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Group lending without joint liability

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ABSTRACT

This paper contrasts individual liability lending with and without groups to joint liability lending. We are motivated by an apparent shift away from the use of joint liability by microfinance institutions, combined with recent evidence that a) converting joint liability groups to individual liability groups did not affect repayment rates, and b) an intervention that increased social capital in individual liability borrowing groups led to improved repayment performance. First, we show that individual lending with or without groups may constitute a welfare improvement over joint liability, so long as borrowers have sufficient social capital to sustain mutual insurance. Second, we explore how the lender's lower transaction costs in group lending can encourage insurance by reducing the amount borrowers have to pay to bail one another out. Third, we discuss how group meetings might encourage insurance, either by increasing the incentive to invest in social capital, or because the time spent in meetings can facilitate setting up insurance arrangements. Finally, we perform a simple simulation exercise, evaluating quantitatively the welfare impacts of alternative forms of lending and how they relate to social capital.

1. Introduction

While joint liability lending by microfinance institutions (MFIs) continues to attract attention as a key vehicle of lending to the poor, recently some MFIs have moved away from explicit joint liability toward individual lending. The most prominent such institutions are Grameen Bank of Bangladesh and BancoSol of Bolivia.[1] However, interestingly, Grameen and other such MFIs who have made this shift have chosen to retain the regular group meetings that traditionally went hand-in-hand with joint liability lending.

It is not clear what factors are actually driving this trend, to the extent it exists.[2] Nevertheless, these phenomena raise the question of the costs and benefits of using joint liability, and the choice between group loans with and without (explicit) joint liability. The existing literature, in general, has focused more on the benefits of joint liability. Besley and Coate (1995) is an early exception, showing that while joint liability can increase repayment rates by inducing borrowers to insure one another (repaying on behalf of their unsuccessful partners), there are also states of the world where a borrower who is expected to repay her partner's loan may instead default, even though she would be willing and able to pay back her own loan. Using a limited enforcement or "ex-post moral hazard" framework introduced in the group lending context by Besley and Coate (1995), in this paper we study several issues raised by this apparent shift.

Our analysis is motivated by evidence from Giné and Karlan (2014) who find that randomly converting joint liability groups to individual liability at a Philippines MFI had no effect on average repayment rates. We analyze how by leveraging the social capital of borrowers, individual liability lending (henceforth, IL) can mimic or even improve on the insurance arrangement reached under explicit joint liability (EJ), increasing repayment and borrower welfare. When this occurs, we term it "implicit joint liability" (IJ). Intuitively, in those states of the world where a borrower is able to repay her own loan but not that of her partner, IJ allows her to do this, yet in states of the world where she *could* repay her partner's loan, social capital is leveraged to encourage her to do so. EJ does not permit such flexibility. The model has subtle implications for contract choice. From the existing literature, the general impression is that all else equal, more social capital increases the advantage of explicit joint liability relative to individual liability, such that individual liability is optimal for low social capital and joint liability for high social capital. We show that the relationship is not so straightforward. For low social capital, individual liability is still preferred, for intermediate levels of social capital, explicit joint liability is preferred,

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[1] For a discussion of the reasons for the shift in Grameen Bank's lending strategy, see Muhammad Yunus's article "Grameen Bank II: Lessons Learnt Over Quarter of A Century," at http://www.grameen.com/index.php?option=com_content task = view id = 30 Itemid = 0, accessed 18 December 2012.

[2] In a companion paper (de Quidt et al., 2013), we present data from the MIX Market suggesting a modest decline in the use of "solidarity group" lending between 2008 and 2010 (the years for which good quality data on lending methods are available). This is the closest measure we have of the use of explicit joint liability. Solidarity group loans are those for which "some aspect of loan consideration depends on the group, including credit analysis, liability, guarantee, collateral, and loan size and conditions" (see http://www.mixmarket.org/about/faqs/glossary). In that paper we propose a theoretical argument that commercialization, in particular, the rise of for-profit MFIs, could be playing a role in the decline of joint liability lending.

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but for high social capital individual liability can once again dominate, due to its ability to induce welfare-improving implicit joint liability.

Since the previous argument does not rely on borrowing groups (though we believe implicit joint liability is likely to be easier in a group context), we next introduce a purely operational argument for group lending under IL. Group lending can reduce the lender's transactions costs, shifting the time burden to the borrowers. This is valuable because it enables the lender to cut interest rates, relaxing the borrowers' repayment incentive constraints, thus increasing repayment and welfare.

Finally, we consider evidence from Feigenberg et al. (2013), who find that an increase in the meeting frequency of individual liability borrowing groups created social capital, which led to a subsequent improvement in repayment rates. We discuss two mechanisms by which group meetings could create social capital or foster mutual insurance. First, because the more time borrowers spend together in groups, the more incentive they have to invest in social capital. Second, because maintaining an insurance arrangement requires spending time together, so group meetings can serve the dual purpose of repayment and insurance. Both mechanisms suggest that increasing meeting length or frequency could lead to more mutual insurance, however if borrowers are able to coordinate among themselves to spend time together, independent of the lender, artificially increasing meeting length or frequency with the aim of fostering insurance cannot increase welfare. In other words, an additional friction is required for the intervention of Feigenberg et al. (2013) to be welfare-improving.

Without any concrete evidence we can only speculate about what our theory implies about the apparent shift away from EJ to IL. The first part of our argument suggests that switching from EJ to IL can increase repayment rates if borrowers have sufficient social capital. This prediction is consistent with the evidence from Giné and Karlan (2014). Although the average effect on repayment of conversion to individual liability was zero, interestingly, repayment improved among borrowers with strong social ties, and deteriorated among borrowers with weak social ties, consistent with our theory.[3] The third part of our argument suggests that the creation of social capital through EJ may have paved the path for IJ in some cases, to the extent that it became the more efficient lending arrangement.

Finally, we carry out some simple simulation exercises using empirically estimated parameters. The goal is to complement the theoretical analysis and to get a quantitative sense of the welfare effects as well as the relevant parameter thresholds that determine which lending method is preferred. Our key findings are as follows. First, in low social capital environments, EJ does well compared to IJ. For example, at our benchmark parameter values, when social capital is worth 10% of the loan size, the welfare attainable under IJ is 32.4% lower than that under EJ. However, with social capital worth 50% of the loan size, the welfare attainable under EJ is 5% lower than that under IJ, and the advantage of IJ grows as the variance of borrower income increases. Second, we find that the interest rate, repayment rate and borrower welfare are all insensitive to social capital under EJ, whereas in the case of IJ, they are all highly sensitive. This is what we would expect, since EJ leverages both social capital and joint liability, while IJ leverages only social capital. To illustrate, under our benchmark parameter values, an increase in social capital from 10% of the loan size to 50% of the loan size increases borrower welfare under IJ by around 50%, while the effect is negligible under EJ. When borrower incomes are uncorrelated, the insensitivity of EJ to the level of social capital suggests that it is a fairly robust contracting tool across lending contexts. However, when borrower incomes are positively correlated the advantage of EJ disappears. Intuitively, EJ requires groups to either all repay or all default. When incomes are positively correlated it is common to have multiple project failures, and since bailing all of them out is hard, the whole group defaults. IJ is robust to such states of the world because it does not require the whole group to repay.[4]

Although the model highlights the potential costs of EJ, it is premature to write off EJ as a valuable contractual tool. Thus far we have one high quality randomized study of contractual form (Giné and Karlan, 2014) in which EJ seems not to play an important role. However in our theoretical analysis there are always parameter regions over which EJ is the most efficient of the simple contracts we analyze. A recent randomized control trial by Attanasio et al. (Forthcoming) finds stronger consumption and business creation impacts under EJ (albeit no significant difference in repayment rates — note that in their context mandatory group meetings are not used under either IL or EJ). Fenella et al. (2012) analyze an episode in which a lender switched from IL to EJ and found a significant improvement in repayment performance. For the same reasons, Banerjee (2013) stresses the need for more empirical work in the vein of Giné and Karlan (2014) before concluding that EJ is no longer relevant.

It is instructive to briefly look at the types of contracts currently used by MFIs. Cull et al. (2009) find that around two thirds of the MFIs in their sample (drawn from the MIX Market) predominantly use solidarity group loans (see footnote 1 above) or village banking, while around one third use individual lending; we find similar figures in de Quidt et al. (2013). Our concept of IJ is relevant to the "individual" category; the MIX Market notes that "loans based on consideration of the sole borrower, but disbursed through and recollected from group mechanisms, are still considered individual loans." A notable example is the Indian MFI Bandhan, which is one of the top MFIs in India, and is listed as having 3.6 m outstanding loans in 2011. Bandhan does not use joint liability but disburses the majority of its loans through borrowing groups. Unfortunately, we do not have data on the method of disbursement of the sample of loans classified as individual, but we believe that many institutions are indeed using groups to disburse individual loans.

Much of the existing theoretical work has sought to characterize conditions under which explicit joint liability can lead to efficiency gains compared to traditional individual liability loans (see Ghatak and Guinnane (1999) for a review) by relaxing the underlying incentive or self-selection constraints. Since most of the literature assumed competitive lenders, the benefits of these gains are passed on to borrowers via relaxation of borrowing constraints, and/or lower interest rates. A key mechanism that is used to explain persistence of poverty in development economics has at its center credit market imperfections, which are caused by informational and institutional frictions. While these can to some degree be mitigated by the use of collateral, by definition the poor do not have much in the way of collateralizable wealth. Therefore, they are likely to be credit constrained, thereby leading to a vicious cycle. A lot of the attention attracted by microfinance is because of its potential ability to tap into the information and enforcement advantages of the social networks the borrowers belong to, and harness it via joint liability to relax borrowing constraints. The literature has rationalized group lending starting with alternative types of credit market frictions – adverse selection, ex ante moral hazard, and ex post moral hazard or costly state verification – by highlighting the role of joint liability in generating peer selection, peer monitoring, and peer pressure. One of the broad theoretical points that emerge from the existing literature is that joint-liability loans are not always feasible, or even if they are, are not always efficient relative to individual-liability loans. Therefore, the fact that joint liability has both costs and benefits has always been implicit in the literature, but the focus mainly has been on mechanisms that harness the benefits. The model of Besley and Coate (1995), which is closest to ours in terms of the underlying credit market friction of ex post moral hazard, is an exception. It shows that joint liability gives borrowers an incentive to repay on behalf of their partner

[3] See Giné and Karlan (2014), Table 8. This suggests that the joint distributions of social capital and returns (which determine the size of the changes in repayment rates) are such that the two effects average out to zero.

[4] See also Allen (2014) for closely related discussions.

when the partner is unable to repay her own loan. If borrowers can threaten social sanctions against one another, this effect is strengthened further. However, there are two problems with EJ. Firstly, since repaying on behalf of a partner will be costly, incentive compatibility requires the lender to use large sanctions and/or charge lower interest rates, relative to individual liability.[5] Secondly, when a borrower is unsuccessful, sometimes EJ induces the successful partner to bail them out, but sometimes it has a perverse effect, inducing them to default completely, while under IL they would have repaid. Rai and Sjöström (2004) and (Bhole and Ogden (2010) approach these issues from a mechanism design perspective — designing cross-reporting mechanisms or stochastic dynamic incentives that minimize the sanctions used by the lender. Baland et al. (2013) provide an alternative explanation of the apparent trend away from what we call EJ toward IL, based on loan size. They find that the largest loan offered under IL cannot be supported under joint liability, and for borrowers with access to both types of lending arrangements, the benefits from the latter are increasing in borrower wealth. We do not focus on this angle but briefly touch on the issue of loan size in Section 2.5. Allen (2014) shows how partial EJ, whereby borrowers are liable only for a fraction of their partner's repayment, can improve repayment performance by optimally trading off risk-sharing with the perverse effect on strategic default. We focus on how simple individual liability lending with no joint liability can achieve these effects, as side-contracting by the borrowers can substitute for the lender's enforcement mechanism.

Our model is also related to Rai and Sjöström (2010). In that paper, borrowers are assumed to have enough social capital to support incentive-compatible loan guarantees through a side-contract, provided they have sufficient information to enforce such side contracts. The role of groups is to provide publicly observable repayment so as to enable efficient side-contracting. In contrast, in our setting, repayment behavior is common knowledge among the borrowers, and it is the amount of social capital that is key. Groups play a role that depends on meeting costs and time use introduced in the next two sections.[6]

Other than the above mentioned papers, our paper is also broadly related to the theoretical literature in microfinance that has emerged in the light of the Grameen Bank of Bangladesh abandoning explicit joint liability and switching to the Grameen II model, focusing on aspects other than joint liability, such as sequential lending (e.g., Chowdhury, 2005), frequent repayment (Fischer and Ghatak, 2010; Jain and Mansuri, 2003), exploring more general mechanisms than joint liability (e.g., Laffont and Rey, 2003), and exploring market and general equilibrium (Ahlin and Jiang, 2008; de Quidt et al., 2013; McIntosh and Wydick, 2005).

The paper is structured as follows: in Section 2 we present the basic model where in principle lending may take place with or without group meetings. We introduce our concept of implicit joint liability and show when it will occur and be welfare improving. Section 3 formalizes a key transaction cost in group and individual lending — the time spent attending repayment meetings. Section 4 then shows how meeting costs can give borrowers incentives to invest in social capital. Section 5 presents results of a simulation of the core model, and Section 6 summarizes the results and concludes.

2. Model

We model a lending environment characterized by costly state verification and limited liability. Borrowers are risk neutral, have zero outside option, no savings technology and limited liability. They have access to a stochastic production technology that requires 1 unit of capital per period with expected output $\overline{R}$, and therefore must borrow 1 per period to invest. There are three possible output realizations, $R \in \{R_h, R_m, 0\}$, $R_h \geq R_m > 0$ which occur with positive probabilities p_h, p_m and $1 - p_h - p_m$ respectively. We define the following:

$$p \equiv p_h + p_m$$
$$\Delta \equiv p_h - p_m$$
$$\overline{R} \equiv p_h R_h + p_m R_m.$$

We will refer to p as the probability of "success", and $\overline{R}$ as expected output. We assume that output is not observable to the lender and hence the only relevant state variable from his perspective is whether or not a loan is repaid. Since output is non-contractible, the lender uses dynamic repayment incentives, as in Bolton and Scharfstein (1990). We assume that if a borrower's loan contract is terminated following a default, she can never borrow again. Under individual liability (IL), a borrower's contract is renewed if she repays and terminated otherwise. Under explicit joint liability (EJ), both contracts are renewed if and only if both loans are repaid.[7]

We assume that pairs of individuals in the village share some pair-specific social capital worth S in discounted lifetime utility, that either can credibly threaten to destroy. In other words, a friendship yields lifetime utility S to each person. If the social capital is destroyed it is lost forever. We assume that each individual has a very large number of friends, each worth S. Thus each friendship that breaks up represents a loss of size S. We discuss microfoundations for S in Section 2.4 below.

