case close social ties in small communities make social sanctions difficult to impose.

One positive aspect of social capital is the fact that a defaulting member may be sanctioned by other members of the group. In the present paper such sanctions are, however, assumed to be only imposed by those borrowers who are *adversely* affected following a default. These include borrowers who are yet to obtain a loan, and may also include borrowers who have obtained a loan, but have already repaid substantially, so that they would prefer not to default. We assume that each such affected member can invoke a penalty of f on each of the deviating borrowers.

While we follow Besley and Coate (1995), among others, in imposing such social sanctions exogenously, the present formulation can perhaps be best interpreted as a reduced form approximation of a model where such penalties are imposed as part of optimal threat strategies. Such an interpretation makes sense in a scenario where social penalties involve exclusion from scarce community assets. In such cases social sanctions may involve no loss of efficiency, and would be easier to sustain as an equilibrium outcome. Sustaining such sanctions, however is much harder if such sanctions are efficiency reducing, e.g. if it involves exclusion from mutual insurance networks. In such scenarios, one then needs to appeal to social preferences, e.g. the presence of altruistic punishers (see Fehr and Schmidt (1999), Gintis *et al.* (2005), and the references therein) to sustain such sanctions.

We next discuss the negative aspects of social capital, i.e. the fact that "borrowers in a group-lending arrangement may collude against the bank and undermine the bank's ability to harness social collateral" (Aghion and Morduch, 2005, pp. 125). In a micro-finance context where borrowers communicate with one another, it seems natural to allow for some collusion.[13] We argue that the observed differences in the impact of social capital on repayment performance can be traced to differences in the extent of collusion. We thus examine two scenarios with different degrees of collusion among the borrowers, limited and complete.

Since, under limited collusion, borrowers cannot make transfers to each other, collusion thus simply involves not invoking the social sanction whenever *all* borrowers benefit from a coordinated default. Under complete collusion, we however allow borrowers to make such transfers among one another. Following Ghatak (2000), one can appeal to non-pecuniary forms of transfers, e.g. providing free labor services and the use of agricultural implements, to justify such side transfers. Furthermore, collusion is formalized very simply in that the group maximizes the aggregate payoff and thus decisions are made keeping the interest of the group in mind. Clearly, in case of complete collusion, social sanctions will never be imposed in case of default.[14]

The issue of when is collusion likely to be complete, i.e. whether side transfers are feasible, is however a complex one and a detailed analysis is beyond the scope of the present paper.

4.1 Two Stage Lending Schemes

For the analysis in this section, we shall take the group size n to be exogenously given. In what follows, we first study *two stage* group contracts in the presence of dynamic joint liability.

[12]Such social sanctions may involve exclusion from inputs, trade credit, social and religious events, day-to-day courtesies, communal assets, informal insurance networks, etc. See de Quidt *et al.* (2012) for a discussion of possible alternative formulations of social capital.

[13]One extreme example of such borrower collusion is from India where a woman defrauded MFIs to the tune of five hundred thousand rupees by setting up groups with the sole objective of appropriating the loan amount (Srinivasan, 2009).

[14]In the Grameen, for example, there seems to be some effort at fostering a group identity. At least three of the resolutions (12, 13 and 14), emphasize group payoff and joint welfare maximization. Source: http://www.grameen-info.org, accessed May 7, 2009.

In *two-stage group lending* arrangements, the set of borrowers are divided into two groups, 1 and 2. The first group of borrowers, $(n-m)$ in size, receives a loan of k each at $t^1 = 0$, while the remaining m borrowers receive k each at some later date $t^2 > 0$.

Let $y^i(t^i + \tau, k), \tau \in [0,1]$, denote a repayment schedule faced by a borrower in group $i, i = 1, 2$, receiving her loan k at date t^i. We represent such a scheme by $< n, m, t^2, k, y^i(t^i\tau, k) >$.

As before, we assume that there is limited liability on part of the borrowers so that the repayment obligations at any date can not exceed the aggregate returns generated till that date. We will further assume that the lender gets the same payoff from each individual loan, thus ruling out cross-subsidization by the lender. Finally, we assume that $y^i(t^i + \tau, k) \geq 0, i = 1, 2$ for all $\tau \in [0, 1]$.

4.2 Two Stage Lending Schemes without Side Payments

In this sub-section we examine a scenario where side transfers are not possible, so that only 'limited collusion' can be sustained.

Fix any two stage lending scheme with repayment obligations given by $y^i(t^i+\tau, k)$. Let $P^i(t)$ denote the continuation payoff to a borrower in group i at time t, assuming that no member of the group ever defaults on her loan. Similarly, given a default at t, let $D^i(t)$ denote the default payoff of a borrower in group i at t, *gross* of social sanctions. Since default by any member leads to the liquidation of all existing projects, as well as denial of future loans, it follows that $D^i(t)$ depends only on t and not on either the number, or the identity of those who default.

A borrower is said to be *active* at t, if she is yet to complete her project at that date. We assume that social sanctions at any date t are imposed only by the members that are active at that date. Let $L(t)$ denote the set of active borrower at t for whom $P^i(t) \geq D^i(t)$. The members of $L(t)$ are those who are *adversely affected* if default were to take place at t. Our assumption of limited collusion requires that a defaulting member be sanctioned only by the members of $L(t)$, i.e. by those who are *adversely* affected because of a default. Let $l(t)$ denote the size of $L(t)$ and $f > 0$ denote the social sanction that can be imposed on a defaulting borrower.[15]

A two stage lending scheme $< n, m, t^2, k, y^i(t^i + \tau, k) >$ satisfies the no default condition if, for all $t \in [0, 1 + t^2]$, and for an active borrower in group i, $i = 1, 2$,

$$D^i(t) > P^i(t) \quad \text{implies that} \quad D^i(t) - l(t)f \leq P^i(t). \tag{7}$$

We should note that if $D^i(t) \leq P^i(t)$, then a borrower in group i will prefer not to default even if no social sanctions are imposed on her and thus the no default condition will be automatically satisfied for such a borrower.

We say that a *two-stage group arrangement* with project size k is r*-feasible* if there exists a repayment scheme $< y^i(t^i + \tau, k) >$ such that

- the no default condition in (7) is satisfied for all borrowers in group $i = 1, 2$, and
- for each borrower, the lender receives a payoff of $k(1 + r)$.

Given $r \geq c$, the last condition ensures that the MFI breaks even.

Remark 5. *Consider a group lending scheme with* simultaneous *lending, so that group members are all provided a loan amount k at $t^1 = 0$. If $k > k^I(r)$, then $b(k) > \pi(k, r)$ and thus all*

[15] In an earlier version, $L(t)$ was defined as the set of borrowers who are strictly worse off because of a default decision. While the qualitative results under these two assumptions are virtually identical, under the present formulation, the set of feasible projects turns out to be a closed set, a property that will be used in the analysis in Section 5.

borrowers will be better off defaulting on their loans and not invoking the social sanctions. Simultaneous group lending thus can not improve upon individual lending. For group lending to do better, lending then has to be sequential so that $t^2 > 0$.

