# Market Structure and Borrower Welfare in Microfinance*

Short title: Market Structure and Borrower Welfare

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**Abstract**

Motivated by recent controversies surrounding the role of commercial lenders in microfinance, and calls for regulation of the sector, we analyse borrower welfare under different market structures, considering a benevolent non-profit lender, a for-profit monopolist, and a competitive credit market. To understand the magnitude of the effects analysed, we simulate the model with parameters estimated from the MIX Market database. Our results suggest that market power can have severe implications for borrower welfare, while despite possible enforcement externalities competition typically delivers similar borrower welfare to non-profit lending.

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**JEL codes:** O16, G21, D4

*Commercialisation has been a terrible wrong turn for microfinance, and it indicates a worrying "mission drift" in the motivation of those lending to the poor. Poverty should be eradicated, not seen as a money-making opportunity.*

Muhammad Yunus, New York Times, January 14th 2011[1]

Lately, microfinance has often been in the news for the wrong reasons. The success of microfinance institutions (henceforth, MFIs) across the world has been tremendous over the last two decades, culminating in the Nobel Peace Prize for the Grameen Bank and its founder Dr. Muhammad Yunus. However, in the last few years there has been some controversy about the activities of some MFIs that has stirred a broader debate about commercialisation and mission drift in the sector.[2] There are concerns that some MFIs are profiteering at the expense of poor borrowers, attracted by the high repayment rates, and charging very high interest rates which seemingly contradicts the original purpose of the MFI movement, namely making capital accessible to the poor to lift them out of poverty.[3] While the discussion has been mostly about "commercialisation", there is an implicit assumption that these lenders enjoy some market power, for example, in Yunus's statement that microcredit has "[given] rise to its own breed of loan sharks".[4] This critique is acknowledged within the MFI sector and has led to calls for tougher regulations,

[1]Accessible at `http://www.nytimes.com/2011/01/15/opinion/15yunus.html`

[2]For instance, SKS in Andhra Pradesh, India, Banco Compartamos of Mexico, LAPO of Nigeria. See, for example, MacFarquahr (New York Times, April 13, 2010), and Sinclair (2012).

[3]In addition, the results from several randomised experiments in India, Mongolia, Morocco, and the Philippines suggest that while microfinance has a positive effect in starting small businesses, but it did not have a statistically significant effect reducing poverty. See Banerjee *et al.* (2015), Attanasio *et al.* (2015), Crépon *et al.* (2015), and Karlan and Zinman (2009). By design these studies look at a single MFI and its borrowers rather than addressing industry or market level issues. Nevertheless the results suggest the need to look at factors that might be limiting the impact of microfinance on its stated goal of poverty alleviation.

[4]The New York Times, 14th January 2011.

for example, in the form of a the "Micro Finance Institutions (Development and Regulation) Bill" currently tabled in the Indian Parliament.

The academic literature on microfinance, both theoretical and empirical, has not kept pace with these developments.[5] It has typically assumed lenders to be non-profits or to operate in a perfectly competitive market, and more generally, tended to ignore the issue of market structure in considering the welfare effects of microfinance (see for example, the review by Banerjee (2013)). Our paper aims to fill this gap both theoretically and empirically. We are the first, to the best of our knowledge, to study the welfare effects of commercialisation and market power in the context of microfinance, paying special attention to the particular structure of typical microcredit contracts.

Most existing work has looked at the remarkable repayment rates achieved by MFIs. In a world where lenders are not necessarily acting in the best interests of borrowers, we need to look beyond repayment rates. More broadly, the existing literature, both theoretical and empirical, has typically adopted a partial equilibrium framework focusing on one MFI and a given set of borrowers, we look at the broader market and institutional environment within which a MFI operates. This allows us to evaluate borrower welfare beyond repayment rates - looking at the types of loans offered, interest rates, and the extent of credit rationing.

We first study the behaviour of a monopolist lender who may either be a profit-maximiser, or a non-profit who maximises borrower welfare subject to a break-even constraint. Much of the microfinance literature has shown how joint liability lending can be used by MFIs to leverage borrowers' social capital and local information

[5] Exceptions are Cull *et al.* (2007), Cull *et al.* (2009) and Baquero *et al.* (forthcoming).

in order to lend to otherwise unbankable customers and increase their welfare. We show that when the lender is a for-profit he can instead leverage these to extract higher rents at the borrowers' expense. In particular, borrowers with more social capital may be worse off than those with less. However, given that borrowers are credit constrained and have very few outside options, they are still better off borrowing than not borrowing, and they are better off when the lender offers joint liability than individual liability.

We then show that competition between for-profit lenders can eliminate this exploitation, but has an ambiguous effect on borrower welfare because of an enforcement externality, in the spirit of Hoff and Stiglitz (1997) and Shapiro and Stiglitz (1984). Competition undermines borrowers' incentives to repay their loans and thus leads to credit rationing. One of the interesting trade-offs that emerges therefore is that of rent extraction under monopoly with the enforcement externality under competition.

Our framework suggests that one must look at the combination of the contractual form (individual or joint liability) and lender objectives (for-profit or nonprofit) to understand better the welfare effects of lending in this sector, going beyond a discussion of repayment and interest rates. In our characterisation, we show that some (low social capital) borrowers receive individual liability contracts, while others (high social capital) receive joint liability contracts, and the relevant cutoff thresholds of social capital depend on the lender's profit motive.