We assume a single lender with opportunity cost of funds equal to $\rho > 1$. In the first period, the lender enters the community, observes S and commits to a contract to all potential borrowers. The contract specifies a gross interest rate, r and EJ or IL. We assume the lender to be a non-profit who offers the borrower welfare maximizing contract, subject to a zero-profit constraint.[8]

In this section we ignore the role of groups altogether — being in a group or not has no effect on the information or cost structure faced by borrowers and lenders. Although borrower output is unobservable to the lender, we assume it is observable to other borrowers. As a result, they are able to write informal side contracts to guarantee one another's repayments, conditional on the output realizations. For simplicity, in the theoretical analysis we assume that such arrangements are formed between pairs of borrowers.[9]

EJ borrowers will naturally side contract with their partner, with whom they are already bound by the EJ clause. Specifically, we assume that once the loan contract has been fixed, pairs of borrowers can agree a "repayment rule" which specifies each member's repayment in each possible state $Y \in \{R_h, R_m, 0\} \times \{R_h, R_m, 0\}$. Then in each period, they

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5 This issue is the focus of the analysis in Rai and Sjöström (2010). Because of this, de Quidt et al. (2013) show that with a for-profit monopolist lender borrowers are better off under EJ than IL lending, because the lender must typically charge lower interest rates under EJ.

6 Furthermore, in our model, borrowers are better off when they guarantee one another as their probability of contract renewal is higher. In (Rai and Sjöström, 2010) this is not the case as the lender is assumed to use a punishment that simply imposes a utility cost on the borrowers in case of default. In fact, the optimal contract delivers the same borrower welfare whether they guarantee one another or not.

7 The assumptions of no savings, permanent exclusion and simple contracts are fairly standard in this literature. No savings is necessary for dynamic incentives to be effective (Bulow and Rogoff, 1989), but we think not too extreme an assumption in the microfinance context, see e.g. Dupas and Robinson (2013a,b). There is some evidence (e.g. Allen, 2014) and plenty of theoretical work on more flexible contracts, e.g. Rai and Sjöström (2004), Tedeschi (2006), Bhole and Ogden (2010), de Quidt et al. (2013), we assume strict dynamic incentives and simple contracts to focus attention on the key social capital mechanism, and because we believe these are a good approximation to typical MFI practices. Relaxing the strength of dynamic incentives (for example by terminating with some probability smaller than one in the case of default) increases borrower welfare, but it cannot eliminate the central inefficiency in joint liability lending, namely that the lender must sometimes punish a borrower who could not repay her partner's loan but would have repaid her own. This inefficiency stems from the fact that the lender cannot observe the state of the world (income realizations), while borrowers are able to so can more efficiently contract on such states.

8 We abstract from other organizational issues related to non-profits, see e.g. Glaeser and Shleifer (2001).

9 This could be for example because there are two types of investment project available and returns within a project type are perfectly correlated, such that side-contracting with another borrower who has the same project type yields no benefit. In the simulations we extend the analysis to larger groups.

observe the state and make their repayments in a simultaneous-move "repayment game". Deviations from the agreed repayment rule are punished by a social sanction: destruction of S. The repayment rule, social sanction and liability structure of the borrowing contract thus determine the payoffs of the repayment game and beliefs about the other borrower's strategy. To summarize, once the lender has entered and committed to the contract, the timings each period are:

1. Borrowers form pairs, and agree on a repayment rule.
2. Loans are disbursed, borrowers observe the state and simultaneously make repayments (the repayment game).
3. Conditional on repayments, contracts are renewed or terminated and social sanctions carried out.
4. If an IL borrower's partner was terminated but she repaid, she rematches with a new partner.

We restrict attention to repayment rules that are stationary (depending only on the state) and symmetric (do not depend on the identity of the borrower). This enables us to focus on the stationary value function of a representative borrower. Stationarity also rules out repayment rules that depend on repayment histories, such as reciprocal arrangements. In addition, we assume that the borrowers choose the repayment rule to maximize joint welfare. Welfare maximization implies that social sanctions are never used on the equilibrium path, since joint surplus would be increased by an alternative repayment rule that did not punish this specific deviation. In other words, although there may be many equilibria of the repayment game and associated social game as defined below: we focus on the welfare maximizing one.[10]

Given repayment probability π, the lender's profits are:

$$\prod = \pi r - \rho$$

and therefore the zero-profit interest rate is:

$$\hat{r} \equiv \frac{\rho}{\pi}. \tag{1}$$

By symmetry, for interest rate r, each borrower i pays πr per period in expectation.

There are two interesting cases that arise endogenously and determine the feasibility of borrowers guaranteeing one another's loans. In Case A, $R_m \geq 2r$ and hence a successful borrower can always afford to repay both loans. In Case B we have $R_h \geq 2r > R_m \geq r$, thus it is not feasible for a borrower with output R_m to repay both loans. Case B will turn out to be the more interesting case for our analysis, since in this case there is a cost to using joint liability lending. Specifically there are states of the world (when one borrower has zero output and the other has R_m) in which under joint liability both borrowers will default, since it is not feasible to repay both loans and they will therefore be punished whether or not the successful partner repays her loan. Meanwhile under individual liability, the successful partner is able to repay her loan and will not be punished if she does so.

Consider Case A. If borrowers agree to guarantee one another's loans, they will repay in every state except (0,0), so the repayment probability is $\pi = 1-(1-p)^2 = p(2-p)$, in which case $\hat{r} = \frac{\rho}{p(2-p)}$. Therefore Case A applies if $R_m \geq \frac{2\rho}{p(2-p)}$, i.e. when the successful partner can afford to repay both loans even if her income is only R_m. If this condition does not hold, then it will not be feasible for the successful borrower to help her partner in this state of the world, and therefore Case B applies.

Definition 1. Case A applies when $R_m \geq \frac{2\rho}{p(2-p)}$. Case B applies when $R_m < \frac{2\rho}{p(2-p)}$.

[10] A key implicit assumption is that borrowers cannot renegotiate on social sanctions, otherwise they would never be enacted *off* the equilibrium path either, and social sanctions would be ineffective.

Suppose that borrowers only repay when both are successful, i.e. when both have at least R_m, which occurs with probability p^2. If this is the equilibrium repayment rate, then $\hat{r} = \frac{\rho}{p^2}$. We make a simple parameter assumption that ensures that this will be the highest possible equilibrium interest rate (lowest possible repayment rate), by ensuring that even with income R_m, borrowers can afford to repay $\frac{\rho}{p^2}$.

Assumption 1. $R_m \geq \frac{\rho}{p^2}$.

We also assume that R_h is sufficiently large that a borrower with R_h could afford to repay both loans even at interest rate $\hat{r} = \frac{\rho}{p^2}$. Since this is the highest possible equilibrium interest rate, this implies that R_h is always sufficiently large for a borrower to repay both loans.

Assumption 2. $R_h \geq 2\frac{\rho}{p^2}$.

To summarize, together these assumptions guarantee that $R_m \geq r$ and $R_h \geq 2r$ on the equilibrium path.

We can now write down the value function V for the representative borrower, which represents the utility from access to credit. Suppose that borrower i's loan is repaid with some probability π. Since the repayment rule is assumed to maximize joint welfare, it follows that borrowers' loans are only repaid when repayment leads to the loan contracts being renewed, and therefore the representative borrower's contract is also renewed with probability π. The lender charges an interest rate that yields zero expected profits, $\hat{r} = \frac{\rho}{\pi}$, so the borrower repays $\pi \hat{r} = \rho$ in expectation. Hence, (by stationarity) her welfare is:

$$V = \overline{R} - \rho + \delta\pi V = \frac{\overline{R} - \rho}{1 - \delta\pi}. \tag{2}$$

Given that we normalize the outside option to zero, for any borrower to be willing to repay her loan, the following condition needs to hold: $-r + \delta V \geq 0$. In other words, the value of access to future loans must exceed the interest rate, $r \leq \delta V$. If this condition does not hold, all borrowers will default immediately. We refer to this condition as Incentive Condition 1 (IC1), and it must hold under any equilibrium contract.

Provided IC1 is satisfied, borrower welfare is maximized by achieving the highest repayment rate possible. To see this, suppose the lender charges some interest rate r. Then $V = \frac{\overline{R} - \pi r}{1 - \delta\pi}$. It can be verified that this is increasing in π if and only if IC1 holds. Therefore, since $\pi r = \rho$ in equilibrium, in the subsequent discussion the welfare ranking of contracts will be equivalent to the ranking in terms of the repayment probability.

Using Eq. (2) and $\hat{r} = \frac{\rho}{\pi}$ we can derive the equilibrium IC1 explicitly:

$$\rho \leq \delta\pi\overline{R}. \tag{IC1}$$

By Assumption 1, the lowest possible equilibrium repayment probability π is equal to p^2. For the theoretical analysis we make the following parameter assumption that ensures IC1 is satisfied in equilibrium:

Assumption 3. $\delta p^2 \overline{R} > \rho$.

Now that the model is set up we analyze the choice of contract type.

2.1. Individual liability

Suppose first of all that the borrower does not reach a repayment guarantee arrangement with a partner. Since IC1 is satisfied, the borrower will repay her own loan whenever she is successful, so her repayment probability is p. Her utility V is then equal to $\frac{\overline{R} - \rho}{1 - \delta p}$.

Now we consider when pairs of IL borrowers will agree a repayment guarantee arrangement. If this occurs, we term it implicit joint liability (IJ). Note that at present borrowing groups are not required for this to take place.

Since IC1 holds, the borrowers want to agree on a repayment rule that maximizes their repayment probability. There are many possible such rules that can achieve the same repayment rate, so for simplicity we focus on the most intuitive one: borrowers agree to repay their own loan whenever they are successful, and also repay their unsuccessful partner's loan if possible.[11]

We already know that repayment of the borrower's own loan is incentive compatible by IC1. For it to be incentive compatible for her to repay on behalf of her partner as well, it must be that social sanction outweighs the cost of the extra repayment, i.e. $r \le \delta S$. This gives us a constraint which we term IJ Incentive Constraint 2, or IJ IC2. For equilibrium interest rate $\hat{r} = \frac{\rho}{\pi^{IJ}}$ IJ IC2 reduces to:

$$\rho \le \delta \pi^{IJ} S. \tag{IJIC2}$$

There is a threshold value of S, $\hat{S}^{IJ}$, such that IJ IC2 holds for $S \ge \hat{S}^{IJ}$:

$$\hat{S}_k^{IJ} \equiv \frac{\rho}{\delta \pi_k^{IJ}}, k \in \{A, B\},$$

where k denotes the relevant case. When $S \ge \hat{S}^{IJ}$, it is feasible and incentive compatible for borrowers to guarantee one another's loans, and therefore they will do so as this increases the repayment probability and thus joint welfare. Therefore borrowers always engage in IJ if $S \ge \hat{S}^{IJ}$.

Next we work out the equilibrium repayment probabilities and interest rates in cases A and B respectively. Assume $S \ge \hat{S}^{IJ}$. In Case A, a successful borrower can always afford to repay both loans, so both loans are repaid with probability $\pi_A^{IJ} \equiv 1 - (1-p)^2 = p(2-p)$. In Case B, both loans are repaid whenever both are successful, and in states $(R_h, 0)$, $(0, R_h)$. In state $(R_m, 0)$, borrower 1 cannot afford to repay borrower 2's loan, so she repays her own loan, while borrower 2 defaults and is replaced in the next period with a new partner. Therefore $\pi_B^{IJ} \equiv p^2 + 2p_h(1-p) + p_m(1-p) = p + p_h(1-p)$. Notice that both π_A^{IJ} and π_B^{IJ} are greater than p, the IL repayment probability.

The lender observes whether Case A or Case B applies, and the value of S in the community, and offers an individual liability contract at the appropriate zero profit interest rate. Equilibrium borrower welfare under individual liability is equal to:

$$V_k^{IL}(S) = \begin{cases} \dfrac{\overline{R} - \rho}{1 - \delta p} & S < \hat{S}_k^{IJ} \\ \dfrac{\overline{R} - \rho}{1 - \delta \pi_k^{IJ}} & S \ge \hat{S}_k^{IJ} \end{cases}, k \in \{A, B\}.$$

It is straightforward to see that as S switches from less than $\hat{S}_k^{IJ}$ to greater than or equal to it, $V_k^{IL}(S)$ goes up as $\pi_k^{IJ} > p$.

2.2. Explicit joint liability

Now we analyze EJ contracts. Recall that under EJ, a pair of borrowers are offered a contract such that unless both loans are repaid, both partners lose access to credit in the future. The advantage of this contractual form is that it gives additional incentives to the borrowers to guarantee one another's loans. However, the disadvantage is that when borrower i is successful and j is unsuccessful, there may be states in which borrower i would repay were she under individual liability, but she will default under joint liability because she is either unwilling or unable to repay both loans.

The borrowers will agree a repayment rule, just as under IJ. Since this will be chosen to maximize joint welfare, it will only ever involve either both loans being repaid or both defaulting, due to the joint liability clause that gives no incentive to repay only one loan. Subject to this, because IC1 holds, joint welfare is maximized by ensuring both loans are repaid as frequently as possible.

IC1 implies that when both borrowers are successful, they will both be willing to repay their own loans. We therefore need to consider i's incentive to repay both loans when j is unsuccessful. Borrower i will be willing to make this loan guarantee payment provided the threat of termination of her contract, plus the social sanction for failing to do so, exceeds the cost of repaying two loans. Formally, this requires $2r \le \delta(V^{EJ} + S)$. We refer to this condition as EJ IC2. Rearranging, and substituting for $\hat{r} = \frac{\rho}{\pi^{EJ}}$, we obtain:

$$\rho \le \frac{\delta \pi^{EJ} \left[\overline{R} + \left(1 - \delta \pi^{EJ}\right) S\right]}{2 - \delta \pi^{EJ}}. \tag{EJ IC2}$$

We can derive a threshold, $\hat{S}^{EJ}$, such that EJ IC2 is satisfied for $S \ge \hat{S}^{EJ}$:

$$\hat{S}_k^{EJ} \equiv max\left\{0, \frac{\rho}{\delta \pi_k^{EJ}} - \frac{\delta \pi_k^{EJ} \overline{R} - \rho}{\delta \pi_k^{EJ}\left(1 - \delta \pi_k^{EJ}\right)}\right\}, k \in \{A, B\}$$

where as before, k denotes the relevant Case.

Note that $\hat{S}^{EJ}$ can be equal to zero. This corresponds to the basic case in Besley and Coate (1995) where borrowers can be induced to guarantee one another even without any social capital. This relies on the lender's use of joint liability to give borrowers incentives to help one another, and is not possible under individual liability.

Provided $S \ge \hat{S}^{EJ}$, borrowers are willing to guarantee one another's repayments. The repayment rule will then specify that i repays on j's behalf whenever i can afford to and j is unsuccessful. If $S < \hat{S}^{EJ}$, borrowers will not guarantee one another. They will therefore only repay when both are successful.

We now derive the equilibrium repayment probability under each Case. Firstly, if $S < \hat{S}^{EJ}$, borrowers repay only when both are successful, so $\pi^{EJ} = p^2$ in either Case.