To characterize the set of project sizes k that are r-feasible under such a two stage arrangement, we begin by describing the *immediate and frequent repayment* (IFR) pertaining to each group. For any borrower i who receives a loan of size k at date t^i, this is given by

$$y^i(t^i + \tau, k) = \begin{cases} F(k), & \text{if } 0 < \tau \leq \frac{k(1+r)}{F(k)}, \\ 0, & \text{otherwise.} \end{cases} \tag{8}$$

Lemma 3 below shows that in search of a feasible scheme, it is sufficient to restrict attention to IFR schemes (see Chowdhury *et el.* (2014), Appendix B, for a proof).

Lemma 3 *Fix $k > 0$ such that $\pi(k, r) > 0$. Suppose that project size k is r-feasible under limited collusion with a two stage group lending arrangement. Then, k is r-feasible in a two stage group lending arrangement in which the lender uses only IFR contracts.*

Lemma 3, together with Remark 5, establishes that a combination of sequential lending with IFR is the interesting class of institutions to examine.

Let $k^L(r)$ satisfy

$$\phi(k^L(r), r) = 1.$$

If $k^I(r) > 0$, then it follows that $k^L(r)$ is uniquely defined (this is because of Lemma 2 and the fact that as k increases to $k^0(r) > 0$, where recall that $\pi(k^0(r), r) = 0$, $\phi(k^0(r), r)$ goes to infinity.) Furthermore, $k^L(r) > k^I(r)$.

We now show that a necessary condition for a project size k to be r-feasible, is that k can not be more than $k^L(r)$.

First, note that in an IFR scheme, the default payoff for each borrower is decreasing in time. Thus, for the feasibility of such a scheme, it is sufficient to check the default incentives of the borrowers at exactly three dates: $t = \{0, t^2, 1\}$.

Now at $t = 0$, if there is a default, this will *adversely* affect the remaining m members as they would be denied any future loan. These borrowers will thus impose a penalty f on any defaulting members. Thus, the maximum payoff that a defaulting member gets at $t = 0$ is $b(k) - mf$. The continuation payoff for a borrower, however, is $\pi(k, r)$. Thus, the no default condition at $t = 0$ is

$$b(k) - mf \leq \pi(k, r). \tag{9}$$

Now consider the date t^2 at which the remaining m borrowers receive their loans. Since $k > k^I(r)$, for the second group of members not to default, the first group of borrowers must impose the social sanction. Thus, as in (9), we must also have

$$b(k) - (n - m)f \leq \pi(k, r). \tag{10}$$

Now for group 2 borrowers to be sanctioned by the first group, default at t^2 must *adversely* affect the borrowers in that group. Since the continuation payoff of the first group of borrowers at any date is at most $\pi(k, r)$, it follows that at t^2, for group 1 members to impose the sanction, a necessary condition is

$$b(k)(1 - t^2) \leq \pi(k, r). \tag{11}$$

Finally, at $t = 1$, since the first group of borrowers would have completed their projects, no further sanctions will be forthcoming from this group. Thus, at $t = 1$, the no default condition for a borrower in the second group is simply

$$b(k)t^2 \leq \pi(k,r). \tag{12}$$

Adding equations (11) and (12), one obtains $b(k) \leq 2\pi(k,r)$ as a necessary condition for k to be r-feasible. This is equivalent to $\phi(k,r) \leq 1$, i.e. $k \leq k^L(r)$, thus establishing the claim.

It may be of interest to observe that $k^L(r)$ is independent of the magnitude of either f, or n. Thus, no matter how large either f or n is, project size larger than $k^L(r)$ can not be r-feasible. The next proposition establishes sufficient conditions on f and n for which project size $k^L(r)$ is in fact r-feasible.

Proposition 2. *Assume that* $b(k^L(r)) - \pi(k^L(r),r) \leq \frac{nf}{2}$.[16] *Then, under limited collusion and a two stage sequential lending scheme, a project of size* k *is* r*-feasible if and only if* $k \leq k^L(r)$.

Before we turn to proving this result, a couple of remarks might be useful.

Remark 6. *Since for any* $f > 0$ *(no matter how small), it is always possible to choose* n *large enough such that the condition in Proposition 2 is satisfied, it follows that the conclusion of Proposition 2 holds as long as the choice of* n *is unrestricted for the MFI.*

Remark 7. *It is of interest to examine the maximum* r*-feasible project size when* nf *is small, so that* $b(k^L(r)) - \pi(k^L(r),r) > \frac{nf}{2}$. *It is straightforward to argue that the maximum* r*-feasible project size in that case is given by the maximum* $\hat{k}$ *for which* $b(\hat{k}) - \pi(\hat{k},r) = \frac{nf}{2}$.

Proof of Proposition 2. Necessity is already proved. To prove sufficiency, recall that $\frac{nf}{2} \geq [b(k^L(r)) - \pi(k^L(r),r)]$. Consider any $k > 0$ such that $\phi(k,r) \leq 1$. We will show that there exists a two stage procedure under which k is r-feasible. The interesting case to consider is when $k > k^I(r)$, since for $k \leq k^I(r)$, we can always choose a trivial two-stage group where all borrowers obtain their loans at the same time.

Let $t^2 \in (0,1)$ satisfy

$$t^2 b(k) = \pi(k,r). \tag{13}$$

Since $k > k^I(r)$, it follows that $b(k) > \pi(k,r)$ and thus (13) has a unique solution $t^2 \in (0,1)$.

Consider now a two stage procedure in which half of the n borrowers receive their loan at $t = 0$, half at t^2, and every borrower has a repayment obligation given by the IFR corresponding to (k,r). Since $\frac{nf}{2} \geq [b(k^L(r)) - \pi(k^L(r),r)]$, and $b(k) - \pi(k,r)$ is increasing in k, it follows that at $k \leq k^L(r)$, equations (9) and (10) will both be satisfied as long as a defaulting member faces a sanction of $\frac{nf}{2}$.

Now, in the event of any default at $t = 0$, sanctions will be imposed by the members who are yet to get get their loan as they will be adversely affected. Given (9), none of the borrowers receiving their loans at $t = 0$ is thus going to default.

Next consider $t = t^2$. We show that default at this date by any member in the second group must *adversely* affect all members in the first group who obtained their loan at $t = 0$.

Case (i). $t^2 \geq \frac{k(1+r)}{F(k)}$: In this case, at t^2, the first set of borrowers would have already repaid their loans, and therefore, their continuation payoff at this date equals $F(k)(1 - t^2)$, which is strictly greater than $b(k)(1 - t^2)$.