Finally, we simulate the model using parameters estimated from the MIX Market (henceforth, MIX) dataset and existing research. The attempt to bridge theory and policy debates via quantitative analysis is a novel aspect of the paper. We initially expected that the monopolist's ability to leverage borrowers' social capital would have large welfare effects. We find that forcing the monopolist to use JL when he would prefer IL increases borrower welfare by a minimum of 12% and a maximum of 20%. Meanwhile, switching to a non-profit lender delivers a much larger welfare gain of between 54% and 73%. The qualitative sizes of these effects are robust to a range of parameter values. Secondly, we find that despite its effect on undermining repayment incentives, competition delivers similar borrower welfare to the non-profit benchmark. Taking these results together suggests that regulators should be attentive to lenders with market power, but that fostering competition rather than heavy-handed regulation can be an effective antidote, even in the absence of a strong credit bureau.

Our paper is motivated by a change in the structure of the microfinance industry over recent decades. An industry famous for its humble beginnings–such as Muhammad Yunus' first loans made out of his own pocket–has grown into a much more commercialised concern, with institutions such as SKS and Compartamos making their owners very wealthy indeed. We highlight in Figure 1 two broad trends observed in the MIX Market data that are relevant to this study: first, the share of for-profit lenders in the industry has grown from around 35 percent in the late 1990s, to around 43 percent in 2009. Second, the average number of MFIs per country has doubled over the same period, from 9 to 18.[6]

In a related paper, de Quidt *et al.* (2017), we study the positive question of how commercialisation in microfinance affects the set of contracts offered. In that paper, the borrowers' outside option (determining their repayment incentives) and

[6] Figures constructed using MFI founding dates as recorded in the MIX Market dataset. See de Quidt *et al.* (2017) for further details.

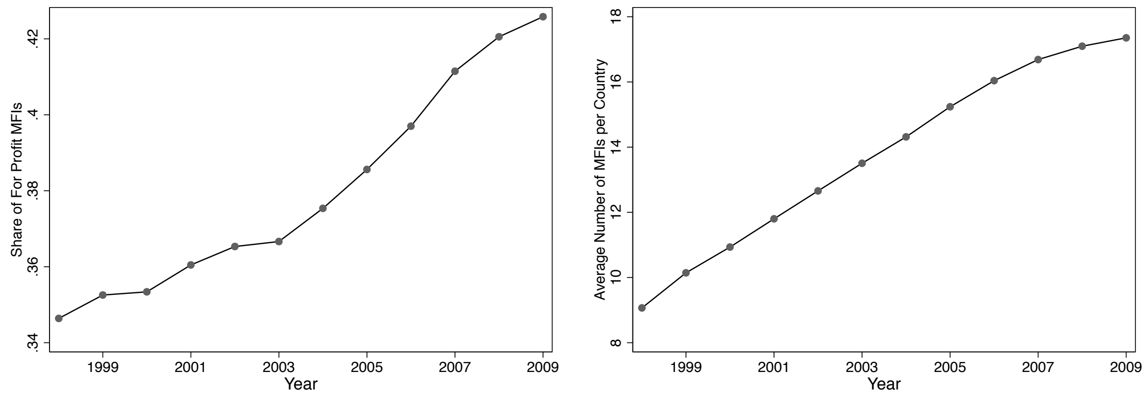


Figure 1: Growth of for-profit lending and competition.

market structure (its scale and the shares of non-profits and for-profits) are treated as exogenous, enabling us to derive comparative statics on how a move toward more competitive, more for-profit microcredit affects the contract offerings. In that paper we show that commercialisation causes a shift away from joint liability credit, a trend that we observe both in the data and in numerous anecdotal accounts. We also test and find empirical support for the model's key comparative static results.

This paper has a distinct and normative objective: to assess the *welfare* effects of commercialisation. This is difficult in the model of de Quidt *et al.* (2017), because welfare depends crucially on its exogenous components, and because computing welfare for a general market structure is intractable. We therefore work in this paper with a more specialised version of the model, in which we a) assume that the borrowers' outside option when considering whether to repay is entirely determined by their likelihood of obtaining a loan from another MFI, and b) focus on three market structures of interest, namely, monopolistic non-profit or for-profit lending, and competitive equilibrium, and derive the contractual and welfare outcomes for each case. The specialisation of the model enables other extensions, such as studying the welfare consequences of unobservable heterogeneity in borrowers' social capital.

Turning to related literature, our model is in the spirit of Besley and Coate (1995) who show how JL can induce repayment guarantees within borrowing groups, with lucky borrowers helping their unlucky partners with repayment when needed. They show a trade-off between improved repayment through guarantees, and a perverse effect of JL, that sometimes a group may default *en masse* even though one member would have repaid had they received an IL loan. Introducing social sanctions, they show how these can help alleviate this perverse effect by making full repayment incentive compatible in more states of the world, generating welfare improvements that can be passed back to borrowers. Rai and Sjöström (2004) and Bhole and Ogden (2010) are recent contributions to this literature, both using a mechanism design approach to solve for efficient contracts (although neither include the social capital channel). In de Quidt *et al.* (2016) we study "implicit joint liability" contracts, individual liability contracts that are able to leverage borrowers' social capital to induce mutual insurance. The model in that paper has the same structure as this paper but focuses on a single non-profit lender and expands the set of borrowers' potential output realisations to highlight key differences in mutual insurance under implicit and explicit joint liability contracts.