Now suppose $S \ge \hat{S}^{EJ}$. In Case A, both loans can be repaid whenever at least one borrower earns at least R_m. Thus the repayment probability is $\pi_A^{EJ} = p(2-p)$. In Case B, R_m is not sufficient to repay both loans. Therefore both loans are repaid in all states except $(0, 0)$, $(R_m, 0)$, $(0, R_m)$. In these three states both borrowers default. The repayment probability is therefore $\pi_B^{EJ} = p^2 + 2p_h(1-p) = p + \Delta(1-p)$ (recall $\Delta \equiv p_h - p_m$).

Borrower welfare is:

$$V_k^{EJ}(S) = \begin{cases} \dfrac{\overline{R} - \rho}{1 - \delta p^2} & S < \hat{S}_k^{EJ} \\ \dfrac{\overline{R} - \rho}{1 - \delta \pi_k^{EJ}} & S \ge \hat{S}_k^{EJ} \end{cases}, k \in \{A, B\}.$$

Note that $\hat{S}_A^{EJ} \le \hat{S}_B^{EJ}$. This is because the interest rate is lower in Case A, and V is higher (due to the higher renewal probability), so the threat of termination is more potent.

Now that we have derived the equilibrium contracts assuming either IL or EJ, we turn to analyzing the lender's choice of contractual form in equilibrium, which will depend crucially on the borrowers' ability to guarantee one another's loans.

Let us define $V(S) \equiv max\{V^{EJ}(S), V^{IL}(S)\}$ as the maximum borrower welfare from access to credit. Observe that the repayment probability and borrower welfare from access to credit, $V(S)$, are stepwise increasing in S.

2.3. Comparing contracts

In this section we compare borrower welfare under each contractual form. We have seen that EJ has the advantage that it may be able to induce borrowers to guarantee one another even when they have no social capital. However, in Case B it has a perverse effect: in some states of the world borrowers will default when they would have repaid under IL.

[11] An example of an alternative, less intuitive rule that can sometimes achieve the same repayment rate but cannot do better is where borrowers agree to repay their partner's loan, and then repay their own as well if they can afford to do so.

This is most acute when $p_m > p_h$. Then $\pi_B^{EJ} = p + \Delta(1-p) < p$. Therefore in Case B, when $\Delta \le 0$, EJ actually performs worse than IL for all levels of social capital — the perverse effect dominates. Thus for Case B, when $\Delta \le 0$, EJ would never be offered.

We have already derived thresholds for S, $\hat{S}^{IJ}$ and $\hat{S}^{EJ}$, above which borrowers will guarantee one another's loans under individual and joint liability respectively. The lender's choice of contract will depend on the borrowers ability to do so, so first we derive a lemma that orders these thresholds in Case A and Case B.

Lemma 1.

1. $\hat{S}_A^{IJ} > \hat{S}_A^{EJ}$.
2. *Suppose* $p_h \ge p_m$. *Then* $\hat{S}_B^{IJ} > \hat{S}_B^{EJ}$.

Proof. See Appendix. □

Lemma 1 shows that supporting a loan guarantee arrangement requires more social capital under IL than under EJ. The reason for this is that the lender's sanction under EJ is a substitute for social capital in providing incentives to borrowers to guarantee one another.[12]

The lender is a non-profit who offers the borrower welfare-maximizing contract. Therefore he offers IL if $V^{EJ}(S) \le V^{IL}(S)$ and EJ otherwise. This will depend on the Case (A or B), the sign of Δ, and S. We summarize the key result of this section as:

Proposition 1. *The contracts offered in equilibrium are as follows:*

Case A *IL is offered at* $\hat{r} = \frac{\rho}{p}$ *for* $S < \hat{S}_A^{EJ}$, *EJ is offered at* $r = \frac{\rho}{\pi_A^{EJ}}$, *for* $S \in [\hat{S}_A^{EJ}, \hat{S}_A^{IJ})$, *otherwise either EJ or IL are offered at* $r = \frac{\rho}{\pi_A^{EJ}} = \frac{\rho}{\pi_A^{IJ}}$ *(the lender is indifferent).*

Case B $\Delta > 0$: *IL is offered at* $\hat{r} = \frac{\rho}{p}$ for $S < \hat{S}_A^{EJ}$, *EJ is offered at* $\hat{r} = \frac{\rho}{\pi_B^{EJ}}$ *for* $S \in [\hat{S}_B^{EJ}, \hat{S}_B^{IJ})$, *IL is offered at* $\hat{r} = \frac{\rho}{\pi_B^{IJ}}$ *for* $S \ge \hat{S}_B^{IJ}$.

Case B $\Delta \le 0$: *IL is offered at* $\hat{r} = \frac{\rho}{p}$ for $S < \hat{S}_B^{IJ}$, *IL is offered at* $\hat{r} = \frac{\rho}{\pi_B^{IJ}}$ *otherwise.*

Whenever EJ is offered borrowers guarantee one another's repayments. Whenever IL is offered and $S \ge \hat{S}^{IJ}$ *borrowers guarantee one another's repayments.*

Proof. See Appendix. □

The result is summarized in Table 1, which gives the equilibrium contract and repayment probability π in alternate rows. Borrower welfare is not shown, but is easily computed as $V = \frac{pR-\rho}{1-\delta\pi}$, and is strictly increasing in π.

This table shows that there are clear trade-offs in the contractual choice. In Case A, IJ has no advantage over EJ because in both cases borrowers repay both loans whenever successful. In Case B when $\Delta \le 0$, we have already remarked that EJ is always dominated by IL. Therefore basic IL is offered for low S, and when S is high enough, borrowers will begin to guarantee one another, leading to an increase in the repayment rate and a fall in the equilibrium interest rate.

The most interesting case is Case B for $\Delta > 0$. Here there is a clear progression as S increases. For low S, borrowers cannot guarantee one another under either contract, so basic IL is offered. For intermediate S, EJ can sustain a loan guarantee arrangement but IL cannot, so EJ is offered. Finally for high S, borrowers are able to guarantee one another under IL as well. Since this avoids the perverse effect of EJ, the lender switches back to IL lending.

[12] A slight complication arises in the proof because in Case B the repayment probability is higher under IJ, and therefore the interest payment is lower than under EJ. As a result, the size of the guarantee payment that must be incentive compatible is actually smaller under IJ, but the net effect is still that borrowers are more willing to guarantee one another under EJ.

Table 1
Equilibrium contracts and repayment probabilities.

	Case A	Case B, $\Delta > 0$	Case B, $\Delta \le 0$
$S < \hat{S}^{EJ}$	IL (no IJ) p	IL (no IJ) p	IL (no IJ) p
$S \in [\hat{S}^{EJ}, \hat{S}^{IJ})$	EJ $p(2-p)$	EJ $p + \Delta(1-p)$	
$S \ge \hat{S}^{IJ}$	EJ or IL (with IJ) $p(2-p)$	IL (with IJ) $p + p_h(1-p)$	IL (with IJ) $p + p_h(1-p)$

2.4. Microfoundations of social capital

So far we have treated S as a "black box" as is common in the literature. While the primary goal of this paper is to demonstrate how social ties and social interactions can influence the credit market, it is worthwhile to consider conceptualizations of social capital that would be consistent with our setting.

We feel the most natural interpretation of S is as the net present value of lifetime payoffs in a repeated "social game" played alongside the borrowing relationship, similar to the multi-market contact literature, such as Spagnolo (1999), who models agents interacting simultaneously in a social and business context, using one to support cooperation in the other.

Suppose that each period, before loans are disbursed, each pair of friends plays the stage-game in Table 2 (presented in standard normal form), where $s, c, d \ge 0$. Let S be the value of playing (C,C) indefinitely, i.e. $S \equiv \frac{s}{1-\delta}$. If $d \le s$ the stage-game has two Nash equilibria, (C,C) and (D, D). If $d > s$ then only (D,D) is a stage-game equilibrium, but (C,C) can be sustained by trigger strategies in the repeated game if $d < \frac{\delta s}{1-\delta}$, which we assume. When $d \le s$ the stage-game is a coordination game, whereby players can coordinate on either equilibrium, while $d > s$ is a standard prisoner's dilemma. The fact that (D,D) is always an equilibrium is what enables people to credibly threaten to destroy S in response to a deviation, in this case to a deviation in either the social game or the repayment game.

We think of coordination games as a simple model of friendship. Individuals derive a utility benefit s from socializing with their friends, it is costly to extend friendship if it is not reciprocated ($c \ge 0$), but it is not advantageous not to reciprocate ($d < s$). To us, this is the most natural way to think about social capital, essentially borrowers help one another in their borrowing affairs because something bigger is at stake, their social relationships.

The prisoner's dilemma representation can represent, for example, a public goods game. Each partner contributes something to a public good, for example keeping the street in their neighborhood clean, keeping noise down, abiding by social norms, acting honestly in economic transactions. Each is tempted to deviate and not contribute (because $d > s$) but does so to preserve the continuation value δS.

A third motivation is that perhaps borrowers have other insurance arrangements behind the scenes, and help one another in loan repayment to preserve those. For example, suppose that with probability τ a borrower suffers a non-monetary shock z, such as a health shock. One person in the village is especially well-positioned to assist with that (so the cost z is not incurred), at a cost to that person of $c < z$, provided they did not suffer a shock themselves. For instance they could provide childcare, take the person to the hospital, take over their business for a day, and so on. Assume that the setup is symmetric, then the expected per-period utility under a reciprocal arrangement to help one another

Table 2
Social stage-game payoffs.

	C	D
C	s, s	$-c, d$
D	$d, -c$	$0, 0$

is $-(1-\tau)\tau c-\tau^2 z$. Without an arrangement, the utility is $-\tau z$, so the per-period gain from the agreement is $\tau(1-\tau)(z-c)>0$ and the lifetime value is $S \equiv \frac{\tau(1-\tau)(z-c)}{1-\delta}$. Suppose that individuals believe that a partner who has always helped in the past (when able) will always help in the future, but one who has ever deviated will never help again. Then it is clear that they will help when able if $c<\delta S$ provided the partner is expected to always help in the future. If the partner is not expected to help in the future, they too will not help today. This provides a stochastic foundation for S closely related to the social game outlined here.

Finally, we comment on three other interesting features of this setup, that we do not analyze in detail for brevity. The first is that, depending on a timing assumption, the social capital generated in the social game may be useless for guaranteeing microfinance loans. Suppose that first incomes are realized, then the social game is played, then the repayment game is played. If d is large enough, a borrower whose partner was unsuccessful will prefer to first play D in the social game then refuse to bail out her partner. Consider IJ for instance. Now, her incentive constraint (IC2) is $\delta S \geq d+r$, since she gains d by deviating in the social game and saves r by refusing to help her partner. Of course the partner will anticipate this and also play D in the social game, hence the arrangement unravels. These borrowers will not write a repayment rule conditioning on S, because it will not be incentive compatible. One way to think about this issue is that the time period between learning one's partner cannot repay and the repayment meeting cannot be too long.

Second, lending can actually *create* temporary social capital (this bootstrap argument is very similar to the points made in Spagnolo, 1999). Suppose $d>\delta S$, so the only equilibrium in the repeated social game is (D,D) forever. However, suppose the individuals agree to guarantee one another's loans, and to play (C,C) until someone deviates.[13] Now, refusing to repay the partner's loan when required leads to a loss of social capital, this may be enough to sustain mutual insurance in the lending arrangement. Deviating in the social game also destroys social capital, and this renders mutual insurance in the repayment game impossible, leading to a decrease in the repayment rate and thus a fall in V. This additional cost may be sufficient to sustain cooperation in the social game.[14] We choose not to emphasize this point because we are primarily interested in social capital creation induced by the group structure rather than by lending itself.

Third, a comment on the friendship motivation. Throughout, we consider S to be the amount of social capital that can credibly be destroyed. One could think that with close friends or family members, the payoff structure is such that (D,D) is not an equilibrium, and for this reason destroying S is not a credible threat. Mutual insurance (based on such threats) may be less possible in these circumstances. This may be one motivation for why MFIs commonly restrict family members from joining the same joint liability groups.

Finally, throughout we assume that borrowers have a large number of friends (or, in the discussion of social capital creation, a large number of potential friends), and that after loss of S with one friend they can simply form a group with another. In many cases this may not be a plausible assumption. One could also think of S as a reputation value that is lost once and for all. The "many friends" assumption is by no means crucial but it greatly simplifies the analysis, because it enables us to make the repayment problem stationary. Otherwise, loss of S would change the continuation value in the borrowing relationship as well as the social relationship.

[13] Note that by the assumption $d>\delta S$ the social capital created will be dissolved once the lending relationship ends, so S will be worth $\frac{S}{1-\delta\pi_{both}}<\frac{S}{1-\delta}$ where π_{both} is the probability that both loans are repaid.

[14] This argument has one theoretically interesting implication. Suppose that if the lender charges a low interest rate r and offers EJ, the joint liability penalty is enough to induce borrowers to guarantee one another. If the lender increases the interest rate to r', they require social capital to achieve this. As a result, increases in the interest rate can lead to *more* social capital creation.

2.5. A remark on loan size

For simplicity, our core model assumes loans of a fixed size. However, it is interesting to consider what happens as loan sizes grow.

In our view, it is likely to be the case that efficient loan sizes, as determined by the production function, grow faster than social capital. For example, industrialization leads to increases in start-up costs relative to subsistence farming, while development may bring market or contract-based alternatives to social capital such as favor exchange, informal insurance or even, regretfully, traditional notions of friendship. Such developments imply a shift away from EJ and IJ, toward pure IL. To see this, note that the interest payment, r, is proportional to the loan size, so as loan sizes grow relative to S, the IC2 constraints tighten, decreasing the value of EJ. To the extent that groups are used to foster IJ (see below), it also implies a shift away from group lending.

Thus, our model is consistent with a stylized fact that can be seen in, for example, the well-known MIX Market microfinance dataset: loans disbursed to individuals tend to be larger than loans disbursed to groups. The model suggests a causal link from the loan size to the disbursement method.[15]

2.6. Discussion

Borrowers form partnerships that optimally leverage their social capital to maximize their joint repayment probability. Thus when social capital is sufficiently high to generate implicit joint liability, IL lending can dominate EJ: borrower i no longer defaults in state $(R_m, 0)$. This does not however mean there is no role for EJ. In particular, for intermediate levels of social capital, EJ can dominate IL — social capital is high enough for repayment guarantees under EJ but not under IL. We analyze borrower welfare under EJ and IL/IJ quantitatively in the simulations.

Let us compare our theoretical results with the findings of Giné and Karlan (2014), namely, average repayment does not change significantly when there is a random switch from EJ to IL. However, borrowers with stronger social ties are less likely to default relative to those with weaker social ties after switching to IL lending, and that these two effects average out to zero.

If we look at Case A, Case B ($\Delta>0$), and Case B ($\Delta\leq 0$), in all these three cases, for low S, IL (no IJ) dominates EJ (though it should be noted that $\hat{S}^{EJ}$ could be negative depending on parameter values, in which case calling this case that of "low S" would not make sense). We can see that in all these three cases, for high values of $S(S\geq\hat{S}^{IJ})$, IJ (weakly) dominates EJ. For Case A, they achieve the same repayment rate, but in the other two cases IJ achieves a strictly higher repayment rate. In contrast, with medium values of S, EJ strictly dominates IL (no IJ) in Case A and Case B ($\Delta>0$), but not in Case B ($\Delta\leq 0$). Therefore for "medium" levels of S, EJ is likely to dominate IL, unless the parameters of the distribution of returns are such that EJ is never desirable.