[16] Strictly speaking, this condition assumes that n is even. When n is odd, Proposition 2 holds whenever $b(k) - \pi(k,r) \leq \frac{(n-1)f}{2}$. In the sufficiency part, we then take the two sub-groups to be of size $n-1$, and $n+1$.

Case (ii). $t^2 < \frac{k(1+r)}{F(k)}$: In this case, the continuation no default payoff to any such borrower at t^2 is exactly $\pi(k,r)$. Now the default payoff at t^2 equals $b(k)(1-t^2)$ which, by equation (13), equals $b(k) - \pi(k,r)$. Since $\phi(k,r) = \frac{b(k)}{\pi(k,r)} - 1 \leq 1$, it follows that $b(k) - \pi(k,r) \leq \pi(k,r)$. Thus, default at t^2 will adversely affect the first set of borrowers.

Thus in either case a default by any member of the second group adversely affects all members in the first group, and a defaulting borrower at this date will attract a social penalty of f from all $n/2$ borrowers in the first group. Thus, a group 2 member will not default at t^2.

Finally, consider $t = 1$. If at this date, the second group has already repaid their loans, then their continuation payoff is $F(k)t^2$, which is strictly greater than $b(k)t^2$. On the other hand, if at $t = 1$, the second set of borrowers are yet to repay, then the continuation no default payoff to a borrower in this group is $\pi(k,r)$, while by defaulting she obtains $b(k)t^2$. Using (13), it then follows that a borrower can not be strictly better off by defaulting. □

Remark 8. *As in the individual lending scheme, a sequential joint liability scheme does* strictly *better when coupled with IFR, rather than with an one shot repayment scheme (Chowdhury et al. (2014)).*

We end this section with a brief discussion of the role played by some of the assumptions made earlier in Proposition 2, namely that repayments are non-negative, that cross-subsidizing is not allowed and that dynamic joint liability holds.

In case negative repayments are possible (so that the MFI may pay the borrower), one can show that any project size that yields a strictly positive payoff to a borrower is feasible using schemes in which every borrower pays the MFI an amount $F(k)$ at every instant the project is active. When all borrowers have completed their projects, the MFI then returns the amount $F(k) - k(1+r)$ to each of the borrowers (the proof is available on request). Such a scheme however is problematic on several counts, e.g. since it requires the MFI to credibly commit to returning the amount due to the borrowers. Such schemes would also be ruled out in case there is free entry by the MFIs. This is because such schemes would require higher repayments by the borrowers at some point of time. But at such points they may be lured away by competing MFIs, causing such schemes to unravel.

Proposition 2 also depends on the assumption that the lender is not allowed to cross-subsidize. Otherwise one can sustain a project size $k > k^L$, where both the borrowers obtain their loan simultaneously, but are required to repay different amounts. Then the borrower with the smaller repayment obligation may have little incentive to default herself and will therefore impose the social sanction in case of default by the other borrower. Now if the social sanction f is large, then this threat will ensure that the other borrower does not default either. Of course, since such schemes treat borrowers asymmetrically, such contracts might be unacceptable to the borrowers. Further, in the presence of free entry by MFIs, such schemes would unravel as the borrowers with higher repayment obligations may be lured away by other MFIs.

Finally, note that in our framework, there is dynamic joint liability so that once any group member defaults, all projects are dissolved. Such a scheme would then be *ex post* inefficient if default were to take place in equilibrium. However, given the current set up (with no uncertainties in production), no borrower defaults along an equilibrium and therefore, the outcome is efficient *ex ante*, as well as *ex post*.

More importantly however, it can be shown that weaker forms of dynamic joint liability suffices for our analysis. Consider default at time t by some borrower j, leading to borrower j's project being liquidated. Consider now a non-defaulting borrower. For such a borrower, assume instead a weaker form of joint liability under which such a borrower is allowed to continue with her project, but is subject to some penalty, e.g. that arising out of *static* joint liability (whereby non-defaulters are supposed to repay for the defaulters also). As long as the resultant continuation payoff is assumed to be less than the continuation payoff of this borrower in case there was no default, such a borrower will impose the social sanction on the defaulting borrower and Proposition 2 will continue to hold.

4.3 Two Stage Group Lending Schemes with Side Payments

We next study group lending schemes under 'complete collusion' that allows for side transfers among borrowers. We model this situation simply, by taking the group as a single entity that decides on its default decision, so as to maximize the aggregate group payoff.

The possibility of such side transfers have two opposing effects on the repayment incentives. On one hand, since the group acts as a single entity, it follows that social sanctions will never be invoked in this case. This effect, which is in line with Aghion and Morduch (2005, pp. 125), tends to increase default incentives. On the other hand, if the group decides to default early, it takes into account the possible loss such default will inflict on the members who will be denied loans in the future. This effect will then dampen default incentives of the group. Interestingly, however, we show that when n is large such that the condition in Proposition 2 holds, the first effect always dominates and the maximum loan size that is feasible under complete collusion, is strictly less than $k^L(r)$. Even in this case, however, group lending schemes allow one to sustain higher loan sizes compared to that under individual lending.

As earlier, we denote a two-stage scheme by $< n, m, t^2, k, y^i(t^i+\tau, k) >$ in which $y^i(t^i+\tau, k) \geq 0$ for $\tau \in [0, 1]$ and $i = 1, 2$. Since side transfers are possible, to check for default incentives at any time t, one needs to compare the aggregate default payoff of the group and compare it with the non-default continuation payoff for the entire group. Since the social sanction will never be imposed by the group, the magnitude of f does not have any effect on the repayment behavior of the group.

Given $< n, m, t^2, k, y^i(t^i + \tau, k) >$, let $P^G(t)$ denote the *aggregate* continuation payoff of the group assuming the group never defaults on its repayment obligations and $D^G(t)$ denote the group's aggregate default payoff at t.

A *two-stage group arrangement* $< n, m, t^2, k, y^i(t^i + \tau, k) >$ is said to be r-feasible if for all $t \in [0, 1 + t^2]$,

- $P^G(t) \geq D^G(t)$, and
- $\int_{\tau=0}^{1} y^i(t^i + \tau, k)d\tau = k(1 + r)$ for $i = 1, 2$.

In such a case, we say that a project size k is r-feasible under a two stage procedure with side transfers.