Within the microfinance literature there are various approaches to modelling social capital. For instance Besley and Coate (1995) model an exogenously given social penalty function, representing the disutility an agent can impose on her partner as a punishment. We model social capital in a similar reduced-form way as a sanction worth $S$ that a borrower can impose on a partner in response to a violation of an informal contract, thus social capital in our model is a measure of the strength of informal contracting.[7]

There are a number of empirical studies of the role of social capital in group borrowing.[8] Feigenberg *et al.* (2013) study the effect of altering loan repayment frequency on social interaction and repayment, claiming that more frequent meetings can foster the production of social capital and lead to more informal insurance within the group. It is this insurance or repayment guarantee channel on which our model focusses. They also highlight that peer effects are important for loan repayment, even without explicit JL, through informal insurance, and that these effects are decreasing in social distance. There is also some emerging evidence on the relative roles of IL and JL. Giné and Karlan (2014) and Attanasio *et al.* (2015) find no significant difference between group and individual repayment probabilities, although repayment rates are very high under both control and treatment groups. The papers are not strictly comparable as in the first study, group meetings were retained under IL while in the second, group meetings were not used either under IL or JL.

The plan of the paper is as follows. In section 1 we lay out the basic model and analyse the choice of contracts by a non-profit lender who maximises borrower welfare and a for-profit monopolist. In section 2 we analyse the effects of introducing competition to the market. We then simulate the model in section 3, allowing an empirical interpretation of the key mechanisms analysed. Section 4 concludes.

[7] Alternative approaches include Greif (1993), where deviations in one relationship can be credibly punished by total social ostracism. Bloch *et al.* (2008) and Karlan *et al.* (2009) Jackson *et al.* (2012) present models where insurance, favour exchange or informal lending are embedded in social networks such that an agent's social ties are used as social collateral to enforce informal contracts.

[8] See, for example Cassar *et al.* (2007), Wydick (1999), Karlan (2007), Giné *et al.* (2010).

## 1. The Model

We assume that there is a set of risk neutral agents or "borrowers", each of whom has access to a technology costing one unit of output each period that produces $R$ units of output with probability $p \in (0,1)$ and zero otherwise. Project returns are assumed to be independent. In each period the *state* is the vector of output realisations for the set of borrowers under consideration, so when we consider an individual borrower the relevant state is $Y \in \{0, R\}$, while for a pair of borrowers it is $Y \in \{(0,0), (0,R), (R,0), (R,R)\}$. The outside option of a borrower is assumed to be zero. Borrowers do not save and have no assets, so they must borrow 1 unit of output at the start of the period to finance production, and consume all output net of loan repayments at the end of the period. Since they have no assets their liability in any given period is limited to their income in that period. Borrowers have infinite horizons and discount the future with factor $\delta \in (0,1)$. Throughout the paper, we will use "hat" notation ($\hat{x}$) to denote interest rates, utilities, etc arising under the non-profit, "tilde" ($\tilde{x}$) for the monopolist, and "double tilde" ($\tilde{\tilde{x}}$) for competition.

Each period, the state is common knowledge for the borrowers but not verifiable by any third party, so the lender cannot write state-contingent contracts. Borrowers can write contingent contracts with each other but these can only be enforced by social sanctions.

There is a single lender who may be a non-profit who is assumed to choose a contract that maximises borrower welfare subject to a zero-profit condition, or alternatively a for-profit who maximises profits.[9] The lender's opportunity cost of

[9]We do not explore the organisational design issues that might cause non-profits to behave differently than postulated above, as for example in Glaeser and Shleifer (2001).

funds is $\rho \geq 1$ per unit. We assume (purely for simplicity) that the for-profit lender does not discount, i.e. he chooses the contract to maximise current-period profits only. We also assume that the lender has sufficient capacity to serve all borrowers that want credit.

Since output is non-contractible, lenders use dynamic repayment incentives as in, for example, Bolton and Scharfstein (1990). Following much of the microfinance literature we focus attention on IL or JL contracts. The IL contract is a standard debt contract that specifies a gross repayment $r$, if this is not made, the borrower is considered to be in default and her lending relationship is terminated. Under JL, pairs of borrowers receive loans together and unless both loans are repaid in full, both lending relationships are terminated. The lender can choose the interest rate and whether to offer IL or JL. Borrowers are homogeneous in the basic model so the lender offers a single contract in equilibrium.

We assume the lender commits to a contract in the first period by making a take-it-or-leave it offer specifying $r$ and either IL or JL. Borrowers may then agree on an intra-group contract or *repayment rule*, specifying the payments each borrower will make in each possible state of the world.

Throughout the paper we assume the following timing of play. In the initial period:

1. The lender enters the community and commits to an interest rate and either IL or JL for all borrowers.

2. Borrowers may agree a repayment rule.

Then, in this and all subsequent periods until contracts are terminated:

1. Loans are disbursed, the borrowers observe the state and simultaneously make repayments (the repayment game).

2. Conditional on repayments, contracts renewed or terminated.

### *1.1 Intra-group contracting*

Under JL, borrowers form groups of two individuals $i \in \{1,2\}$, which are dissolved unless both loans are repaid. Once the loan contract has been written the borrowers agree amongst themselves and commit to a repayment rule or repayment guarantee agreement that specifies how much each will repay in each state in every future period.[10] In order to prevent the group from being cut off from future finance, a borrower may willingly repay the loan of her partner whose project was unsuccessful (with the understanding that the partner would do the same if the roles are reversed). We assume that deviation from the repayment rule is punished by a social sanction of size $S$, introduced in section 1.2 below.[11] Some examples of possible rules are "both borrowers only repay their own loans," or "both repay their own loans when they can, and their partner's when she is unsuccessful."