In the theoretical model, the optimal lending arrangement is always chosen. But in a randomized experiment, it is chosen randomly, including when it is not optimal. Clearly, Case B ($\Delta\leq 0$) is not consistent with either of the two findings of Giné and Karlan (2014). There, a random switch to IL should have raised repayment rates unconditionally. Case A is consistent with the average repayment rates being the same, but not the fact borrowers with stronger social ties are less likely to default relative to those with weaker social ties after switching to IL. Only Case B is consistent with both facts.

So far, we have ignored the use of groups for disbursal and repayment of loans. However, it is frequently argued (see e.g. Armendáriz de Aghion and Morduch, 2010) that group meetings generate costs that differ from those under individual repayment. In the next section we show that this may induce the lender to prefer one or the other. We then proceed to show that by interacting with the benefits from

[15] Baland et al. (2013) analyze this particular mechanism in detail, also relating loan sizes to borrower wealth.

social capital, group meetings may induce the creation of social capital. This is consistent with the results of a field experiment by Feigenberg et al. (2013).

3. Meeting costs

In this section we lay out a simple model of loan repayment meeting costs. This immediately suggests a motivation for the use of groups. Holding group repayment meetings shifts the burden of meeting costs from the lender to the borrowers. This enables the lender to reduce the interest rate, which in turn makes it easier for borrowers to guarantee one another. Then in the next section we explore how the use of groups might create social capital, and thus generate implicit joint liability.

Since we want to focus on the interplay between meeting costs and social capital under individual liability, we assume that Case B applies and $\Delta \le 0$. Therefore we can ignore EJ and drop the A, B notation.

A common justification for the use of group meetings by lenders is that it minimizes transaction costs. Meeting with several borrowers simultaneously is less time-consuming than meeting with each individually. However, group meetings might be costly for the borrowers, as they take longer and are less convenient than individual meetings. We term IL lending to groups ILG and IL lending to individuals ILI.

We assume that loan repayment meetings have two components, each of which takes a fixed amount of time. For simplicity, we assume that the value of time is the same for borrowers and loan officers[16] Also, for simplicity, we assume that the cost of borrower time is non-monetary so that borrowers are able to attend the meeting even if they have no income. However, more time spent in meetings by the loan officer increases monetary lending costs, for example because more staff must be hired.

Each meeting incurs a fixed and variable cost. The fixed cost includes travel to the meeting location (which we assume to be the same for borrower and loan officer for simplicity), setting up the meeting, any discussions or advice sessions that take place at the meeting, reminding borrowers of the MFI's policies, and so on. This costs each borrower and the loan officer an amount of time worth γ_f irrespective of the number of borrowers in the group.

Secondly there is a variable cost that depends on the number of borrowers at the meeting. This time cost is worth γ_v per borrower in the meeting. This covers tasks that must be carried out once for each borrower: collecting and recording repayments and attendance, reporting back on productive activities, rounding up missing borrowers, and so on. As with the fixed cost, each borrower and the loan officer incurs the variable cost. We assume that for group loans, each borrower also has to incur the cost having to sit through the one-to-one discussion between the loan officer and the other borrower, i.e., in a two group setting, the total variable cost per borrower is $2\gamma_v$ whereas under individual lending, it is γ_v. Therefore, in a meeting with one borrower, the total cost incurred by the loan officer is $\gamma_f + \gamma_v$, and the total cost incurred by the borrower is the same, bringing the aggregate total time cost of the meeting to $2\gamma_f + 2\gamma_v$. In a meeting with two borrowers the loan officer incurs a cost of $\gamma_f + 2\gamma_v$, and similarly for the borrowers. Thus the aggregate cost in this case is $3\gamma_f + 6\gamma_v$. The lender's cost of lending per loan under ILI is $\rho + \gamma_f + \gamma_v$. Under ILG it is $\rho + \frac{\gamma_f}{2} + \gamma_v$. Therefore the corresponding zero-profit interest rates are $\hat{r}^{ILI} \equiv \frac{\rho+\gamma_f+\gamma_v}{\pi}$ and $\hat{r}^{ILG} \equiv \frac{\rho+\frac{\gamma_f}{2}+\gamma_v}{\pi}$.

Accounting for these costs, per-period expected utility for borrowers under ILI is $\overline{R} - \rho - 2\left(\gamma_f + \gamma_v\right)$. Under ILG, the per-period utility is $\overline{R} - \rho - \frac{3}{2}\left(\gamma_f + 2\gamma_v\right)$.[17]

Of course, the first thing to check is whether one lending method is less costly than the other in the absence of any loan guarantee arrangement between borrowers. This is covered by the following observation:

Observation 1. Suppose $S = 0$. The lender uses ILG if and only if $\gamma_v < \frac{\gamma_f}{2}$.[18]

The intuition is straightforward. When $\frac{\gamma_f}{\gamma_v}$ is large, i.e., fixed costs are important relative variable costs (e.g., when a large part of repayment meetings is repetitious) it is economical to hold group meetings. However, the more time is spent on individual concerns, the more costly it is to the borrowers to have to attend repayment meetings in groups because they have to sit through all the bilateral exchanges between another borrower and the loan officer. Microfinance loans are typically highly standardized and so $\frac{\gamma_f}{\gamma_v}$ will be relatively large, which is consistent with the common usage of group lending methods in microfinance.

Now consider borrowers' incentives to guarantee one another's loans. First we observe that for a given γ_v, γ_f, half of the aggregate meeting cost per borrower is borne by the lender under ILI, while only a third is borne by the lender under ILG. The lender passes on all costs through the interest rate, so inspecting the value functions suggests that it is innocuous upon whom the cost of meetings falls. In fact this is not the case. Consider once again IJ IC2: $r \le \delta S$. The only benefit a borrower receives from bailing out her partner is the avoidance of a social sanction, while the cost depends on the interest payment she must make. Therefore a lending arrangement in which the lender bears a greater share of the costs, and thus must charge a higher interest rate, tightens IJ IC2. This gives us the next proposition, which is straightforward:

Proposition 2. *Borrowers are more likely to engage in IJ under group lending than individual lending:* $\hat{S}^{IJG} < \hat{S}^{IJI}$.[19]

The implication of this result is that there is a trade-off between minimizing total meeting costs, and minimizing those costs borne by the lender. It may actually not be optimal to minimize total costs as shown by the following corollary, the proof of which is straightforward and given in the appendix.

Corollary 1. *Suppose* $S \in [\hat{S}^{IJG}, \hat{S}^{IJI})$. *Borrower welfare under ILG may be higher than under ILI, even if* $\gamma_v > \frac{\gamma_f}{2}$.

It is worth pointing out that as in the earlier analysis of IJ, nothing in the results presented so far requires IL borrowers to form insurance arrangements with their own group members. In the next section we analyze the interaction between meeting costs, insurance initiation and social capital creation, which will more naturally lead to insurance arrangements forming within group boundaries.

16 This may not be too unrealistic. For example, the large Indian MFI, Bandhan, deliberately hires loan officers from the communities that they lend to.

17 We need to adapt Assumptions 1, 2 and 3 to reflect the additional costs. We assume $R_m \ge \frac{\rho+\frac{1}{2}(\gamma_f+2\gamma_v)}{p^2}$, $R_h \ge 2\frac{\rho+\frac{1}{2}(\gamma_f+2\gamma_v)}{p^2}$, $\delta p^2 \overline{R} - max\left\{(1+\delta p^2)\left(\gamma_f+\gamma_v\right), (\frac{1}{2}+\delta p^2)\left(\gamma_f+2\gamma_v\right)\right\} \ge \rho$. Notice the implicit simplifying assumption that borrowers must attend the meeting even if they are not repaying. This greatly simplifies the analysis without losing much of the economic intuition, because it ensures that the per-period payoff does not depend upon the probability of repayment; without this assumption the borrowers incur the meeting cost with probability π.

18 Proof: $S = 0$ implies IJ is not possible so $\pi = p$ under ILI and ILG. The result then follows from comparison of per-period borrower welfare.

19 Proof: Borrowers are willing to guarantee their partner's repayments provided $r \le \delta S$. Plugging in for the interest rates under ILG and ILI, we obtain $\hat{S}^{IJG} = \frac{\rho+\frac{1}{2}(\gamma_f+2\gamma_v)}{\delta\pi^{IJ}} < \frac{\rho+\gamma_f+\gamma_v}{\delta\pi^{IJ}} = \hat{S}^{IJI}$.

4. The role of groups

In this section we show how group lending can facilitate mutual insurance among borrowers where individual lending cannot. For example, groups may generate social capital that is then used to sustain IJ. The analysis is motivated by the findings of Feigenberg et al. (2013). In their experiment, borrowers who were randomly assigned to higher frequency repayment meetings went on to achieve higher repayment rates. The authors attribute this to social capital being created by frequent meetings, social capital which can then support mutual insurance.

We think there are two broad classes of mechanisms by which meetings can increase repayment rates. The first is that forcing borrowers to interact frequently, the lender can increase their incentive to invest in social capital. Intuitively, the more time I spend with someone, the greater the benefit to forming a social bond with that person. This is our interpretation of the Feigenberg et al. (2013) findings. The second is that meetings play a more mechanical role in facilitating mutual insurance. This could be because borrowers need to observe one another's outcomes or repayments, or play a message game as in Rai and Sjöström (2010). It could be that meetings help borrowers coordinate on mutual insurance which is too difficult to arrange independently.[20]

We model each of these in turn. On the first, we assume that investing in social capital is costly, such that borrowers do not do it independently. The situation we have in mind is that borrowers have some baseline level of social capital created in the normal run of life, but this is insufficient to sustain mutual insurance in borrowing without an extra incentive to create more. Borrowing groups increase the return to investment in social capital by providing an added benefit: social time spent with the partner. We also discuss informally under what conditions a simpler mechanism – spending time together automatically generates social capital – can have the same effect.

Turning to the second, we assume that sustaining mutual insurance requires borrowers to spend a minimum amount of time with another borrower (their insurance partner) each period. This is perfectly possible under individual lending, but groups have an advantage in that the group meeting time can serve this purpose.

In both frameworks we discuss the welfare consequences of increasing the length of group meetings, which we treat as a simple proxy for the repayment frequency in Feigenberg et al. (2013). We take this approach because changing repayment frequency is non-trivial in our setup.[21]

4.1. Groups and social capital creation

Suppose that initially borrowers do not have any social capital, because creating social capital is too costly. For example, borrowers must invest time and effort in getting to know and understand one another, extending trust that might not be reciprocated, and so forth. Assume that social capital can take two values only, 0 and $S > 0$ and for a pair to generate social capital worth S in utility terms, each must make a discrete non-monetary investment that costs them η. In the absence of microfinance, they prefer not to do so, i.e., $\eta > S$. In the context of the discussion in Section 2.4, η represents an up-front cost in initiating a friendship, favor exchange arrangement, etc.

Once lending is taking place, social capital generates an indirect benefit, by enabling the formation of a guarantee arrangement. This may or may not be sufficient to induce them to make the investment — that would depend on how $\eta - S$ compares with the insurance gains from microfinance. We also assume that group meetings confer an additional benefit, namely that spending time in a group meeting with a partner with whom one shares social capital is less arduous than with a stranger. Naturally this increases the incentive to invest in social capital when groups are used.

To make the point as simply as possible, we assume that the lender can observe whether borrowers have invested in S and adjust the interest rate accordingly to reflect the repayment probability. This of course increases the incentive to invest in S because that leads to an interest rate cut, however it greatly simplifies the analysis while preserving the main point.[22]

Suppose the lender offers ILI and S would be sufficiently large to sustain IJ. If the borrowers prefer to invest in social capital, each time their partner defaults they must invest in social capital with their new partner. We obtain the following result:

Lemma 2. *Borrowers invest in social capital under ILI if and only if*:

$$\eta - S \leq G_1. \tag{3}$$

where

$$G_1 \equiv \frac{\delta p_h(1-p)\left[\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)\right]}{(1-\delta p)(1-\delta(p+\Delta(1-p)))}.$$

The proof is given in the appendix. The greater the welfare gain from insurance, captured by the ratio $p_h(1-p)/(1-\delta p)$, the higher is G_1 so the more likely the borrowers will invest in social capital.

Now assume that under ILG, the per-meeting cost to borrowers is decreasing in S. For simplicity, we assume that the cost to the borrowers of the time spent in group meetings is $(1-\lambda(S))(\gamma_f+2\gamma_v)$. In particular, $\lambda(0)=0$ and $\lambda(S)=\lambda>0$. The larger is λ, the smaller the disutility of group meetings, and when $\lambda>1$, borrowers actually derive positive utility from group meetings that is increasing in the length of the meeting. We can now check when social capital will be created in groups.

Lemma 3. *Borrowers invest in social capital under ILG if*:

$$\eta - S \leq G_2. \tag{4}$$

where

$$G_2 \equiv \frac{\delta p_h(1-p)\left[\overline{R}-\rho-\frac{3}{2}\left(\gamma_f+2\gamma_v\right)\right]+\lambda(1-\delta p)\left(\gamma_f+2\gamma_v\right)}{(1-\delta p)(1-\delta(p+\Delta(1-p)))}.$$

The proof is given in the Appendix. The greater the welfare gain from insurance, the higher is G_2, but in addition, G_2 is increasing in λ, which represents the reduction in the cost of attending group meetings when the borrowers have social capital. The larger is G_2, the more likely borrowers are to invest in social capital.

Lemmas 2 and 3 suggest that there may exist an interval, $(G_1, G_2]$ for $\eta - S$ over which groups create social capital but individual borrowers do not. The condition for this to be the case is derived in the next

[20] It could even be that without the group, borrowers would be less able to interact. Indeed, in some conservative societies, social norms may prevent women from attending social gatherings (for instance under the Purdah customs in some parts of India and the Middle East). Then externally mandated borrowing groups can be a valuable vehicle for social interaction. See, for instance Sanyal (2009), Anderson et al. (2002), Kabeer (2005).

[21] Feigenberg et al. (2014) discuss a treatment that comes closer to our setup: increasing the meeting frequency without changing the repayment frequency.

[22] We thank a thoughtful referee for suggesting this approach. The working paper version of the paper analyzes the more complicated case in which the interest rate does not adjust.

proposition, which follows from straightforward comparison of Eqs. (3) and (4):

Proposition 3. *If the following condition holds*:

$$\lambda > \frac{\delta p_h(1-p)\left(\gamma_v - \frac{\gamma_f}{2}\right)}{(1-\delta p)\left(\gamma_f + 2\gamma_v\right)} \tag{5}$$

then there exists a non-empty interval for $\eta - S$ over which both Eqs. (3) and (4) are satisfied. If $\eta - S$ lies in this interval, groups create social capital, and individual lending does not.