As in Lemma 3, it can be shown that in our search for an optimal two stage group lending arrangement, it is sufficient to restrict attention to IFR schemes.[17]

Given such a two stage scheme, to check for the no default conditions for the group, consider $t = 0$, when the first group of borrowers, numbering $n - m$, receive their loans. If they default, the group will have an aggregate payoff of $(n - m)b(k)$ and thus the group will not default at $t = 0$ if

$$(n - m)b(k) \leq n\pi(k, r). \tag{14}$$

Consider now the date t^2 at which the remaining m borrowers receive their loans. Now if the group plans to default at this date, the net payoff is given by $(n-m)b(k)(1-t^2)+mb(k)$, whereas

[17] The proof is available upon request.

the *maximal possible* continuation payoff at t^2 in case of no default is $n\pi(k,r)$. A *necessary* condition for default to be unprofitable at t^2 is then $(n-m)b(k)(1-t^2)+mb(k) \leq n\pi(k,r)$ which can be re-written as

$$nb(k) - t^2(n-m)b(k) \leq n\pi(k,r). \tag{15}$$

Dividing both sides of the preceding inequality by $n\pi(k,r)$ and recalling that $\phi(k,r) = \frac{b(k)}{\pi(k,r)} - 1$, we find, after rearranging terms that $\phi(k,r) \leq \frac{t^2(n-m)b(k)}{n\pi(k,r)}$. Whereas from (14) it follows that $\frac{(n-m)b(k)}{n\pi(k,r)} \leq 1$. Combining the preceding two inequalities, it then follows that

$$\phi(k,r) \leq \frac{t^2(n-m)b(k)}{n\pi(k,r)} \leq t^2. \tag{16}$$

Finally, at $t = 1$, the default payoff is $mb(k)t^2$, while the maximum continuation payoff for these m borrowers is at most $m\pi(k,r)$. For default to be non-profitable at date $t = 1$, it is therefore necessary that

$$t^2 \leq \frac{\pi(k,r)}{b(k)}. \tag{17}$$

Equations (16) and (17) thus imply that for feasibility of a scheme, t^2 should neither be too late (otherwise default incentives at $t = 1$ are too large), nor too early (otherwise default incentives at $t = t^2$ are too large).

We now provide a set of necessary conditions for a project size k to be r-feasible.

Let $k_1(r)$ and $k_2(r)$ satisfy

$$\phi(k_1(r),r) = \frac{\pi(k_1(r),r)}{b(k_1(r))}; \quad \text{and} \quad \phi(k_2(r),r) = \frac{k_2(r)(1+r)}{F(k_2(r))},$$

respectively. We need Lemma 4 below (the proof is in Chowdhury *et al.* (2014)):

Lemma 4 *Under A.1, we have*

(a) $k \leq k_1(r)$ *if and only if* $\phi(k,r) \leq \frac{\phi(k,r)}{b(k)}$, *and*

(b) $k \leq k_2(r)$ *if and only if* $\phi(k,r) \leq \frac{k(1+r)}{F(k)}$.

Given Lemma 4, it then follows that $k_1(r)$ and $k_2(r)$ are well defined. Further, Lemma 4 also establishes that $k^C(r)$, defined as solving

$$k^C(r) = min\{k_1(r), k_2(r)\},$$

is well defined and satisfy $\phi(k,r) \leq min\{\frac{\pi(k,r)}{b(k)}, \frac{k(1+r)}{F(k)}\}$ if and only if $k \leq k^C(r)$.

Proposition 3 below shows that for any n, if a project of size k is r-feasible, then $k \leq k^C(r)$. The converse, however, does not necessarily hold. The difficulty arises because with n being a fixed integer and $\phi(k,r)$ taking values in a continuum, it may not be possible to satisfy the default constraints at all the dates using only finitely many group compositions.[18] On the other hand, if the choice of n was unrestricted, one can prove

Proposition 3. *(a) [Necessity.] If a project of size k is r-feasible, then the project size k cannot be too large, i.e. $k \leq k^C(r)$.*

[18]If one is willing to ignore the integer issue and treat n as a continuous variable, then it is easy to modify the present proof of Proposition 3 and show that for any n, a project size k is r-feasible if and only if $k \leq k^C(r)$.

(b) *[Sufficiency.] If for a project of size k it is the case that $k < k^C(r)$,*[19] *then there exists a group size n and a group lending arrangement $< n, m, t^2 >$ with immediate and frequent repayment for which a project of size k is r-feasible.*

Proof. Please see Chowdhury *et al.* (2014).

Remark 9. *Interestingly, for the complete collusion case, it is not necessarily the case that for every parameter configuration, the maximum r-feasible project size using a one shot repayment is strictly less than $k^C(r)$ (Chowdhury et al., 2014, provides an example that demonstrates this).*

We now use Propositions 1, 2 and 3, to compare the maximal loan size that can be sustained under various lending schemes and various scenarios. Recalling that $k^I(r)$ (respectively $k^L(r)$) is the maximum loan size that is r-feasible under individual lending (respectively two-stage lending with limited collusion), we have

PROPOSITION 4. *$k^L(r) \geq k^C(r) \geq k^I(r)$, with both inequalities being strict whenever $k^I(r) > 0$.*

Proof. Suppose that $k^I(r) > 0$, then $k^I(r)$ is given by $\phi(k^I(r), r) = 0$. Moreover, since $\phi(k^C(r), r) > 0$ and $\phi(k, r)$ is increasing in k, we have $k^C(r) > k^I(r)$. From the definition of $k^C(r)$, we have $\phi(k^C(r), r) \leq \frac{k^C(r)(1+k^C(r))}{F(k^C(r))} < 1 = \phi(k^L(r), r)$ and thus by Lemma 2, $k^C(r) < k^L(r)$. □

One interesting implication of the fact that $k^C(r) < k^L(r)$, is that if $\frac{nf}{2}$ is large enough so that Proposition 2 holds, then larger loan sizes can be sustained under group lending in case collusion is limited, a result that is consistent with Abbink *et. al.* (2006), Wydick (1999), Gine and Karlan (2014) and Ahlin and Townsend (2007), who find that the extent of default increases as cooperation among group members increase.

The intuition of this result is not straightforward as there are two countervailing forces at work here. First, the fact that social sanctions have no bite under complete collusion, makes loans harder to recover, the fact that default decisions take group payoffs into account, makes loans easier to recover. Which effect should dominate? Given any $f > 0$, if n is large enough, then aggregate social sanction can be made large enough to control default incentives under limited collusion. Since social penalties have no bite in the case of complete collusion, it then follows that a larger project size is r-feasible under limited collusion. On the other hand, if n or f are small, then aggregate social sanctioning has a very limited role in constraining default under limited collusion. Thus, in this case the first effect is negligible, so that a higher project size will be feasible under the complete collusion case.

4.4 Sequential Lending and IFR: An Interactive Effect

This subsection demonstrates that a scheme involving both sequential group lending and IFR amounts to more than the sum of its parts (i.e. IFR and sequential group lending), in the sense that the *interaction* between the two generates significant synergies in terms of the maximal r-feasible project size k.