The agreed repayment rule can be seen as a device that fixes the payoffs of a two-player "repayment game" for each state of the world. Since the state is common knowledge to the borrowers, each period they know which repayment game they are playing. Either a borrower pays the stipulated amount, or she suffers a social sanction and may also fail to ensure her contract is renewed. The repayments

[10]It is plausible that such agreements could expand to include others outside the group. For simplicity we assume that this is not possible, perhaps because borrowers' output realisations or borrowing and repayment behaviour are only observable to other borrowers within their group.

[11]In de Quidt *et al.* (2016), we show how social sanctions can enable borrowers to guarantee repayments without an explicit JL clause. With the binary production function in this paper such behaviour will not arise in equilibrium.

stipulated in the rule must constitute a Nash equilibrium (i.e. be feasible and individually incentive-compatible). We assume that the pre-agreed rule enables the borrowers to coordinate on a particular equilibrium by fixing beliefs about their partner's strategy. This in turn implies that social sanctions never need to be enacted on the equilibrium path since there will be no deviations from the rule and both borrowers know the state.

For simplicity, we restrict attention to repayment rules that are symmetric (i.e., do not condition on the identities of the players), and stationary (depend only on the current state and social capital). Thus we can focus on a representative borrower with a time-independent value function. Symmetry prevents one borrower from taking advantage of the other using the threat of social sanction as leverage. Furthermore we focus on repayment rules that induce a joint welfare-maximising equilibrium. This implies that the total repayment in any state will be either zero or $2r$, and that social sanctions will not be used on the equilibrium path but only to punish off-equilibrium deviations.

### *1.2 Social Sanctions*

A central theme in the microfinance literature is how the innovative lending mechanisms used by MFIs can harness social capital and local information among borrowers to overcome standard asymmetric information problems that make profitable lending to the poor difficult. With altruistic or competitive lenders the typical result is that the greater the lender's ability to access these, the better.

In this paper we show how under market power this result is reversed. Specifically, joint liability borrowers with a lot of social capital can be worse off than those with a little. This mirrors recent work on property rights (Besley *et al.* (2012)) that shows that in an insufficiently competitive market, an improvement in borrowers' ability to collateralise their assets can make them *worse off*, in contrast to the standard view of the "de Soto effect." This, however only represents a partial point against joint liability lending: it turns out that banning the use of joint liability would make borrowers still worse off.

There are many possible ways to model social capital. We adopt a very simple reduced form approach. We model social capital as borrowers' ability to enforce informal contracts amongst themselves. Such contracts specify actions that a borrower must take in certain states of the world, and if she deviated from the agreement she is punished by a sanction worth $S$ in utility terms.[12] Borrowers in our model form loan guarantee or informal insurance arrangements to assist one another in times of difficulty, backed by social sanctions. With an altruistic or competitive lender, the standard intuition follows: larger social sanctions can support more efficient lending contracts, increasing borrower welfare. When the lender has market power, more social capital still increases efficiency, but the lender can exploit the borrowers' sanctioning ability to extract more rents, potentially making them worse off.

In the core model we assume that $S$ is observable and homogeneous across borrowers, and explore the comparative statics of varying the borrowers' informal enforcement ability. In an extension in section 1.4, we discuss the consequences of heterogeneity.

[12] This is closely related to the approach of Besley and Coate (1995) and the informal sanctions in Ahlin and Townsend (2007).

### 1.3 *Loan contracts*

With a single lender, contract termination means no credit ever again (unlike under competition in section 2, when a borrower cut off by one lender can later obtain a loan from another). Since borrowers must be given a rent for dynamic incentives to be effective, any incentive-compatible contract will satisfy their participation constraint.

If a borrower's contract is renewed with probability $\pi$, it must be that her expected per-period repayment is $\pi r$. Thus the value of access to credit for a representative borrower is $V = pR - \pi r + \delta \pi V$, which simplifies to:

$$V = \frac{pR - \pi r}{1 - \delta \pi}. \tag{1}$$

We can use (1) to derive the first incentive constraint on the lender. No borrower or group of borrowers will repay a loan if $r > \delta V$, i.e. if the benefit of access to future credit is worth less than the interest payment. This reduces to the constraint $r \leq \delta p R$, which we term Incentive Constraint 1 (IC1). We define $r_{IC1}$ as the interest rate at which IC1 binds:

$$r_{IC1} \equiv \delta p R.$$

When IC1 binds, $V = pR$. This caps the lender's rent extraction: borrowers cannot be made worse off than if they took one loan and defaulted immediately.

### 1.3.1 *Joint liability and social capital exploitation*

First we consider joint liability lending. Recall that the lender observes the borrowers' social capital, $S$, then offers a contract.

Suppose the lender offers a contract with interest rate $r$, satisfying IC1. The borrowers now agree on a repayment rule to maximise joint welfare. Since IC1 is satisfied, joint welfare is higher when both loans are repaid than when both default, so the optimal rule will repay both loans in all states except $(0, 0)$ (when repayment is not possible). A minimal symmetric rule that achieves this is "both repay own loans in state $(R, R)$, and the successful borrower bails out her partner in states $(R, 0)$ and $(0, R)$." Under this rule, each loan is repaid with probability $1 - (1 - p)^2$, which simplifies to:

$$q \equiv p(2 - p).$$

Notice that $q > 1$.