Thus, when creating social capital sufficiently offsets the cost to borrowers of attending group meetings, borrowing groups may create social capital and guarantee one another's loans, while individual borrowers may not do so. We can see that the threshold for λ in Eq. (5) is negative if $\frac{\gamma_f}{2} > \gamma_v$ and so the condition (5) is always satisfied if group lending has a cost advantage to the lender. Even if this is not the case, and $\gamma_v - \frac{\gamma_f}{2} > 0$ the critical threshold for λ is always strictly less than 1 and therefore, there always exists a λ high enough (but strictly less than 1) such that the condition (5) would hold. However it does not yet establish that the use of groups is necessarily welfare-improving. In other words, observing that groups are bonding and creating social capital does not tell the observer that group lending is the welfare-maximizing lending methodology. All it tells us is that investment is preferred to no investment under ILG, and no investment is preferred to investment under ILI. The welfare ranking of these two will depend on the meeting costs, η and S. The following proposition addresses the welfare question.

Proposition 4. *Suppose condition (5) is satisfied and $\eta - S \in (G_1, G_2]$. Borrower welfare under ILG is higher than that under ILI if:*

$$\eta - S \le G_3 \tag{6}$$

where

$$G_3 \equiv \frac{\delta p_h(1-p)(\bar{R}-\rho) + 2\left(1-\delta\pi^{IJ}\right)\left(\gamma_f+\gamma_v\right) - \frac{1}{2}(1-\delta p)\left(\gamma_f + 2\gamma_v\right)(3-2\lambda)}{(1-\delta p)(1-\delta(p+\Delta(1-p)))}.$$

The derivation simply compares welfare under ILI when borrowers do not invest to welfare under ILG when they do. G_3 is higher the larger is the meeting cost under ILI relative to under ILG. It is also increasing in λ, representing the reduction in the cost of attending group meetings when the borrowers have social capital. Eq. (6) is always satisfied provided group meeting costs are low enough and λ is high enough.

We conclude this analysis with an observation that combines the above results. If meeting costs are lower under group lending then it dominates individual lending both from an efficiency and a social capital creation perspective.

Observation 2. Suppose $\lambda > 0$ and total meeting costs per borrower are weakly lower under ILG than ILI, i.e. $\gamma_v \le \frac{\gamma_f}{2}$. Then $G_1 < G_2 < G_3$, i.e.

1. There always exists an interval for $S = 0.3$ over which groups create social capital and individuals do not.
2. Borrower welfare is weakly higher under ILG than ILI for all values of $\eta - S$.

The strict ordering also holds for $\lambda = 0$ if $\gamma_v < \frac{\gamma_f}{2}$.

4.1.1. Meeting frequency and social capital creation

Now we take this basic framework and carry out one particular comparative-static exercise, motivated by the findings of Feigenberg et al. (2013). They find that groups that were randomly assigned to meet more frequently have better long-run repayment performance, which they attribute to higher social capital and informal insurance within the group. It is not possible to model repayment frequency in our simple setup, but nevertheless our model is able to capture some of this intuition.

We model an increase in meeting frequency as an increase in meeting costs, represented by an increase in either γ_f or γ_v. The more time spent in group meetings, the greater the benefit from social interaction within those meetings, captured by λ. Intuitively, it may not be too costly to attend meetings once a month with a stranger, but the more frequent those meetings are, the greater the incentive the borrowers have to build social capital.

However, more frequent meetings require more of the loan officer's time as well, leading to higher lending costs and a higher interest rate. This reduces the borrowers' incentive to invest in S, since the higher meeting costs reduce the value of maintaining access to credit.

The net effect on borrowers willingness to invest in S is positive if λ is sufficiently large, as shown by the following proposition.

Proposition 5. *Increases in γ_f or γ_v make borrowers under group lending more willing to invest in social capital if and only if the following condition holds:*

$$\lambda > \frac{3\delta p_h(1-p)}{2(1-\delta p)} \tag{7}$$

The proof is immediate from inspection of Eq. (4). This proposition suggests that an increase in meeting costs could actually be welfare-improving. Notice that the right hand side of Eq. (7) is strictly smaller than $\frac{3}{2}$, and note too that if $\lambda \ge \frac{3}{2}$ then the utility of meeting with one's partner more than offsets the welfare cost of time in meetings, such that increase in meeting time strictly increase borrower welfare.

However, under the more realistic assumption that $\lambda < \frac{3}{2}$, increasing meeting costs is welfare-decreasing, even if it leads borrowers to invest in S and generate insurance. The reason is that the condition for borrowers to create S, Eq. (4) reduces to a simple comparison between the value of credit under an always-invest and a never-invest regime, with borrowers receiving the maximum of these two. When $\lambda < \frac{3}{2}$ payoffs under either regime are strictly decreasing in γ_f and γ_v, so increasing meeting times decreases welfare. The intuition is straightforward: since borrowers are optimally deciding whether to invest in social capital, their welfare cannot be increased by adding additional costs, even if doing so changes their choice. Feigenberg et al. (2013)'s intervention may not have been welfare improving.[23] To obtain a welfare increase, one must add a friction such as a coordination failure between borrowers (leading them to fail to invest optimally), or an externality. For example, if the lender's break-even constraint is sufficiently tight that he must exit the market if borrowers do not mutually insure, but borrowers do not internalize this cost because there are many of them, interventions that push borrowers into investing in S could enable the lender to stay in business, increasing welfare.

Observation 3. Suppose $\lambda < \frac{3}{2}$. Then increases in meeting costs are welfare decreasing, even if they generate social capital creation and mutual insurance.

4.1.2. Mechanical social capital creation

An alternative possibility is that groups mechanically create social capital simply by spending time together. Perhaps surprisingly it turns out that this mechanism cannot sustain IJ. Suppose that each time a borrower obtains a new partner, automatically S is created between them. Can they use this social capital to insure one another? The answer is no,

[23] A thoughtful referee pointed out that their intervention (increasing meeting frequency) was temporary, which weakens but does not eliminate the incentive to invest in S. Could a temporary intervention be welfare improving? Since borrowers are optimally investing in S, the answer is, again, no in this framework.

as can be seen by considering their modified IJ IC2. If a borrower repays on behalf of her unsuccessful partner, she keeps her S at cost r. If she does not, she receives a new partner and new S next period. Thus her incentive constraint is $\delta(V+S)-r \geq \delta(V+S)$ which cannot hold for positive r. Mutual insurance requires a cost to deviating. One way to restore this is to assume that it takes time for social capital to be generated, which decreases the right hand side of the condition (V is lower because mutual insurance is not possible until new S is generated). The analysis above can capture this mechanism in a simple reduced form way via the cost of social capital formation, η.

4.1.3. Meetings lower the cost of investment

An alternative way to use our framework is as follows. Assume that there are no direct benefits to having social capital in group meetings ($\lambda = 0$), but that group meetings lower the cost of investment in social capital or the cost of setting up mutual insurance ($\eta^{ILG} < \eta^{ILI}$). Then, naturally, group meetings will lead to more insurance.

4.2. Meetings facilitate insurance

Suppose that borrowers have social capital, but mutual insurance requires borrowers to spend regular time together, for example to observe one another's income and repayments. This can either be held during a borrowing group meeting at zero additional cost or, if there is no group meeting, independently at cost γ_i. Under ILG, borrowers are able to sustain insurance, and their utility is:

$$V_{ins}^{ILG} = \frac{\overline{R}-\rho-\frac{3}{2}\left(\gamma_f+2\gamma_v\right)}{1-\delta\pi^{IJ}}$$

IJ IC2 in this case is $\delta S \geq \frac{\rho+\frac{\gamma_f}{2}+\gamma_v}{\pi^{IJ}}$.

Under ILI, borrowers can choose not to hold insurance meetings, in which case their utility is

$$V_{aut}^{ILI} = \frac{\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)}{1-\delta p}$$

or they can hold additional insurance meetings, enabling them to sustain insurance, earning utility equal to

$$V_{ins}^{ILI} = \frac{\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)-\gamma_i}{1-\delta\pi^{IJ}}$$

IC2 in this case is $\delta S \geq \frac{\rho+\gamma_f+\gamma_v}{\pi^{IJ}}$.

ILI borrowers will choose not to hold insurance meetings if $V_{aut}^{ILI} > V_{ins}^{ILI}$ or:

$$\gamma_i > \frac{\delta p_h(1-p)\left(\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)\right)}{1-\delta p} \tag{8}$$

If Eq. (8) holds then ILG generates mutual insurance and ILI does not. ILG is efficient if $V_{ins}^{ILG} > V_{aut}^{ILI}$. If Eq. (8) does not hold then both generate insurance and ILG is efficient if $V_{ins}^{ILG} > V_{ins}^{ILI}$. Both inequalities are strict if $\gamma_v \leq \frac{\gamma_f}{2}$, but both can be satisfied even if this condition does not hold, because group lending either increases the repayment rate or economizes on independent meeting costs (γ_i).

Now suppose that the total time required for insurance is γ_i but the group meetings take only $\gamma_f + 2\gamma_v < \gamma_i$. Should the lender increase the length of the group meeting, or leave it to the borrowers to independently spend the additional time? The answer is that the lender should *not* lengthen the meetings. To see this, suppose the borrowers simply spend an additional $\gamma_i - \gamma_f - 2\gamma_v$ independently after the meeting. Then their utility becomes:

$$V_{bor}^{ILG} = \frac{\overline{R}-\rho-\frac{1}{2}\left(\gamma_f+2\gamma_v\right)-\gamma_i}{1-\delta\pi^{IJ}}$$

while IC2 remains unchanged. They will choose to do so if $V_{bor}^{ILG} > V_{aut}^{ILG}$ where $V_{aut}^{ILG} = \frac{\overline{R}-\rho-\frac{3}{2}\left(\gamma_f+2\gamma_v\right)}{1-\delta p}$ or:

$$\gamma_i < \frac{\delta p_h(1-p)\left(\overline{R}-\rho-\frac{3}{2}\left(\gamma_f+2\gamma_v\right)\right)}{1-\delta p}+\gamma_f+2\gamma_v \tag{9}$$

Suppose instead the lender adds $\gamma_i - \gamma_f - 2\gamma_v$ to the length of the meeting. Then the lender's meeting costs increase to γ_i per borrower, which is passed on through the interest rate. Borrower welfare becomes:

$$V_{len}^{ILG} = \frac{\overline{R}-\rho-\frac{3}{2}\gamma_i}{1-\delta\pi^{IJ}} < V_{bor}^{ILG}.$$

Moreover, IC2 tightens, becoming: $\delta S \geq \frac{\rho+\gamma_i}{\pi^{IJ}}$, so it is possible that mutual insurance is no longer possible at all.

We can go one step further. Suppose that Eq. (9) does not hold, so that borrowers do not voluntarily hold insurance meetings, and suppose also that $\delta S \geq \frac{\rho+\gamma_i}{\pi^{IJ}}$ such that if the lender were to lengthen the meetings, borrowers *would* insure one another. Is it efficient to do so? The answer is clearly no, since we know that $V_{aut}^{ILG} > V_{bor}^{ILG} > V_{len}^{ILG}$.

Intuitively, the argument is as follows. If mutual insurance of microfinance loans requires borrowers to spend time with one another, it may be efficient to use group meetings since this "kills two birds with one stone," the group meeting time does the job. However, any additional time required should be arranged independently by the borrowers, it is not efficient to artificially lengthen the group meetings for this purpose. This is because it uses up the lender's time, which must be compensated through a higher interest rate that both decreases borrower welfare and tightens their incentive compatibility constraint. As in the previous section, holding group meetings can be efficient, but increasing meeting time (or meeting frequency) is not, even if it increases mutual insurance between the borrowers. An additional friction is required for this intervention to be welfare increasing.

5. Simulation

In this section, we simulate a simple extension of the model calibrated to empirically estimated parameters. This enables us to illustrate the costs and benefits of explicit joint liability and explore under which environments it will be dominated by individual liability lending that induces implicit joint liability.

We find that in low social capital environments, EJ does quite well compared to IJ. For example, when the standard deviation of project returns is half of the loan size, for social capital worth 10% of the loan size, the welfare attainable under IJ is 32.4% lower compared than the welfare under EJ. However, with social capital worth 50% of the loan size, the welfare attainable under EJ is 5% lower than under IJ. For social capital worth around 30% of the loan size, EJ and IJ perform approximately equally well in terms of borrower welfare. This analysis thus gives us insights into the extent of the perverse effect of EJ. With high enough social capital under IJ, the borrowers now have enough social capital to help one another when they can afford to do so, but are not penalized in states of the world where only some of the group can repay. We also find that the interest rate, repayment rate and borrower welfare are highly insensitive to social capital under EJ, whereas IJ is highly sensitive to social capital. Intuitively, this is because under EJ mutual insurance is motivated both by the lender's sanctions and social sanctions, while under IJ it depends only on social sanctions. For example, when the standard deviation of project returns is half of the loan size, the EJ net interest rate is 11.3% (and barely changes as we vary S), while the IJ net interest rate ranges between 10.4% and 21.4% for levels of S valued at 10% to 50% of the loan size respectively. The difference in the interest rate translates correspondingly into borrower welfare. If borrowers share social capital worth 10% of the c is $V^{IJ} = 2.29$ (valued in units of the loan size), which is 35.9% lower than the $V^{IJ} = 3.57$ attained by borrowers who share social capital worth 50% of the loan size. We also find that the welfare and interest rate differences between low and high levels of social capital S are increasing in the variance of project returns.

From theory we know the basic tradeoff between EJ, Il and IJ and how that changes with social capital. What this analysis adds is to give a quantitative magnitude to the relevant thresholds and also suggests some policy implications. In low social capital environments, despite its well known costs (Besley and Coate, 1995) EJ is an effective device to induce repayment incentives and moreover it is robust to uncertainty about the level of social capital. The analysis also suggests that there are significant welfare gains to be had from investment in social capital when lenders are using individual liability lending.

5.1. Approach

We approach the simulations in a very similar way to de Quidt et al. (2013). First, while it is theoretically convenient to model groups of size two, these require empirically implausibly high returns to investment for the borrowers to be able to repay on one another's behalf, so instead we extend the model to groups of size 5, the group size originally used by Grameen Bank and others. That is, under EJ, we assume five borrowers jointly liable for five loans. Under IL we assume that borrowers are liable for one loan, but if they so choose they can form insurance arrangements in groups of five. As in the theoretical analysis we abstract from issues of optimal group size (see e.g. Baland et al., 2013). We assume a fixed loan size, normalized to 1, which we use as the numeraire throughout. We assume a loan term of 12 months.

Social capital was previously defined between pairs of borrowers. In larger groups it will be efficient for all members of the borrowing group to threaten social sanctions against a borrower who deviates from the agreed repayment rule (recall that the repayment rule is set optimally so sanctions do not occur on the equilibrium path), since this maximizes the achievable repayment probability. To maintain consistency with the theoretical discussion, we use S to represent the total social capital that a deviating borrower stands to lose, i.e. we assume that each borrower shares social capital worth $S/4$ with each other borrower, such that the total sanction for a deviation is equal to S. For example, if $S = 0.2$ this means that the group has social capital worth 20% of the loan size (i.e. each pair within the group has social capital worth 5% of the loan size).