Consider a situation where $1 + b'(0) \geq F'(0)$ and $b'(0) \geq 1$. Since, $\forall k$, $F(k) - k \leq b(k)$, it follows that $F(k) - k(1 + r) \leq b(k)$, i.e. $k^I(r) = 0$. It then follows from Proposition 1 that for

[19] It might be of some interest to note that while $k^C(r)$ satisfies the necessary condition for *feasibility*, it is not possible to construct a two stage feasible arrangement if $\phi(k^C(r))$ is an irrational number (see the proof of the Proposition 3).

every $r \geq 0$, no positive positive project size is r-feasible under individual lending with IFR. Next consider group lending with one shot repayment. Since $\lim_{k \to 0} F'(k) = \lim_{k \to 0} \frac{F(k)}{k} \leq 2$, by strict concavity, $\frac{F(k)}{k} < 2$ for $k > 0$. Whereas by mimicking the argument in Remark 8 in Chowdhury *et al.* (2014), it can be shown that irrespective of whether collusion is limited, or complete, for any k to be feasible, it must be the case that $\frac{F(k)}{k(1+r)} \geq 2$, so that $\frac{F(k)}{k} \geq 2$. Thus no positive project size is r-feasible under either limited or complete collusion using one shot repayment contracts.

Consider now group lending using IFR. It can be shown that even under these conditions, a combination of these two can not only sustain a strictly positive project size, but possibly even the efficient one (see Propositions 2 and 3 for sufficient conditions). In Chowdhury *et al.* (2014) we also provide an example demonstrating this point. Thus, there exists a broad range of parameter values for which neither IFR, nor sequential lending can sustain any positive project size by themselves, but a combination can sustain strictly positive amounts, thus establishing the existence of an interactive effect.

Thus this interactive effect not only provides a justification for considering a framework with both IFR and sequential group lending, but further an explanation as to why, in reality, these two schemes often go together (in particular in case of those MFIs following the Grameen I mechanism). Moreover, this result has significant implications for empirical analysis as it suggests that any empirical work that examines either IFR or sequential lending in isolation, may significantly underestimate the power of sequential lending when combined with IFR.

4.5 Multi-stage Group Lending Schemes

So far, our analysis has focussed on the situation where the lender is restricted to use group lending schemes with a limited number of stages, in particular schemes with two stages. While this appears to be a reasonable assumption empirically, it is of some interest to analyze how our results would be modified if the lender could use a group lending scheme with any number of stages. An earlier version of this paper had a detailed analysis of this issue. For completeness, we report only the main findings here (the exact statements and proofs are available on request).

First, in the case of limited collusion, we demonstrated that for any $f > 0$, and (k, r) such that $\pi(k, r) > 0$, one can always choose n large enough and a group lending scheme with S stages, $S \geq 2$, in which the project size k is r-feasible, demonstrating the power of sequential lending. The role of sequentiality is critical here, as the multi-stage nature of the scheme ensures that by the time the penultimate group of borrowers complete their projects, the final group of borrowers would be nearing the end of their own projects, and would have no incentive to default. Moreover, we find that the corresponding repayment scheme need not be too protracted. However, in an environment of complete collusion, the result is strikingly different. Indeed, we showed that for any given (k, r), if a project size k is r-feasible, then it must be that $\phi(k, r)$ is no more than 2. This result thus strengthens our intuition that complete collusion may have serious efficiency costs, even when rather complex schemes are allowed for.

We end this section by pointing out a connection between the group liability contract under complete collusion, and the contract under a scenario where there is only one single borrower who can, however, undertake more than one possible project.[20] Assume that there are n projects of the type that we have considered so far. Then, using our earlier analysis, it follows that if the MFI funds all the n projects at $t = 0$, then because of the incentive constraints, each project can be funded up to at most $k^I(r)$, i.e. the maximal r-feasible level under individual lending.

[20]We thank Maitreesh Ghatak and an anonymous commentator for bringing this point to our attention.

The lender, however, can improve matters by financing only $n-m$ of the projects at $t=0$, and fund the remaining m projects at some appropriate date later on, provided the borrower does not default on any of the existing projects. It is clear that this situation is isomorphic to the situation of group lending with complete collusion and thus from Proposition 3, such staggered financing will enable larger k to be r-feasible for each of these projects.

5 Endogenous Choice of r, k,the Number of Borrowers, Group Composition, and Lending Schemes

In this section, we endogenously solve for several variables of interest, including the decision regarding whether to opt for individual, or group lending.[21] We therefore consider a scenario where, under individual lending, the MFI decides on (i) the common loan size k for each of the borrowers, (iii) the common rate of interest r on each loan, and (iii) N, the number of borrowers that it wants to lend to. Further, in case of a group lending arrangement, the lender also has to decide on the number of groups, say m, as well as the size of each group, call it n, so that the total number of borrowers lent to, $M = mn$.

The objective behind developing this framework is to then use it to analyze several questions of interest and possible policy relevance in the next section. To keep the analysis tractable and simple, when considering the group lending regime, we will only consider a scenario with limited collusion. The task of characterizing the optimal contract in the case of complete collusion turns out to be significantly more complicated.

In what follows, we allow for the possibility that the MFI is socially motivated, i.e. it cares for its borrowers, which is, as discussed earlier, a natural assumption in this context. The overall payoff of the MFI from lending to a single borrower, denoted $W(k, r; c, \beta) = (r-c)k + \beta\pi(k, r)$, puts some weight on the borrower's payoff $\pi(k, r)$, where this weight is captured by $\beta \in [0, 1)$. For $\beta = 0$, we have a profit-maximizing MFI.

The following assumption will be maintained in the rest of the analysis.

A.2. *$F(k) - \mu b(k)$, is strictly concave in k, for all $\mu \in [0, 1]$.*

Note that A.2 is satisfied whenever either $b(k)$ is convex, or $b(k) = \gamma F(k)$, $\gamma \in (0, 1)$.

For ease of exposition, we begin by fixing N under individual lending, as well as n and m under group-lending, and then characterize the optimal choices of (k, r) under both regimes. These results are then used to develop a framework in which one can endogenously solve for n, m and N.