Repayment of own loans in state $(R, R)$ is incentive compatible by IC1 (borrower stands to lose at least $\delta V$ if she does not repay $r$ when her partner is also repaying $r$). Now suppose borrower $j$ is called upon to assist $i$. If she does not, she loses future credit access, worth $V$, and is socially sanctioned next period, costing $S$. Thus the following incentive constraint (IC2) must hold: $R - 2r + \delta V \geq R - \delta S$. This reduces to an upper bound on the interest rate, which we call $r_{IC2}$:

$$r_{IC2}(S) \equiv \frac{\delta[pR + (1 - \delta q)S]}{2 - \delta q}.$$

In addition, a limited liability constraint must hold: $R \geq 2r$. We can ignore this without qualitatively affecting the results by the following parameter assumption:

**ASSUMPTION 1** $\delta p \leq \frac{1}{2}$.

Now consider a lender offering a JL contract. If $r_{IC2}(S) \geq r_{IC1}$, the borrowers always guarantee one another when $r \leq r_{IC1}$, repaying with probability $q$, and always default if $r \geq r_{IC1}$. Suppose then that $r_{IC2}(S) < r_{IC1}$. If he offers $r \leq r_{IC2}(S)$, the borrowers will guarantee one another's loans and repay with probability $q$. If he sets $r \in (r_{IC2}(S), r_{IC1}]$, the borrowers will not be able to help one another with repayment, so will only repay in state $(R, R)$, which occurs with probability $p^2$. Lastly, if he sets $r > r_{IC1}$, the borrowers always default. Clearly the latter cannot be an equilibrium. In addition, as we show when we discuss contract choice, a contract with $r > r_{IC2}(S)$ will always be dominated by an individual liability contract, so we ignore this possibility and focus on JL contracts under which borrowers repay with probability $q$.

Consider first a non-profit, altruistic lender offering joint liability loans. Assuming incentive-compatibility, the repayment probability is $q$ and hence the zero profit interest rate is $\hat{r} = \frac{\rho}{q}$. Plugging into (1), the equation for borrower welfare under the nonprofit is:

$$\hat{V}^{JL} = \frac{pR - \rho}{1 - \delta q}.$$

Note that $\hat{V}^{JL}$ does not depend on $S$.

Now consider a for-profit monopolist. The profit-maximising interest rate binds the tighter of IC1 and IC2. We define the following threshold value of $S$:

$$\bar{S} \equiv pR.$$

For $S < \bar{S}$, IC2 is tighter than IC1, while for $S \geq \bar{S}$, IC1 is the tightest. Thus we obtain the monopolist's interest rate, $\tilde{r}^{JL}$, and borrower welfare, $\tilde{V}^{JL}(S)$ as follows.

$$\begin{aligned}
\tilde{r}^{JL}(S) &= \min\{r_{IC1}, r_{IC2}(S)\} \\
\tilde{V}^{JL}(S) &= \frac{pR - q\min\{r_{IC1}, r_{IC2}(S)\}}{1-\delta q} \geq pR.
\end{aligned}$$

Note that for $S < \bar{S}$, $\tilde{r}$ is increasing in $S$, and therefore borrower welfare is decreasing in $S$, which we state as a proposition.

**PROPOSITION 1** *Under joint liability lending a monopolist for-profit lender exploits the borrowers' social capital by charging higher interest rates to borrowers with high social capital. Thus borrower welfare decreases in social capital.*

One way of viewing this result is that the lender's motivation matters more as the amount of borrower social capital increases, as the difference between borrower welfare under the nonprofit and for-profit monopolist increases. We will return to this issue later on when we consider equilibrium contract choice.[13]

As discussed above, much of the microfinance literature has shown how different aspects of MFIs' lending methodologies can be thought of as leveraging social capital and local information among borrowers to address various asymmetric in-

[13]The result also follows if we assume a lender that puts weight $\alpha$ on profits and $1-\alpha$ on borrower welfare (subject to a zero profit condition). By linearity in $r$ of $V$ and lender profits, there is an $\alpha$ threshold above which the lender behaves as a for-profit, and below which as a non-profit.

formation or weak enforcement issues. Proposition 1 shows that this not need be a force for good from the perspective of borrowers: a monopolist may be able to use their social capital against them to extract more rents.

We have assumed that $S$ is homogeneous and observable, so that the lender can choose the interest rate accordingly. Why can't the borrowers resist the lender's exploitation by refusing to use their ability to socially sanction one another? The problem is that threatening to do so is not credible. Conditional on the contract offered, the borrowers are better off using their ability to socially sanction to agree the most efficient repayment rule. Refusing to do so makes them less likely to be able to repay their loans and therefore worse off. The lender is a natural Stackelberg leader in this context - he simply commits to a single contract in period zero and the borrowers adjust accordingly. We consider the issue of heterogeneity of $S$ as an extension below.

### *1.3.2 Individual Liability*

Under individual liability the only incentive constraint is the one that ensures a borrower will repay her own loan, IC1. Provided IC1 holds ($r \leq \delta p R$), individual liability borrowers will repay whenever successful.[14] Then borrowers repay with probability $p$, so the nonprofit charges $\hat{r}^{IL} = \frac{\rho}{p}$, with borrower welfare $\hat{V}^{IL} = \frac{pR-\rho}{1-\delta p}$. The for-profit monopolist chooses $r$ to bind IC1, giving the following interest rate

[14] The limited liability constraint, $R \geq r$ is implied by IC1.

and borrower welfare:

$$\tilde{r}^{IL} = r_{IC1}$$
$$\tilde{V}^{IL} = \frac{pR - pr_{IC1}}{1 - \delta p} = pR.$$

It is clear that under the non-profit, borrower welfare under JL exceeds that under IL, due to the higher repayment probability. However, we also obtain a somewhat surprising result:

**PROPOSITION 2** *Despite the monopolist's exploitation of their social capital under joint liability, borrowers are still better off than under individual liability.*

Joint liability lending has received some negative press of late, in part due to perceptions of excessive peer pressure among borrowers. Our model captures this in one particular way: a lender with market power can exploit borrowers' ability to socially sanction one another to charge higher interest rates. It is thus surprising that the same lender would make borrowers worse off under individual liability.