We obtain our parameter values from de Quidt et al. (2013). $\overline{R}$, the expected return to borrowers' investments, is set to 1.6, i.e. a 60% annual return, based on De Mel et al.'s (2008) preferred estimates of the rate of return to capital among microenterprises in Sri Lanka. The lender's cost of capital, ρ, is set to 1.098, which was estimated using lender cost data from the MIX Market database of financial information from MFIs around the world. Lastly, we set δ equal to 0.864. This is the midpoint between the value implied by the return on US treasury bills and a lower bound, based on IC1, estimated from the MIX data by de Quidt et al. (2013). In the Appendix we show robustness to $\delta = 0.95$.

The two key ingredients that drive the trade-off between explicit and implicit joint liability are the level of social capital and the shape of the borrowers' return distribution function. We do not have data on social capital, so instead we estimate the equilibrium interest rate, repayment rate and welfare for a range of values for S. This enables us to say, for example, how much social capital is required for implicit joint liability to perform as well or better than explicit joint liability.

It is more difficult to explore how the shape of the returns distribution affects the trade-off between EJ and IJ. In the theoretical analysis it was convenient to illustrate the key intuition using a simple categorical distribution with three output values and associated discrete probabilities. With larger groups, this distribution function is less useful. It no longer gives a simple and intuitive set of states of the world in which EJ does and does not perform well (with a group of size n, there are 3^n possible states of the world). More problematic is that the distribution has four parameters (p_m, R_m, p_h, R_h), only one of which can be tied down by our calibrated value of $\overline{R}$. As a result, it is very difficult to perform meaningful comparative statics — there are too many degrees of freedom.[24]

Therefore, for the main simulations we use the most obvious two-parameter distribution function, the Normal distribution.[25] Fixing the mean at $\overline{R}$, we can vary the shape of the distribution by changing the standard deviation. The range for σ was chosen to obtain the highest and lowest possible repayment rates at which the lender is able to break even. For the benchmark simulations, we assume the borrowers' returns are uncorrelated, but we also allow for positive and negative correlations in an extension.

To simulate the model, for each contract we work out a welfare-maximizing repayment rule for the borrowing group, i.e. one that maximizes the repayment rate, subject to the borrowers' incentive constraints. Solving analytically for the equilibrium repayment probability (which then gives us the interest rate and borrower welfare) is complex, so instead we simulate a large number of hypothetical borrowing groups and use these to compute the equilibrium repayment probability. We describe the simulation approach in detail in Appendix B.

5.2. Results

The main results for uncorrelated borrower incomes are presented in Fig. 1. The standard deviation σ of individual borrower returns is varied on the horizontal axis of each figure.

For the distribution and parameter values used, it turns out that individual liability is in fact marginally loss-making for all σ, so we just present results for implicit joint liability and explicit joint liability for values $S \in \{0.1, 0.3, 0.5\}$.

The figures show that increasing the variance of returns is bad for repayment and thus welfare under both contracts. This is unsurprising: higher variance income processes are more difficult to insure (the required transfers between members tend to be larger), so states in which members cannot or will not help one another out become more common. Increasing S partially mitigates this effect since it increases the size of incentive-compatible transfers between borrowers.

Our simulated repayment rates vary between around 85% to close to 100% as the variance of borrower income decreases. These high repayment rates follow from the fact that the calibrated mean return $\overline{R}$ is higher than the lender's cost of funds, ρ, so near perfect repayment is attainable for sufficiently low variance. However, these values are fairly typical for microfinance repayment rates. For example, in de Quidt et al. (2013) we conservatively estimate a repayment rate in the MIX Market dataset of around 0.92. Using the simulated repayment rate, we can obtain the zero-profit interest rate and borrower welfare. The net interest rate varies between 10% and 30% per year (again, these are not unreasonable values for the microfinance context), while borrower welfare varies between around 1.8 and 3.7 multiples of the loan size.

[24] We perform one exercise in the appendix, where we vary $p_h - p_m$ while holding p, R_h, R_m constant. The confound here is that the mean return also varies as we vary p_h and p_m.

[25] One complication arises, namely the possibility of negative income realizations. For simplicity, we allow these to occur, but we assume that a) only borrowers with positive incomes can assist others with repayment, and b) to repay that borrower's loan, her group members need only transfer r, not $r - y_i$ where y_i is her (negative) income realization.

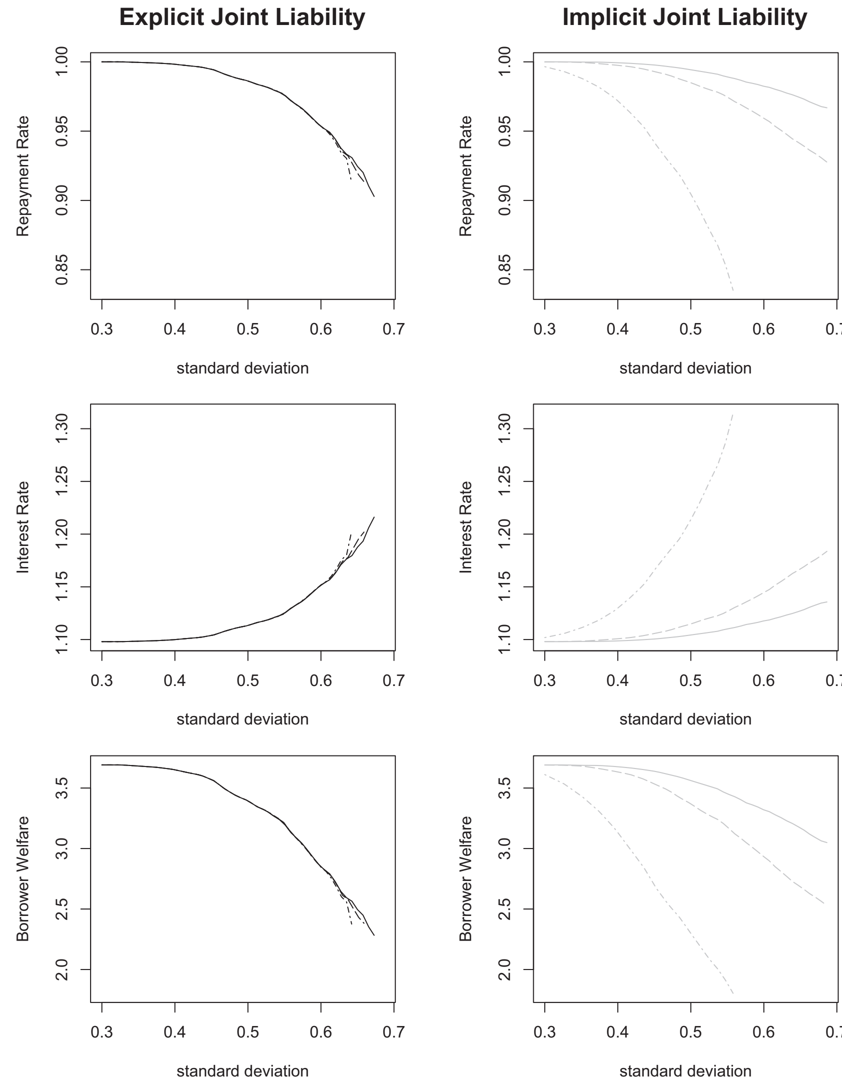

Fig. 1. Simulation results for uncorrelated borrower returns. Explicit joint liability results are in the left column and implicit joint liability in the right column. Each figure plots the relevant object (repayment rate, interest rate and borrower welfare) for three levels of social capital, $S = 0.1, 0.3, 0.5$. The standard deviation of the individual borrower's income is varied on the horizontal axis of each figure.

One of the most striking lessons we learn from the graphs is that the interest rate, repayment rate and borrower welfare are highly insensitive to social capital under explicit joint liability. The reason is that social capital is only shifting the borrowers from default to repayment in states of the world where they can afford to help one another and where the joint liability penalty is not already sufficient. The probability that such a state occurs is lower, the bigger the group of borrowers. Meanwhile, implicit joint liability is highly sensitive to social capital, since the only sanction available is coming through the social capital. For example, at $\sigma = 0.5$, the IJ repayment rate is 91% for $S = 0.1$, 98% for $S = 0.25$, and close to 100% for $S = 0.5$, while the EJ repayment rate is fixed at 98% throughout.[26]

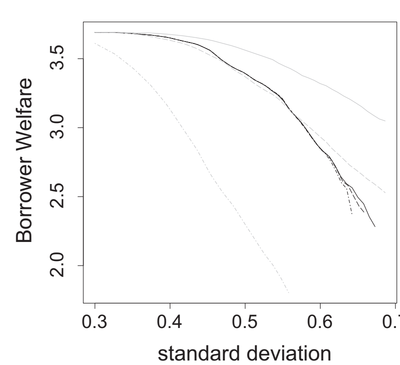

Fig. 2. Simulation results for uncorrelated borrower returns. Explicit joint liability results are in black and implicit joint liability in grey. The figure plots borrower welfare for three levels of social capital, $S = 0.1, 0.3, 0.5$. The standard deviation of the individual borrower's income is varied on the horizontal axis.

[26] Note that in de Quidt et al. (2013) we find that the interest rate and borrower welfare are sensitive to social capital when the lender is a monopolist, since higher social capital relaxes IC2, and therefore enables the lender to increase the interest rate. The non-profit lender, as modeled in this paper, does not do this.

In order to more easily compare EJ and IJ, in Fig. 2 we overlay the welfare curves for EJ and IJ. The simulation exercise emphasizes much of the core intuition from the model. When S is low, explicit joint liability tends to dominate since the joint liability clause gives the borrowers an additional incentive to help one another. When π is high, implicit joint liability dominates, due to the perverse effect of JL — the borrowers now have enough social capital to help one another when they can afford to do so, but are not penalized in states of the world where only some of the group can repay.

To give a numerical example of the magnitudes of the welfare gains from EJ and IJ as a function of $\pi(r)$, consider the case of a standard deviation of project returns of 0.5. Here for social capital worth 10% of the loan size for example, the welfare attainable under IJ, $V^{IJ} = 2.29$ is 32.4% lower than the welfare under EJ $V^{EJ} = 3.39$. This highlights the clear welfare gains that are possible under EJ in environments with low S. These gains disappear however for higher levels of S. With social capital worth 50% of the loan size, the welfare attainable under EJ $V^{EJ} = 3.39$ is in fact 5% lower than that attainable under IJ, $V^{IJ} = 3.56$. The higher levels of social capital make it incentive compatible to help each other out, when they are able to, while not being punished when not the whole group is able to repay.

The graph also highlights that the welfare under the EJ and IJ contracts are almost completely overlapping when $S = 0.3$.

While these results illustrate the problems with strict EJ,[27] we also interpret them as showing why EJ should not be prematurely dismissed as an important contractual tool (as also recently argued by Banerjee, 2013). Many of the candidates for alternative mechanisms discussed in the literature are complex and potentially difficult to implement, so we have focused on two extremely simple mechanisms that we feel are empirically relevant. What we find is that implicit joint liability can perform very well, provided borrowers have enough social capital: borrowers have to be willing to impose sanctions on one another worth at least 30% of their loan size. Meanwhile EJ functions well in our simulations even for low levels of social capital. This illustrates how important the lending environment, and in particular borrowers' social ties are for determining the preferred contract in our framework.

5.3. Correlated returns

As an extension, we now present simulation results when borrowers' returns are correlated. A number of recent papers have analyzed how correlated returns affect repayment behavior under joint liability lending.[28] As a simple extension, we consider how our EJ and IJ borrowers are affected by introducing positively or negatively correlated returns into the model. We simulate the borrowing group's per-period income vector $[Y_1,..., Y_n]$ as a multivariate Normal distribution. We fix the standard deviation at 0.5, the midpoint of the range considered in the previous section, and vary the pairwise correlation between group members from -0.25 to 0.45.[29] We graph the results in Figs. 3 and 4.[30]

The main conclusion from this analysis is that for a given level of social capital, EJ is significantly more sensitive to the strength of correlation between borrower incomes. EJ requires all loans to be repaid. When borrower incomes are only weakly correlated, there will typically only be a small number of failures in a group, which are relatively easy for the other members to assist with. With a strongly positive correlation this is no longer the case, it becomes more common to have large numbers of failures. In this environment IJ is an advantage because the borrowers are not penalized when their partners default. This becomes evident when comparing the gradient of the IJ curves relative to the EJ curves as the correlation increases.

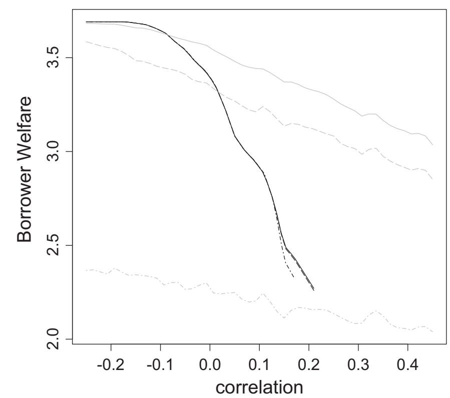

Fig. 3. Simulation results for correlated borrower returns. Explicit joint liability results are in black and implicit joint liability in grey. The figure plots borrower welfare for three levels of social capital, $S = 0.1, 0.3, 0.5$. The correlation between pairs of borrower's returns is varied on the horizontal axis.

6. Conclusion

Anecdotal evidence suggests that MFIs making individual liability loans still commonly use group repayment meetings. Giné and Karlan (2014) found that removing joint liability but retaining groups had no average effect on repayment, but seemed to increase repayment among borrowers with high social capital and reduced it among borrowers with low social capital. We ask whether groups do more than just facilitate the lender's operations.

We show that when individually liable borrowers have sufficient social capital to continue to guarantee one another's repayments, which we call implicit joint liability (IJ), they can replicate or improve on the repayment performance of explicit joint liability (EJ). However this first result does not depend upon the use of groups, provided borrowers are able to side contract on loan repayments outside of repayment meetings.

We next show that when individual and group repayment meetings are costly, mutual insurance or IJ are easier to sustain under group lending, because IJ depends crucially on the interest rate, which in turn depends on the share of total meeting costs borne by the lender. Group meetings reduce the lender's share of meeting costs, enhancing the advantages of IJ.

The second experimental paper highlighting the role of groups is Feigenberg et al. (2013). They find that varying meeting frequency for a subset of individually liable borrowing groups seemed to have persistent positive effects on repayment rates. They suggest that this is due to improved informal insurance among these groups due to higher social capital. We analyze situations under which microcredit might induce borrowers to create social capital, which in turn enables them to sustain IJ. We derive conditions under which group lending is more likely than individual lending to create social capital. Relating to one of the key findings of Feigenberg et al. (2013), we derive conditions under which more frequent meetings, modeled here as an increase in the amount of time borrowers and loan officers must spend in loan repayment meetings, increase borrowers' incentive to invest in social capital. This

[27] Problems that have also received attention in Besley and Coate (1995), Rai and Sjöström (2004), Bhole and Ogden (2010), Rai and Sjöström (2010) and Allen (2014).

[28] For example, Laffont (2003), Ahlin and Townsend (2007) and Allen (2014).

[29] For correlation smaller than −0.25 we essentially have 100% repayment everywhere, and for greater than 0.45 there is typically no lending equilibrium.