5.1 Individual Lending

Consider the MFI's optimization problem given the total number of borrowers, N. Since all borrowers are identical, the optimization problem of the MFI simplifies to maximizing the per borrower payoff, i.e.

$$\max_{k,r} W(k, r; c, \beta) = [(r-c)k + \beta\pi(k, r)],$$

subject to the no default constraint

$$0 \geq \phi(k, r),$$

[21] We are grateful to Maitreesh Ghatak of this journal and to an anonymous commentator who suggested that we study these questions.

obtained from Proposition 1.[22]

It is easy to check that at the optimal solution, denoted (k_I, r_I), the no default constraint for a borrower must bind. Otherwise $\phi(k_I, r_I) > 0$. Next since $\beta < 1$, by increasing the interest rate slightly the MFI can increase its overall payoff, while ensuring that the ND constraint is satisfied. Thus given $\phi(k_I, r_I) = 0$, it follows that $rk_I = F(k_I) - k_I - b(k_I)$. Substituting this into $W(k, r; c, \beta)$, one can rewrite the per borrower payoff to the lender as

$$F(k_I) - k_I(1 + c) - (1 - \beta)b(k_I).$$

The choice of k_I then solves[23]

$$F'(k_I) - (1 - \beta)b'(k_I) = 1 + c. \tag{18}$$

Finally, r_I is given from the equation that $\phi(k_I, r_I) = 0$, so that

$$r_I = \frac{F(k_I)}{k_I} - 1 - \frac{b(k_I)}{k_I}.$$

Note that (k_I, r_I) is independent of N. Further, relating these choices to Proposition 1, we find that $k_I = k^I(r_I)$, i.e. the MFI selects the maximal r_I-feasible project size if (i) r is set equal to r_I and (ii) the no default condition binds.

Let $W_I = W(k_I, r_I; c, \beta)$ denote the per borrower payoff of the MFI evaluated at the optimal individual lending contract.

5.2 Group Lending with Limited Collusion

Assume now that the MFI decides to lend to a group consisting of n borrowers with limited collusion possibilities. Then, to maximize per borrower MFI payoff $W(k, r; c, \beta)$, the lender will choose (k_g, r_g) to maximize

$$W(k, r; c, \beta) = [(r - c)k + \beta\pi(k, r)],$$

subject to the no default constraint obtained from Proposition 2, i.e.

$$1 \geq \phi(k, r).$$

We shall focus on the case where $\frac{n_g f}{2} \geq b(k_g) - \pi(k_g, r_g)$, thus ensuring that k_g is r-feasible.[24]

As before, the no default constraint binds at the optimum. Thus the choice of (k_g, r_g) satisfies $\phi(k_g, r_g) = 1$, which yields $\frac{b(k_g)}{\pi(k_g, r_g)} = 2$. Using this condition, one can rewrite the per borrower objective function of the lender as

$$F(k_g) - k_g(1 + c) - (1 - \beta)\frac{b(k_g)}{2}.$$

[22] It is possible that at the optimum, the per borrower *profit* of the MFI, i.e. $(r - c)k$, could be negative. To ensure that the MFI makes a non-negative profit for each borrower, one can introduce an additional constraint, namely $(r - c)k \geq 0$, in the MFI's optimization problem. This will not qualitatively affect any of our results.

[23] The second order condition is satisfied since for all k, $F''(k) - (1 - \beta)b''(k) < 0$ (from (A.2)).

[24] In Remark 10 of Chowdhury *et al.*, 2014, we discuss how our results change if $\frac{n_g f}{2} < b(k_g) - \pi(k_g, r_g)$, so that Proposition 2 does not apply.

The optimal k_g is then obtained from

$$F'(k_g) - (1-\beta)\frac{b'(k_g)}{2} = 1 + c, \tag{19}$$

and r_g can be solved using the fact that $\phi(k_g, r_g) = 1$, or that

$$r_g = \frac{F(k_g)}{k_g} - 1 - \frac{b(k_g)}{2k_g}.$$

Note that (k_g, r_g) do not depend on either the number of groups, or on group composition, as long as the condition $\frac{n_g f}{2} \geq b(k_g) - \pi(k_g, r_g)$ is satisfied. Further, comparing the outcome with Proposition 2, we find that $k_g = k^L(r_g)$, i.e. the MFI selects the maximal r_g-feasible project size.

Let $W_g = W(k_g, r_g; c, \beta)$ denote the per borrower payoff of the MFI evaluated at the optimal group lending contract with limited collusion.

5.3 Comparing Project Size and Per Borrower Payoff under the Two Regimes

We first observe that $k_g > k_I$.[25] If not, then from equation (19), we have

$$\begin{aligned} 0 &= F'(k_g) - (1+c) - (1-\beta)\frac{b'(k_g)}{2} \\ &> F'(k_g) - (1+c) - (1-\beta)b'(k_g) \\ &\geq F'(k_I) - (1+c) - (1-\beta)b'(k_I) \end{aligned}$$

where the first inequality follows as $b'(k) > 0$, and the second inequality follows as we have assumed that $k_I \geq k_g$ and $F''(k) - (1-\beta)b''(k) < 0$ (from A.2). This, however contradicts equation (18).

Second, note that the per borrower payoff of the MFI is higher under group-lending, i.e. $W_g > W_I$. Note that $W_g \geq W_I$ since (k_I, r_I) satisfies the no default condition under group-lending, so that (k_I, r_I) is feasible under the group lending regime as well. The strict inequality follows since the optimal choice has $k_g > k_I$.

How does the payoffs of the borrower compare under these two arrangements? Since $\phi(k_I, r_I) = 0$, it follows that under the individual lending regime, the payoff to the borrower $\pi(k_I, r_I)$ equals $b(k_I)$. On the other hand, since $\phi(k_g, r_g) = 1$ under the optimal group lending contract, the payoff to the borrower $\pi(k_g, r_g)$ equals $\frac{b(k_g)}{2}$. Thus, even though $k_g > k_I$, the borrower's payoff in the group lending contract need not be higher than that under the individual contract. Intuitively, a relaxation of the no default constraint under group lending improves the lender's options. This not only allows it to increase project size, but also possibly ask for higher interests. Depending on which effect dominates, the borrower's payoff may either increase, or decrease. In fact in Chowdhury *et al.* (2014) we provide an numerical example that explicitly solves for the optimal (k, r) under both scenarios, showing that depending on the parameter values, a group lending arrangement could provide the borrower with a lower payoff.

5.4 Optimal Choice of Lending Regime

In this sub-section, we develop a framework which not only endogenizes the choice of n, m and N, but moreover compares the relative profitability of these two regimes for the MFI.

[25] Without further restrictions on $F(k)$ and $b(k)$, one cannot compare the optimal choices of r_g and r_I.