The reason is straightforward. Under both contracts, the lender is constrained by IC1: it must be individually rational to repay a loan, at least when the partner is repaying. This constraint puts a lower bound on borrower welfare of $pR$. Under joint liability, for low levels of social capital the lender faces an additional constraint, IC2, that forces him to cut interest rates below individual liability levels in order to induce borrowers to guarantee one another's repayments. Furthermore, borrowers benefit directly from the higher repayment probability under JL.

One implication of this result is worth noting in the context of the policy debates surrounding microfinance. Our model speaks to any lender (and not just MFIs) with market power, using dynamic incentives to enforce repayment. Regulators should be alert to abuses by standard, IL-using lenders, who may or may not be formally registered as MFIs or even consider themselves to be MFIs.

### 1.3.3 *Equilibrium contracts*

So far we have analysed IL and JL in isolation. Now we turn to the choice of contract in equilibrium. IL lending can earn non-negative profits as long as expected repayment at $r_{IC1}$, equal to $pr_{IC1}$, exceeds the opportunity cost of funds, $\rho$. To use IL lending as a benchmark, we retain this throughout as an assumption.

**ASSUMPTION 2** *$\delta p^2 R > \rho$.*

JL can be used profitably provided that expected revenue when the tightest of IC1 and IC2 binds exceeds the opportunity cost of capital, i.e. $q \min \{r_{IC1}, r_{IC2}(S)\} \geq \rho$. This yields a threshold level of social capital, $\hat{S}$, above which JL lending can break even. Since borrowers are better off under JL, this is the switching point for the non-profit lender. We obtain:

$$\hat{S} \equiv \max \left\{ 0, \frac{(2-\delta q)\rho - (2-p)\delta p^2 R}{\delta q(1-\delta q)} \right\} < \bar{S}.$$

A simple condition that we shall make use of throughout for is $p \leq \delta q$, or

$$1 + \delta p - 2\delta \leq 0. \tag{2}$$

Condition (2) is sufficient but not necessary for $\hat{S} = 0$ and therefore if it holds the non-profit always offers JL.

Since the for-profit monopolist lender maximises per-period profits, $\Pi = \pi r - \rho$, he chooses the contract offering the highest per-period revenue $\pi r$. Therefore he offers JL provided $q\tilde{r}^{JL}(S) \geq p\tilde{r}^{IL}$. This gives us a second threshold, above which JL is offered by the monopolist:

$$\tilde{S} \equiv \max\left\{0, \frac{p^2 R(p - \delta q)}{q(1 - \delta q)}\right\}.$$

Condition (2), which was sufficient for the non-profit to offer JL for all $S$, is *necessary and sufficient* for the monopolist to offer JL for all $S$. The for-profit monopolist lender offers JL over a (weakly) smaller range of $S$ than the non-profit lender ($\tilde{S} \geq \hat{S}$), a finding that we show in de Quidt *et al.* (2017) extends to generalised market structures.

Let us define an efficient contract as one that maximises $V(S) + \frac{\pi r - \rho}{1 - \delta \pi}$, i.e. the sum of borrower welfare and profits, both discounted at the borrowers' discount rate. The following observation is then straightforward:

**PROPOSITION 3** *Monopoly for-profit lending is inefficient when* $S \in [\hat{S}, \tilde{S})$.

In summary, under IL, the value of future credit determines the maximum incentive compatible interest rate – we call this $r_{IC1}$. Under JL, the borrower can also be disciplined through social sanctions ($S$) from her partner. This leads to a second incentive compatibility condition which affects the interest rate. The sum of the required repayment for both group members must now be lower that the gain from future borrowing plus the utility loss from social sanctions, giving us a second interest rate $r_{IC2}$.

Without social sanctions, it is always the case that $r_{IC2} < r_{IC1}$ since under JL borrowers have to be willing to pay for their partners while under IL they only need to pay for themselves. As the level of social sanctions increases, the second condition is relaxed, and borrowers can be charged higher interest rates under JL contracts. Non-profit lenders do not exploit the higher social capital to raise interest rates, but may be able to switch to JL, so borrower welfare is always increasing in $S$. The monopolist, on the other hand, raises interest rates for groups with higher $S$. This is the core message of Proposition 1. Whenever the monopolist does offer JL, it is better than IL for borrowers than IL since repayment rates are higher. This is captured by Proposition 2. For intermediate levels of $S$, where the non-profit would use JL, the monopolist continues to prefer IL because it cares about profits, not borrower welfare. This is Proposition 3.

The use of group lending to leverage borrowers' social capital has been criticised for putting stress on borrowers and suggested as an important motivation for the tendency of some lenders to move toward individual loans.[15] In our model, a monopolist using JL is bad for borrowers, but he is even worse with IL. The problem is market power, and restricting contract choice without paying attention to this may be bad for both efficiency and equity.