[30] Note that the graphs are less smooth than those in Fig. 1. This is because for the benchmark simulations we are able to reuse the same underlying random draws for each set of output realizations, simply by rescaling as the standard deviation changes. This is not possible when considering variously correlated returns, so we need to generate a new sample of borrower output realizations for each value of the correlation coefficient, and this naturally introduces some extra noise.

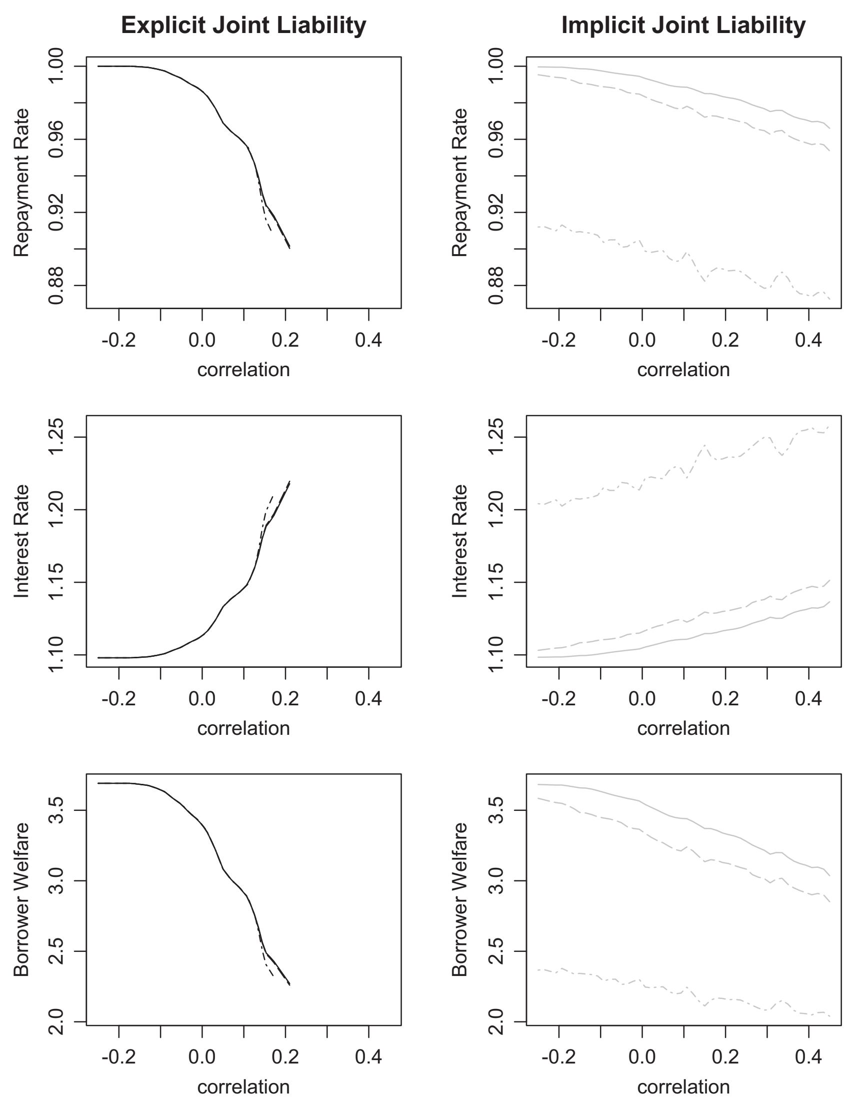

Fig. 4. Simulation results for correlated borrower returns. Explicit joint liability results are in the left column and implicit joint liability in the right column. Each figure plots the relevant object (repayment rate, interest rate and borrower welfare) for three levels of social capital, $S = 0.1, 0.3, 0.5$. The correlation between pairs of borrower's returns is varied on the horizontal axis of each figure.

provides a theoretical foundation for Feigenberg et al. (2013)'s observation. However, in our framework it is inefficient for lenders to do this in the absence of some other friction preventing borrowers from privately coordinating among themselves.

Finally, we carry out a simulation exercises to assess the quantitative magnitudes of the effects of alternative forms of lending, as well as some of the relevant thresholds of social capital. We find that EJ is insensitive the the level of social capital, while IJ is sensitive and, when borrower incomes are uncorrelated, outperforms EJ for social capital worth at least 30% of the loan size. When borrowers's incomes are positively correlated the advantages of IJ are increased.

In addition to fitting some of the key findings from Giné and Karlan (2014) and Feigenberg et al. (2013), our model makes at least two new empirical predictions, for which unfortunately we believe the relevant data do not currently exist. The first is that the benefits of joint liability are non-monotone in social capital, such that we should expect to see lenders using joint liability in intermediate, but not low or high social capital environments. The second is that group lending without joint liability, to the extent it creates social capital, is more valuable in communities with low than with high preexisting social capital, so among individual liability lenders we might expect the use of groups to be negatively correlated with social capital.

Appendix A. Mathematical appendix

Proof of Lemma 1

Proof. Comparing the expressions for $\hat{S}^{EJ}_A$ and $\hat{S}^{IJ}_A$, it is immediate that $\hat{S}^{EJ}_A < \hat{S}^{IJ}_A$ since $\pi^{EJ}_A = \pi^{IJ}_A$ and $\delta\pi^{EJ}_A\overline{R} - \rho > 0$ by Assumption 3.

Now consider Case B. It is obvious that if $\hat{S}^{EJ} = 0$, $\hat{S}^{IJ} > \hat{S}^{EJ}$, since $\hat{S}^{IJ} > 0$. Suppose therefore that $\hat{S}^{EJ} > 0$. We have:

$$\hat{S}^{IJ} - \hat{S}^{EJ} = \frac{\delta\pi^{EJ}_B\overline{R} - \rho}{\delta\pi^{EJ}_B\left(1 - \delta\pi^{EJ}_B\right)} + \frac{\rho}{\delta\pi^{IJ}_B} - \frac{\rho}{\delta\pi^{EJ}_B}.$$

So:

$$\begin{aligned}
&\delta\pi_B^{IJ}\pi_B^{EJ}\left(1-\delta\pi_B^{EJ}\right)\left(\hat{S}^{IJ}-\hat{S}^{EJ}\right)\\
&\quad=\pi_B^{IJ}\left(\delta\pi_B^{EJ}\overline{R}-\rho\right)-p_m(1-p)\left(1-\delta\pi_B^{EJ}\right)\rho\\
&\quad=\delta\pi_B^{IJ}\pi_B^{EJ}\overline{R}-\rho+\left(1-\pi_B^{IJ}\right)\rho-p_m(1-p)\rho+\delta\pi_B^{EJ}p_m(1-p)\rho\\
&\quad=\delta p^2\overline{R}-\rho+\delta pp_h(1-p)\overline{R}-p_m(1-p)\rho\\
&\qquad+\delta\left(p\Delta(1-p)+p_h\Delta(1-p)^2\right)\overline{R}+\left(1-\pi_B^{IJ}\right)\rho+\delta\pi_B^{EJ}p_m(1-p)\rho.
\end{aligned}$$

The last line uses the fact that $\pi_B^{IJ}\pi_B^{EJ}=p^2+pp_h(1-p)+p\Delta(1-p)+p_h\Delta(1-p)^2$. This expression is positive because of Assumption 3 and $p_h > p_m$. □

Proof of Proposition 1

To compare IL and EJ, we consider first Case A, then Case B with $p_h > p_m$, and lastly Case B with $p_h \le p_m$.

In Case A, borrower repayment guarantees under IL offer no advantage over EJ, so provided $S \ge \hat{S}_A^{EJ}$, EJ is the borrower welfare-maximizing contract (with indifference for $S \ge \hat{S}^{IJ}$). For $S < \hat{S}_A^{EJ}$, borrower will not mutually guarantee under EJ and also default unless their partner is successful, so IL is preferred to EJ:

$$V_A^{EJ}(S)-V_A^{IL}(S)=\begin{cases}-\dfrac{\delta p(1-p)\left(\overline{R}-\rho\right)}{(1-\delta p)\left(1-\delta p^2\right)} & S<\hat{S}_A^{EJ}\\ \dfrac{\delta p(1-p)\left(\overline{R}-\rho\right)}{(1-\delta p)(1-\delta p)(2-p)} & S\in\left[\hat{S}_S^{EJ},\hat{S}_A^{IJ}\right)\\ 0 & S\ge\hat{S}_A^{IJ}\end{cases}$$

In Case B, with $p_h > p_m$, EJ dominates IL when borrowers guarantee one another under EJ but not under IL, for $S \in [\hat{S}_B^{EJ}, \hat{S}_B^{IJ})$, so EJ is preferred in this region. However, once IJ is possible, for $S \ge \hat{S}_B^{IJ}$, it dominates EJ. This is because borrower 1 repays her own loan in state $(R_m, 0)$, while she would default under EJ. We have:

$$V_B^{EJ}(S)-V_B^{IL}(S)=\begin{cases}-\dfrac{\delta p(1-p)\left(\overline{R}-\rho\right)}{(1-\delta p)\left(1-\delta p^2\right)} & S<\hat{S}_B^{EJ}\\ \dfrac{\delta\Delta(1-p)\left(\overline{R}-\rho\right)}{(1-\delta p)(1-\delta(p+\Delta(1-p)))} & S\in\left[\hat{S}_B^{EJ},\hat{S}_B^{IJ}\right)\\ -\dfrac{\delta p_m(1-p)\left(\overline{R}-\rho\right)}{(1-\delta(p+p_h(1-p)))(1-\delta(p+\Delta(1-p)))} & S\ge\hat{S}_B^{IJ}\end{cases}$$

Lastly, in Case B with $p_h \le p_m$, EJ is always dominated by IL. This is because under EJ the highest possible repayment probability is $p + \Delta(1-p)$, which is weakly smaller than p, the lowest possible repayment probability under IL. Therefore we do not need to know the ordering of $\hat{S}_B^{EJ}$ and $\hat{S}_B^{IJ}$ for this case — EJ will never be used.

Proof of Corollary 1

Suppose that total meeting costs are higher under ILG: $\frac{3}{2}\left(\gamma_f+1\gamma_v\right)>2\left(\gamma_f+\gamma_v\right)$ or $2\gamma_v > \gamma_f$. Suppose also that $S \in [\hat{S}^{IJG}, \hat{S}^{IJI})$. Then group lending sustains IJ but individual lending does not. Welfare is higher under group lending if:

$$\frac{\overline{R}-\rho-\frac{3}{2}\left(\gamma_f+2\gamma_v\right)}{1-\delta(p+p_h(1-p))}>\frac{\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)}{1-\delta p}$$

Taking the limit as $\gamma_f \to 2\gamma_v$, it is clear that this condition holds strictly, while $\hat{S}^{IJG} > \hat{S}^{IJI}$ continues to hold, thus the corollary follows for a non-trivial interval of costs by a standard open set argument.

Proof of Lemma 2

Consider a hypothetical equilibrium in which the borrowers do invest in social capital and repay with probability $\pi^{IJ} \equiv p + p_h(1-p)$. They are charged $\hat{r}=\frac{\rho+\gamma_f+\gamma_v}{\pi^{IJ}}$.

At the beginning of the first period, the borrower and her partner pay cost η and create social capital. Then, each period with probability $p + \Delta(1-p)$, both loans are repaid and both contracts renewed. With probability $p_m(1-p)$, only borrower i's loan is repaid. As a result, at the beginning of the next period, she must again pay cost η to create social capital with her new partner.[31]

Consider an ILI borrower in the first period, or one whose partner has just defaulted. IC1 is satisfied by the modified Assumption 3 in footnote 3. As we are considering an equilibrium in which she invests in social capital, we use an "IJI" superscript to denote the fact that IJ is taking place. If she invests in social capital with the new partner, she earns utility U, defined as follows:

$$U_1^{IJI}=S-\eta+W_1^{IJI}$$

where

$$W_1^{IJI}=\left(\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)\right)+\delta(p+\Delta(1-p))W_1^{IJI}+\delta p_m(1-p)U_1^{IJI}.$$

The first term in W is the per-period utility under ILI. The second term represents the continuation payoff when both borrowers repay and have their contracts renewed. This occurs with probability $p + \Delta(1-p)$. In this case she earns W_1^{IJI} next period. The third term represents the continuation payoff if she repays but her partner defaults, which occurs with probability $p_m(1-p)$. In this case she matches with a new partner and therefore earns U_1^{IJI} next period.

Substituting for W, we can write U as:

$$\begin{aligned}
U_1^{IJI}&=S-\eta+\frac{\left(\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)\right)+\delta p_m(1-p)U_1^{IJI}}{1-\delta(p+\Delta(1-p))}\\
&=\frac{\left(\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)\right)+(1-\delta(p+\Delta(1-p)))(S-\eta)}{1-\delta\pi^{IJ}}
\end{aligned}$$

Now we check for a deviation. In this context, a deviation is to defer investing in social capital by one period, i.e. to undergo one period without social capital (and therefore with repayment probability p), then invest in social capital next period. She prefers not to deviate if:

$$U_1^{IJI}\ge\left(\overline{R}-\rho-2\left(\gamma_f+\gamma_v\right)\right)+\delta pU_1^{IJI}. \tag{10}$$

The first term on the right hand side represents the per-period utility of a borrower under ILI without social capital, paying an interest rate of $\hat{r}=\frac{\rho+\gamma_f+\gamma_v}{p}$ (recall that we assumed the lender adjusts r to reflect the repayment probability). With probability p her loan is repaid, and in the next period she invests in S, thus receiving continuation value U_1^{IJI}. Substituting for U_1^{IJI} and rearranging yields condition (3). It is easy to check that this condition is equivalent to checking whether welfare is higher under an always-invest than a never-invest regime.

Proof of Lemma 3

Hypothesize an equilibrium in which borrowers invest in social capital. IC1 is satisfied by the modified Assumption 3 in footnote 17.

[31] Since no social capital is destroyed on the equilibrium path, the S created with the original partner is not lost but cannot be leveraged in the credit contract.

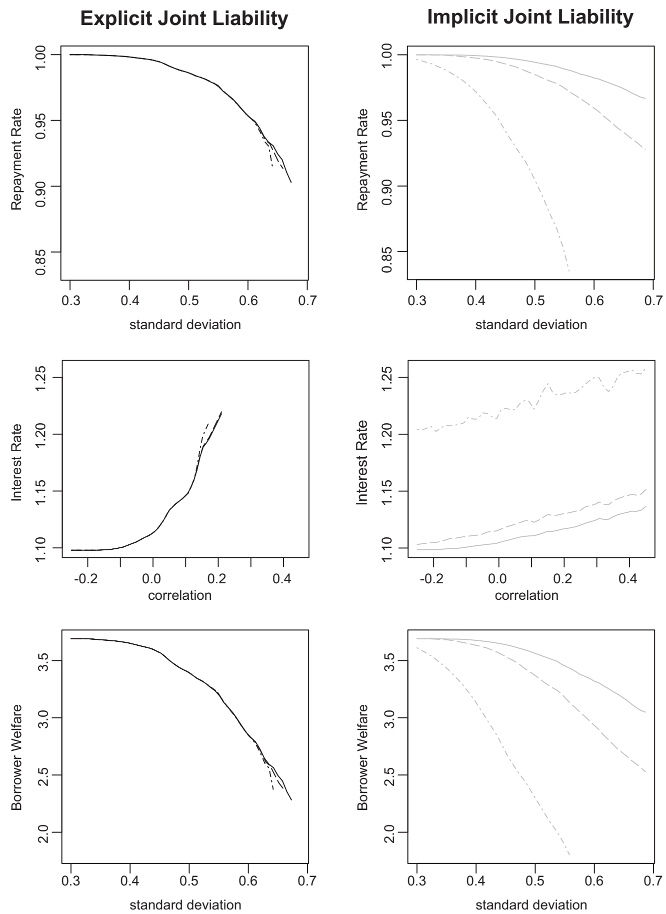

Fig. 5. Simulation results for uncorrelated borrower returns with a discount factor of 0.95. Explicit joint liability results are in the left column and implicit joint liability in the right column. Each figure plots the relevant object (repayment rate, interest rate and borrower welfare) for three levels of social capital, $S = 0.1, 0.3, 0.5$. The standard deviation of borrower's returns is varied on the horizontal axis of each figure.