To this end, we posit costs involved in lending to the borrowers. Under individual lending with N borrowers, the lending cost is denoted $C(N)$. This cost is transactional and arises in the process of disbursement of loans, as well as the collection of the interest payments. Under sequential lending, there is an additional cost arising out of the fact that with loans being staggered, there would be diseconomies of scale. Further, the longer overall repayment period in this case adds to coordination costs since additional meetings have to be held, and the MFI has to deal with borrowers at different phases of project maturity. Furthermore, it is conceivable (although we do not model it here) that some unanticipated exogenous shocks may force a borrower to default involuntary. Under a group arrangement, such shocks will then lead to other projects being liquidated and/or social sanctions being invoked, thus increasing the overall cost of group lending. In general, then, one will expect group lending arrangements to have an additional cost component that depends on n, the number of borrowers in each group. We denote this component of the cost as $\lambda G(n)$, $\lambda > 0$, so that with m groups this cost becomes $\lambda m G(n)$. Thus the total costs under group lending is $C(mn) + \lambda m G(n)$. We assume that $C(N)$ and $G(n)$ are increasing and convex in their respective arguments, with $C(0) = G(0) = 0$.

We first consider the decision problem of the lender under individual lending. As argued in sub-section 5.1 earlier, for every borrower the MFI lends to, the optimal contract is (k_I, r_I) and the optimal per borrower payoff is W_I. With N borrowers, the net payoff of the MFI is

$$NW_I - C(N).$$

Let N_I^* denote the optimal number of borrowers under individual lending.

Under the group lending regime, the per borrower payoff to the lender from a group equals W_g. Therefore the total net payoff of the MFI when it lends to m groups, with each group containing n borrowers, is given by

$$nmW_g - C(mn) - m\lambda G(n).$$

Let n^* be the minimum even integer for which the no default condition holds, i.e. $\frac{n^* f}{2} \geq b(k_g) - \pi(k_g, r_g)$. Since the lender's maximand can equivalently be written as $mn[W_g - \frac{C(mn)}{mn} - \frac{\lambda G(n)}{n}]$, it follows that at the optimal choice of m and n, n must equal n^*. The optimization problem for the lender thus reduces to choosing an m so as to maximize

$$mn^* W_g - C(mn^*) - m\lambda G(n^*).$$

Let (m^*, n^*) denote the optimal choice under the group lending scheme.

We now provide a simple condition that determines whether the lender prefers group or individual lending. Let λ^* satisfy

$$W_g - W_I = \frac{\lambda^* G(n^*)}{n^*}. \tag{20}$$

Given that $W_g > W_I$, λ^* as defined in (20) is unique and strictly positive. We now argue that the MFI prefers individual lending to group lending if and only if $\lambda > \lambda^*$.

First consider the case where $\lambda > \lambda^*$. If the lender uses the individual lending program and lends to $m^* n^*$ borrowers, its net profit would have been $m^* n^* W_I - C(m^* n^*)$. Note that this payoff exceeds that from group lending if and only if $m^* n^* W_I - C(m^* n^*) > m^* n^* W_g - C(m^* n^*) - m^* \lambda G(n^*)$, i.e. $W_g - W_I < \frac{\lambda G(n^*)}{n^*}$, which is true given that $\lambda > \lambda^*$.

Next consider the case where $\lambda < \lambda^*$. Let m be defined as $\frac{N_I^*}{n^*}$, and consider a group lending regime where the lender lends to m groups, each containing n^* lenders. Since $\lambda < \lambda^*$, a similar argument as above establishes that group lending will be the preferred choice for the MFI.[26]

Finally, note that under the group lending the marginal net benefit per borrower is simply given by $W_g - \frac{\lambda G(n^*)}{n^*}$ while the marginal net benefit per borrower is W_I. Thus, ignoring integer constraint on the choice of the borrowers, it follows that the total number of borrowers under the group lending scheme mn^* is strictly greater than N_I^* if and only if $\lambda < \lambda^*$. We summarize the above discussions in the following proposition.

PROPOSITION 5. *Consider the MFI's choice over both the lending regimes, individual versus group lending with limited collusion.*

(i) *The optimal project size is larger under group-lending, i.e.* $k_g > k_I$.

(ii) *A borrower's payoff under group lending is strictly greater than that under individual lending if and only if* $b(k_I) < \frac{b(k_g)}{2}$.

(iii) *The MFI prefers the individual lending regime to the group lending regime if and only if* $\lambda > \lambda^*$, *where* λ^* *solves equation (20).*

(iv) *Outreach is higher under a group-lending mechanism if and only if the MFI prefers group-lending to individual lending.*

Note that this paper is one of the very few in the literature to compare the outcomes, in particular project size and outreach, under individual and group lending. One of the papers that does perform this exercise is de Quidt *al. (2012)* who compares the behavior of for-profit MFIs with market power, with not-for-profit lenders. They consider a framework with simultaneous lending and social capital. They find that the MFI prefers group contracts when the social capital is large. In contrast to our results however, they find that borrowers always prefer a group lending contract to an individual lending contract.

6 Effects of Competition: Transition to Individual Lending?

In recent years there has been a large increase in competition in the MFI sector all over the world, including in India. While such competition has been linked to various issues in the literature, e.g. double-dipping, default and even farmer suicides,[27] here we focus on a phenomenon that was roughly contemporaneous with the increase in MFI competition, namely a move away from group to individual lending in many cases. While such a transition can of course be triggered by various reasons, e.g. by an exogenous coordinated shock in the form of a cyclone as in case of Grameen I, we shall argue that our framework can provide a rich explanation for this transition that links it to the increased competition among MFIs.

To this end we focus on several possible effects of such increased competition, namely (i) increased competition for donor funds, possibly resulting in a higher opportunity cost of fund c for the MFIs, (ii) mission drift, leading to a fall in β, (iii) an increase in the reservation utility of the borrowers, i.e. $\bar{u}$, as the borrowers have access to competing MFIs and (iv) a decrease in

[26]This argument uses the fact $\frac{N}{n^*}$ is an integer. If this was not the case, one could choose $\hat{m}$ to be the largest integer for which $\hat{m}n^* \leq N$ and then use a mixed scheme, where $\hat{m}n^*$ borrowers are served under the group regime while the remaining borrowers $N - \hat{m}n^*$ are served individually. The total payoff from this scheme must be strictly higher than the individual regime whenever $\lambda < \lambda^*$.

[27]Please see Guha and Roy Chowdhury, 2013, 2014, and Quidt *et al.*, 2012, for a discussion.

social sanctions.[28,29]

6.1 Change in the Opportunity Cost of Fund for the MFI

To examine the impact of a small increase in c, totally differentiate equations (18) and (19) with respect to c, to get

$$\begin{aligned}\frac{dk_I}{dc} &= \frac{1}{F''(k_I) - (1-\beta)b''(k_I)},\\ \frac{dk_g}{dc} &= \frac{1}{F''(k_g) - (1-\beta)b''(k_g)/2}.\end{aligned}$$

From A.2, it is immediate that $\frac{dk_I}{dc} < 0$ and $\frac{dk_g}{dc} < 0$. Thus with an increase in c, the optimal project size decreases under both individual and group lending regimes. Further, since the payoffs of all borrowers equal $b(k_I)$ under individual, and $b(k_g)/2$ under group lending, the payoff to a borrower must also decrease since project size decreases under both lending schemes.