In the simulation section we analyse the welfare implications of market power in detail. However the model allows us to easily make one policy-relevant remark on the effect of interest rate caps (a key component of some of the regulatory efforts, e.g., the Indian Microfinance Bill). The first-order effect is that the lender will be forced to cut his rates, essentially a transfer to the borrowers, increasing borrower

[15]See, for example, Grameen II at http://www.grameen.com/.

welfare. There is a second-order effect on contract choice as well. If the lender is offering JL he will continue to do so. However, if he is offering IL but the cap lies below $\tilde{r}^{JL}(S)$, he will switch to JL, further improving borrower welfare. The reason is that the lender must now charge the same rate under IL and JL, but the JL repayment rate is higher. Thus in our framework, correctly calibrated interest rate caps can be an effective tool for borrower protection.

We have assumed that individual liability borrowers cannot side-contract among themselves to guarantee one another's repayments. However, this may be an overly strong assumption as they have an incentive to do so if this enables them to repay more frequently. We have a related paper on the effects of such side-contracting (de Quidt *et al.* (2016)) which we term "implicit joint liability" or IJ.

### 1.4 Heterogeneity

The analysis so far assumes that social capital $S$ is homogeneous and observable across borrowers. In web appendix A.2, we extend the model to allow borrowers to have heterogeneous, unobservable social capital (either zero, or a fixed positive amount $S_h$), and solve for the relevant pooling or separating contract offers under different values of $S_h$. The main finding is an additional channel of exploitation of social capital. In separating equilibrium high $S$ borrowers receive JL and low $S$ borrowers IL contracts, and an increase in the social capital of the high types enables the lender to increase the interest rate faced by both types. Intuitively, the IL interest rate is constrained by a truth-telling constraint; if it is too high relative to the JL interest rate, low social capital borrowers switch to JL contracts. An increase in $S_h$ allows the lender to increase the JL interest rate and therefore also the IL interest rate.

## 2. Competition

The previous section showed how relaxing the assumption of altruistic non-profit lending affects borrower welfare. A for-profit lender with market power charges higher interest rates, inefficiently under-uses joint liability and exploits the social capital of joint liability borrowers by charging higher interest rates to those with more social capital. In this section we explore to what extent competition can mitigate these problems.[16]

To begin with, suppose that competitive lenders share information on defaulting borrowers, for example through a credit bureau, and refuse to lend to any borrower with a bad history. In that case, competition is identical to our nonprofit lender: free entry ensures that lenders break even and all borrowers can access credit.

We will focus on the more interesting case where information sharing between lenders is imperfect, so a borrower may default at one lender and go on to borrow elsewhere. This creates an important trade-off as the market becomes more competitive. On the one hand, competition constrains lenders' ability to charge monopoly interest rates – in the limit they earn zero profits and borrowers retain all the surplus from the relationship. As a result, in a competitive market more social capital unambiguously improves borrower welfare, because it increases the space of feasi-

[16] Recent work on competition in microfinance has studied issues of adverse selection and multiple borrowing. For example, in McIntosh and Wydick (2005) competition can can be harmful by preventing lenders from cross subsidising their bad borrowers with profits on good borrowers. The model presented here is an analytically solvable special case of that in de Quidt *et al.* (2017), where we make the simplifying assumption that borrowers' outside option is fully determined by the availability of credit from other lenders.

ble contracts and the extra surplus goes to the borrower. However, competition also creates an *enforcement externality*; the availability of alternative lenders undermines borrowers' incentive to repay their current lender (Hoff and Stiglitz, 1997). As a result, while the monopolist was able to internalise the externality and supply the entire market, to preserve repayment incentives under competition there must be credit rationing, such that a borrower knows it will take time to find a new lender if they default on their current loan. Our main finding (Proposition 5) is that the welfare ranking of competition and for-profit monopoly lending is ambiguous.

We shall begin by laying out the intuition behind the modelling assumptions we make, and how they drive the results. The model is closely analogous to Shapiro and Stiglitz (1984). In a model with a finite number of lenders, each default diminishes the stock of potential future lenders and thus changes the borrower's incentive to default on future loans. To avoid the need to track all borrowers' histories over time, our first key assumption is that the market is made up of a very large (effectively infinite) number of atomistic lenders. Default means permanent termination by the current lender, but leaves a very large stock of potential future lenders, so we do not need to track which lenders a borrower has defaulted at and borrowers' incentive constraints do not change over time. Defaulters enter a pool of borrowers waiting to find a new lender, and we simply track the size of this pool (which is positive and stable in equilibrium).

Second, we assume free entry of lenders. As new lenders enter the market, the incentive constraints that must be satisfied by existing lenders tighten (since there are more potential to lenders to match to once a borrower enters the pool). This forces them to cut interest rates. Entry continues until lenders are just breaking even and incentive constraints are binding, at which point we have found the competitive equilibrium. This enables us to pin down the equilibrium contracts offered, find the equilibrium market scale (the fraction of borrowers served in a given period), and solve for total welfare, which is the sum of the welfare of those currently borrowing and those waiting to find a new lender.

Free entry ensures that all potential surplus is captured, subject to incentive compatibility, and goes to borrowers. Thus, as social capital increases, which relaxes incentive constraints under JL, the market is more likely to be able to offer JL loans and the feasible market scale increases. This increases borrower welfare.

The remaining assumptions are technical. Given the excess demand for credit, we assume each period there is a random matching procedure of potential borrowers to lenders until capacity is filled. As lenders earn zero profits under any matching, the random matching assumption is innocuous. We also assume that borrowers have many potential group partners (with the same value of "$S$"). Deviating in one repayment game destroys that pair's social capital but borrowers can form a group with a new partner (and $S$) in the future. This simplifying assumption ensures we do not need to track the *social capital* history of borrowers.