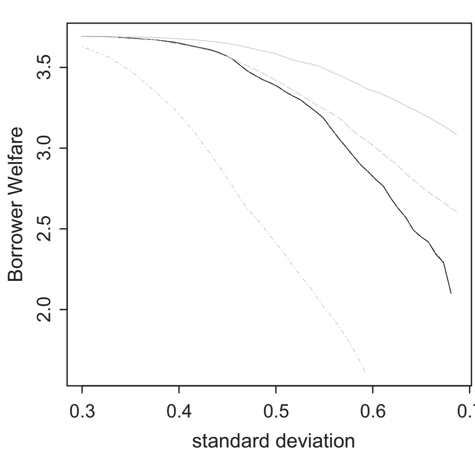

Fig. 6. Simulation results for uncorrelated borrower returns with a discount factor of 0.95. Explicit joint liability results are in black and implicit joint liability in grey. The figure plots borrower welfare for three levels of social capital, $S = 0.1, 0.3, 0.5$. The standard deviation of the individual borrower's income is varied on the horizontal axis.

We need to check that no borrower prefers to deviate by deferring their investment by one period, exactly as in Lemma 2. We define the value functions analogously to those in the proof of Lemma 2:

$$U_1^{IJG} = S - \eta + W_1^{IJG}$$
$$W_1^{IJG} = \left(\overline{R} - \rho - \frac{1}{2}\left(\gamma_f + 2\gamma_v\right)(3 - 2\lambda)\right) + \delta(p + \Delta(1-p))W_1^{IJG} + \delta p_m(1-p)U_1^{IJG}.$$

Where the possession of social capital reduces the borrowers' cost of group meetings by $\lambda(\gamma_f + 2\gamma_v)$. The appropriate substitutions yield:

$$U_1^{IJG} = \frac{\overline{R} - \rho - \frac{1}{2}\left(\gamma_f + 2\gamma_v\right)(3 - 2\lambda) + (1 - \delta(p + \Delta(1-p)))(S - \eta)}{1 - \delta\pi^{IJ}}$$

There will be no deviation if $U_1^{IJG} \geq \left(\overline{R} - \rho - \frac{3}{2}\left(\gamma_f + 2\gamma_v\right)\right) + \delta p U_1^{IJG}$. Simplifying yields condition (4).

Appendix B. Simulation approach

This Appendix outlines the algorithm used to simulate the core model. The simulation was implemented in *R*. The intuition of the simulation procedure is very straightforward. We use a random sample

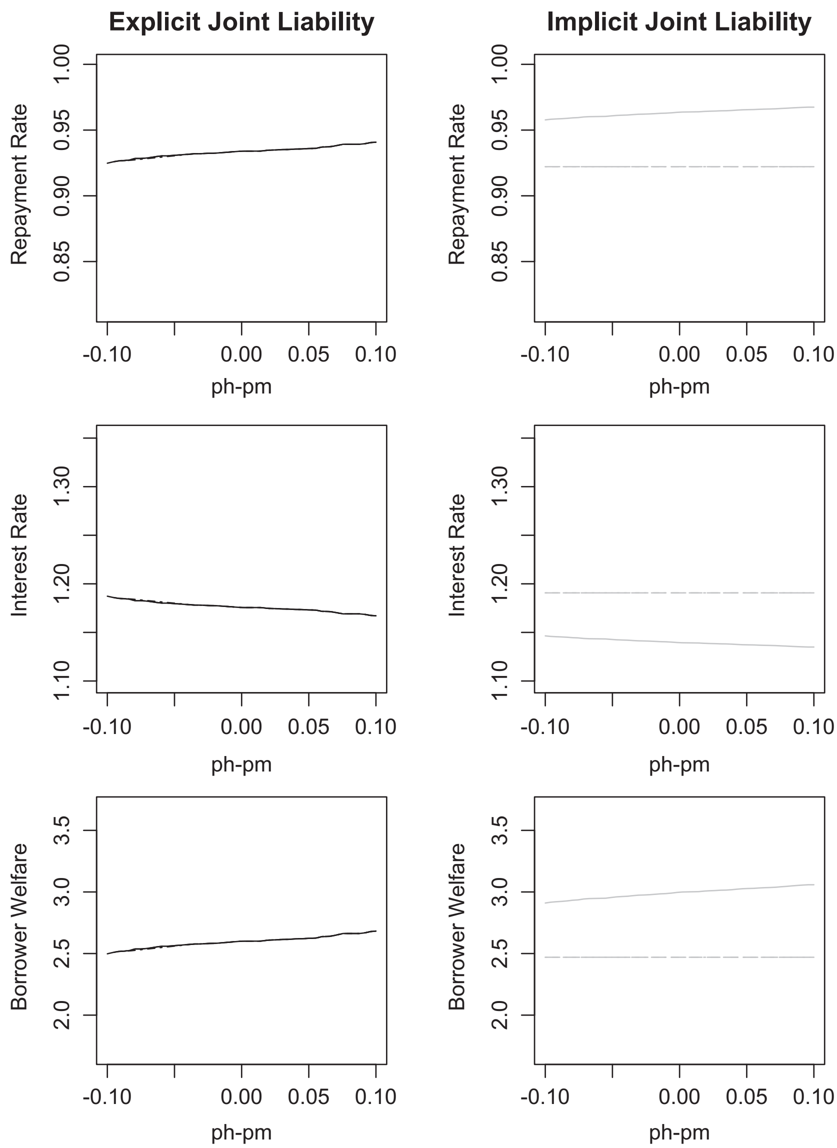

Fig. 7. Simulation results for discrete borrower income distribution. Curves for explicit joint liability are drawn in the left column, and implicit joint liability in the right column. Each figure plots the relevant object (repayment rate, interest rate and borrower welfare) for three levels of social capital, $S = 0.1, 0.3, 0.5$. The difference between p_h and p_m of individual borrower returns is varied on the horizontal axis of each figure.

of N groups with n members each. A group merely constitutes a vector of income realizations. These incomes are drawn from some distribution function F. We assume that F is a Normal distribution with $\mu = \overline{R} = 1.6$, however we allow the standard deviation σ to vary.

Given these income realizations, we compute the repayment rate that would arise under each contract for a given interest rate r. This process gives us a repayment probability function $\pi(r)$ under either contract.

Given this repayment probability function, we can then compute the break-even repayment rate and thus the break-even interest rate under each contract, along with borrower welfare. This then allows us to make comparisons between the two contractual forms.

We now describe in detail how the group-level repayment rate is computed, as this is different under each contract type due to the different incentive constraints.

We denote an income realization of a group i with n p borrowers is represented by an n-vector, $Y_i = (y_1, \ldots, y_n)$, where y_j is group member $j \in 1, \ldots, n$'s income draw.

We want to find a repayment rule analogous to the one outlined in the theory that allows for larger groups and the continuous output distribution. The most obvious way to do this is to construct for each Y_i a "group bailout fund" that can be used for transfers between group members to assist with repayments. Since the incentive constraints differ between EJ and IJ, the construction of the group fund also differs and is described below.

Group lending without joint liability

The relevant incentive constraint under group lending without joint liability implies that the maximum amount a group member j is willing to contribute to the group fund is $c_{ij} = \min\{\max\{0, y_{ij}\}, \delta S\}$.[32] All the transfers are put into a common pool C_i. This pool is then used to ensure the maximum possible number of repayments. The borrowers are sorted in ascending order of the amount of transfer they require to repay their own loan. and transfers made from the fund until it is

[32] As noted in the text, for a borrower with a negative income realization we assume that the group members may pay off her loan but do not pay to bring her income up to zero, and she cannot contribute to the pot.

exhausted.[33] If m group members repay, then we obtain a group level repayment rate $\pi_i = \frac{m}{n}$. As this procedure is repeated for a sample of N groups, we can then estimate the overall repayment probability as the simple average.

The procedure in pseudo-code (groups indexed by i and members by j):

Group lending without JL

1. Generate an $N \times n$ matrix of income realizations from F.
2. For each possible value of the interest rate r:
   (a) For each Y_i: compute the maximum level of contributions that each group member is willing to make to the common pool as $c_{ij} = \min\{\max\{0, y_{ij}\}, \delta S\}$. This pot amounts to $C_i = \sum_n c_{ij}$.
   (b) Compute the redistributions required by members to ensure repayment as $t_{ij} = \max\{0, r - \max\{0, y_{ij}\} + c_{ij}$.
   (c) Order the required transfers in ascending order and redistribute the pot C_i until it is exhausted.
   (d) Compute the group level repayment rate $\pi_i(r)$.
3. Given all the π_i, compute $\pi(r) = \frac{\sum_i \pi_i}{N}$.

Group lending with joint liability

The simulation of this contract is more involved, since the relevant incentive constraint is $c_{ij} \leq \delta(V + S)$. This implies that in order to construct the repayment rate π, a number for the continuation value V is needed. V however, is itself a function of π.

The method proceeds as follows, for each possible value of r. First, we construct a set of possible candidates for $\pi(r)$, denoted $\tilde{\pi}$.[34] Plugging these candidate $\tilde{\pi}$ into the expression for the value function, we obtain the associated $V(\tilde{\pi})$ schedule. Given these candidate $\tilde{V}$'s, the group fund C_i is computed as follows. Each member is willing to contribute at most $c_{ij} = \min\{\max\{0, y_{ij}\}, \delta(\tilde{V} + S)\}$ toward repayment of the group's loan obligations. Explicit joint liability implies that the group will only repay when $C_{ij} = \sum_n c_{ij} \geq nr$. Thus a group's repayment rate is $\pi_i = \mathrm{I}[C_i \geq nr] \in \{0, 1\}$. Taking the average we obtain the simulated repayment rate given $\hat{\pi}(V(\hat{\pi}))$. In other words, taking as given a value for $V(\hat{\pi})$, the implied repayment rate $\hat{\pi}$ is computed. Then, the true π (and thus the true V) is found by solving for the fixed point $\pi = \hat{\pi}(V(\hat{\pi}))$. By iterating over r, we obtain the schedule $\pi(r)$ and the associated $V(\pi(r))$.

The procedure in pseudo code:

Group lending with JL

1. Generate an $N \times n$ matrix of income realizations from F.
2. For each interest rate r:
   (a) Construct a set of candidates for $\tilde{\pi}(r)$.
   (b) For each $\tilde{\pi}(r)$:
      - For each Y_i: compute the maximum level of contributions that each group member is willing to make to the common pool as $c_{ij} = \min\left\{\max\left\{0, y_{ij}\right\}, \delta\left(S + V(\tilde{\pi})\right)\right\}$. This pot amounts to $C_{ij} = \sum_n c_{ij}$
      - The group defaults if $C_{ij} < nr$.
      - Compute the group level repayment rate $\tilde{\pi}_i(\tilde{\pi}) \in \{0, 1\}$.
3. Given all the $\tilde{\pi}_i(V(\tilde{p}))$, compute $\tilde{\pi}(V(\tilde{\pi}))$ as the average and find the fixed point π such that $\pi = \tilde{\pi}(V(\pi))$.

Appendix C. Additional results

Appendix C.1. Simulation results for high discount factor ($\delta = 0.95$)

The discount factor used in the main analysis is relatively low compared to more standard values used in economics, so for robustness we repeat the uncorrelated returns simulations for $\delta = 0.95$. We see a very similar pattern: 1) EJ is still highly insensitive to social capital; 2) IJ is highly sensitive; and 3) both perform approximately equally well for $S = 0.3$, IJ performing better for high S and worse for low S. The key difference is unsurprisingly that the levels of the value functions are inflated by the higher discount factor. Results are graphed in Figs. 5 and 6.

Appendix C.2. Simulation results for piecewise returns

As discussed in the main text, there is no straightforward approach to simulating the model with the discrete returns distribution. The problem is one of too many degrees of freedom. We think a sensible approach is to vary the difference between the parameters p_h and p_m, since we saw in the main draft that for $p_h < p_m$, EJ performs particularly badly. We vary this difference but still hold the sum $p_h + p_m = \overline{p}$ fixed, where $\overline{p} = 0.921$, estimated from the MIX Market data by de Quidt et al. (2013).

We still have three parameters to tie down, namely R_m, R_h and the mean return. We take the following approach. First, we assume down $R_m = \rho/p^2$, motivated by Assumption 1 for the two player model. It implies that the medium return is high enough to repay an individual liability loan. Given this and the value of $\overline{R} = 1.6$, we compute R_h imposing the constraint that $pl = p_m$. This thus gives us the value for R_h, when the difference between p_h and p_m is zero. Given these fixed values, we then simply vary the difference between p_h and p_m, holding everything else, including $p_h + p_m$, constant. When plotting the simulation results as a function of the difference between p_h and p_m in Fig. 7, we see that, as in the theory with groups of two borrowers, EJ performs better the larger is $p_h - p_m$. However, note that as we increase p_h relative to p_m, the mean return is changing as well, so it is difficult to say categorically what is driving the results.

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[33] This in fact implies that in some cases the worse off borrowers will be bailing out the better off borrowers. In particular, it may be that an unlucky borrower gives her whole income to a partner to repay their loan, but defaults on her own loan. This is because the worse off borrowers require a larger transfer, which is thus less likely to be incentive compatible. This mechanism achieves the maximum possible repayment rate and therefore maximizes ex-ante expected utility. This does not imply that a borrower with $y_j > r$ would ever default (i.e. be forced to choose between losing δV and δS). The reason is that all borrowers "above" her in the bail out chain also have $y > r$, so are making net positive contributions to the fund, which therefore has a positive "balance" when her turn comes.

[34] These candidate π's exploit the monotonicity of the $\pi(r)$ schedule. The upper bound on π is given by the previous iteration for a higher r (since repayment must be decreasing in r), while the lower bound on π is globally defined as $\frac{\rho}{(\delta\overline{R})}$, since, by IC1, $\delta\overline{R} \geq r = \frac{\rho}{\pi}$ in any equilibrium with positive repayment. We then construct the candidate $\tilde{\pi}$ as all values ranging between the upper and the lower bound based on some step-size, say 0.001.

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