To examine the effect on the per borrower payoff W_I of the MFI, one can use the envelope theorem to show that $\frac{dW_I}{dc} = -k_I$, and $\frac{dW_g}{dc} = -k_g$, so that both W_I and W_g decreases with an increase in c. Further, since $k_g > k_I$, W_g increases relatively more compared to W_I, so that $W_g - W_I$ increases. Thus from equation (20), it follows that λ^* will decrease for a small increase in c making group lending less profitable.[30]

6.2 For-profit MFIs: Change in β

Increase in competition among MFIs is likely to be associated with mission drift, formalised as a decline in β.[31] How does a small change in β affect the outcome? Totally differentiating equations (18) and (19) with respect to β, we find that

$$\begin{aligned}\frac{dk_I}{d\beta} &= -\frac{b'(k_I)}{F''(k_I) - (1-\beta)b''(k_I)},\\ \frac{dk_g}{d\beta} &= -\frac{b'(k_g)/2}{F''(k_g) - (1-\beta)b''(k_g)/2}.\end{aligned}$$

Given A.2, the optimal project size decreases under both individual, as well as group lending regimes with a fall in β. Consequently, the payoff to a borrower must also decrease under both lending schemes.

We next examine how a change in β affects the per borrower payoff $W(k, r; c, \beta)$ of the MFI under both regimes. From the envelope theorem note that under individual lending $\frac{dW_I}{d\beta} = \frac{\partial W_I}{\partial \beta} = b(k_I)$, whereas $\frac{dW_g}{d\beta} = \frac{\partial W_g}{\partial \beta} = \frac{b(k_g)}{2}$ under group-lending. With a decrease in β, both W_I and W_g will decline. However, W_g will decline relatively more compared to W_I, if and only if

[28] Further, consider a scenario where the interest rate is exogenously fixed by a regulatory agency/government, but is susceptible, in the long run, to competitive pressures. Chowdhury *et al.* (2014) shows that an increase in the number of MFIs would, under certain conditions, cause a switch to individual lending in the long run if competitive pressures force the government to lower the interest rates.

[29] Formally, the argument depends on how these factors affect λ^*. Given Proposition 5(iii), an increase in λ^* indicates whether group lending becomes relatively more profitable compared to individual lending.

[30] This argument assumes that $\frac{n^* f}{2} > b(k_g) - \pi(k_g, r_g)$. If the constraint on n^* binds, one needs to consider the effect of change in n^* since with an increase in c, $\pi(k_g, r_g)$ will decrease and this may necessitate an increase n^*. However, as long as $G(n)/n$ does not increase too quickly with n, we expect our result to hold.

[31] Given the recent crisis in the MFI sector in Andhra Pradesh, India following the entry of large MFIs (de Quidt *et al.*, 2012), the analysis of for-profit MFIs and the possibility of mission drift have gained in importance.

$b(k_I) < \frac{b(k_g)}{2}$. Thus, under the same conditions, λ^* will decrease following a small decrease in β, and group-lending becomes relatively less attractive to the MFI.

6.3 Reservation Utility

With increased MFI competition, one can expect the reservation utility of the borrowers, $\overline{u}$, to increase as they have the option of moving to other MFIs. In order to address the effects of such a change we next explicitly introduce the individual rationality constraint of the borrower, i.e. $\pi(k, r) - \bar{u} \geq 0$. For ease of exposition, we focus on the situation where the individual rationality constraint of the borrower is binding under both the lending regimes. In such a case, both W_g and W_I must decrease with an increase in $\bar{u}$. However, it can be shown that W_g decreases at a faster rate than W_I resulting in a decrease in λ^*. Thus, an increase in $\bar{u}$, associated with increased competition among MFIs may result in individual lending becoming relatively more profitable.[32]

6.4 Social Sanctions

Since social capital/sanctions is one response to incomplete/thin markets, we conjecture that with an increase in MFI competition these mechanisms may become less effective. Moreover, with the sustained process of urbanization going on in most LDCs, it may be argued that social capital would decline among rural borrowers. How does this affect the trade-off between group and individual lending?[33] To begin with note that a change in f does not affect (k_g, n_g). However, from Proposition 2 we know that the group size n^* must satisfy $\frac{n^* f}{2} \geq b(k_g) - \pi(k_g, r_g)$. Thus, a sustained fall in f will lead to an increase in n^*. Given that $G(n)$ is convex and $G(0) = 0$, it then follows from equation (20) that λ^* will decrease. Consequently, with a decline in social capital, individual lending will become relatively more attractive for the MFIs.

Interestingly enough, the first two comparative statics results hinge on the basic theoretical point of our paper, namely that the no default constraint is relaxed under group lending, allowing for greater project sizes.

7 Conclusion

Given the recent success of micro-finance, in particular the high rates of repayment,[34] there is a natural interest in examining whether the innovative institutional features, in particular dynamic features like *sequential financing* and *dynamic joint liability* used by many MFIs, play a role in their success. We argue that a unified explanation of both these aspects can be built around dynamic incentives, in particular the simple idea that sequential lending can help resolve problems arising out of coordinated default. Further it helps clarify how social capital interacts with sequential financing in incentivizing repayment. In fact, this is one of the few papers in the literature that helps explain the mixed empirical findings regarding the impact of social capital.

In addition, the present framework also provides an explanation for early and frequent repayment schemes. *Inter alia*, it identifies a synergy between IFR and sequential lending, arguing that a lending mechanism involving both is more than the sum of its parts. Moreover,

[32]This result however may not necessarily hold when $\bar{u}$ is small and the reservation utility constraint is not binding under the individual lending regime (see Chowdhury *et al.* (2014)).

[33]We are indebted to a anonymous commentator for drawing our attention to this possibility.

[34]Hossein (1988), Morduch (1999) and Christen *et al.* (1994), all argue that the Grameen Bank has a repayment rate in excess of 90 percent.

this synergistic effect has important implications for empirical analysis as well, suggesting that while testing for the efficacy of group lending, any analysis that considers either sequential lending or IFR in isolation, may seriously under-estimate the power of the two taken together.[35]

Further, the tractability of the basic model allows us to endogenize the choice of several variables of interest, including the choice of loan scheme, one of the few papers in the literature to do so. Finally, we put our theory to the test, examining if it can provide an explanation of a somewhat puzzling fact, namely the switch from group to individual lending in recent years. We trace this transition to the increase in MFI competition that happened at the same time. Further, we show that the intuition for this result hinges on the basic theoretical point of our paper, namely that the no default constraint is relaxed under group lending.

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[35]In an earlier version we also examine the effects of gestation lags and uncertainty in project returns, arguing that the results in this paper are largely robust to these extensions.

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