Interestingly, credit rationing might not be necessary in an oligopolistic setting where entry is constrained. Intuitively, when the borrower only has a finite number of potential future lenders, default may be sufficiently costly that the "waiting period" after default is no longer required for incentive compatibility.[17] On the other hand, weaker competition within lenders would reduce the benefit of lower interest rates obtained from perfect competition. We do not give a formal treatment here,

[17]We thank an insightful referee for pointing this out.

because doing away with assumptions of atomistic lenders and zero profits significantly complicates the analysis and introduces strategic considerations between lenders that are beyond the scope of the current paper.[18]

### *2.1 Setup*

We assume a very large number of lending "branches" that may belong to the same or different lenders, with no information sharing between branches. Each branch is capable of serving two IL borrowers or one JL pair. The population mass of branches is $l$, while we normalise the population of borrower *pairs* to 1. If $l < 1$ there will be rationing in the credit market: not all borrowers can obtain a loan in a given period. If $l > 1$ then some branches will have excess capacity.

Every borrower has a large number of potential partners, so even after being socially sanctioned a borrower is assumed to be able to form a new group with social capital $S$. At the start of a period, borrowers will be either "matched", in an existing relationship with a lender, or "unmatched", waiting to find a lender. Since branches are atomistic the probability of a borrower rematching to a branch at which she previously defaulted is zero, and so an unmatched borrower's matching probability does not depend on her history. Unmatched branches post a contract offer and are randomly matched to borrowers until all borrowers are matched or there are no more unmatched lenders. Each period, loans are made according to the contracts agreed, the repayment game is played, and any defaulters have their contracts terminated, rejoining the pool of unmatched borrowers.

[18] In de Quidt *et al.* (2017) we provide a model in which "competitiveness," proxied by the outside option of the borrower, varies smoothly. This could be thought of as capturing degrees of competition in a reduced form way. We use the model to study how competitiveness changes the types of contracts offered, but the reduced form model does not permit us to study borrower welfare.

Our first observation is that there must be credit rationing in equilibrium, or there would be no dynamic repayment incentives and all borrowers would default.

**OBSERVATION 1** *There is credit rationing in equilibrium, i.e.* $l < 1$.

Since there is rationing, every branch will be able to attract borrowers every period. Therefore each branch can act as a local monopolist, offering the more profitable of IL and JL at the highest $r$ that satisfies the (appropriate) IC1 and IC2.[19] In equilibrium, entry occurs until lenders earn zero profits, at the intersection of the zero-profit interest rate and the tightest repayment constraint. We assume that if both IL and JL break even, lenders offer the borrowers' preferred contract, JL, which rules out equilibria in which both IL and JL are offered.[20]

Conjecture that proportion $\eta$ branches offer IL loans, and $1-\eta$ offer JL. Each period, a fraction $(1-p)$ of the IL borrowers default, creating vacancies in their respective branches. This is equivalent to there being $(1-p)\eta l$ vacant IL branches at the beginning of the next period (although note that in general there will be zero, one or two vacancies at a given branch). Similarly, there are $(1-\eta)l$ JL branches. Of these, a fraction $(1-q)$ of the borrower pairs will jointly default each period, leaving $(1-q)(1-\eta)l$ vacant JL branches at the beginning of the next period. The total proportion of unmatched borrower *pairs* at the beginning of a period is therefore $P \equiv (1-p)\eta l + (1-q)(1-\eta)l + (1-l)$. Thus an unmatched borrower randomly matches with an IL branch with probability $\frac{(1-p)\eta l}{P}$, and a JL branch with probability $\frac{(1-q)(1-\eta)l}{P}$, otherwise she must wait until next period.

[19] Instant costless replacement of defaulters means that even patient lenders would simply maximise per-period profits.

[20] There is a single value of $S$, termed $\tilde{\tilde{S}}$, at which mixed equilibria could occur.

In competitive equilibrium, IL loans will be repaid with probability $p$ and JL loans with probability $q$, leading to interest rates $\tilde{\tilde{r}}^{IL} = \frac{\rho}{p}$ and $\tilde{\tilde{r}}^{JL} = \frac{\rho}{q}$. A borrower who defaults on her loan (with probability $1-p$ or $1-q$ depending on contract) becomes unmatched, and receives utility $U$. We obtain:

$$\begin{aligned}
\tilde{\tilde{V}}^{IL} &= \frac{pR-\rho}{1-\delta p} + \frac{\delta(1-p)U}{1-\delta p} \\
\tilde{\tilde{V}}^{JL} &= \frac{pR-\rho}{1-\delta q} + \frac{\delta(1-q)U}{1-\delta q} \\
U &= \frac{(1-p)\eta l}{P}\tilde{\tilde{V}}^{IL} + \frac{(1-q)(1-\eta)l}{P}\tilde{\tilde{V}}^{JL} + \frac{\delta(1-l)}{P}U \\
&= \chi(l,\eta)\frac{pR-\rho}{1-\delta}.
\end{aligned}$$

The function $\chi$ is defined as:[21]

$$\chi(l,\eta) \equiv \frac{(1-p)(1-\delta q)\eta l + (1-q)(1-\delta p)(1-\eta)l}{(1-\delta p)(1-\delta q)(1-l) + (1-p)(1-\delta q)\eta l + (1-q)(1-\delta p)(1-\eta)l}$$

$$\chi(l,\eta) \in [0,1],\ \chi_l \geq 0,\ \chi_\eta \geq 0.$$

Total welfare is the combined welfare of matched and unmatched borrowers:

$$\begin{aligned}
Z &\equiv \eta l\tilde{\tilde{V}}^{IL} + (1-\eta)l\tilde{\tilde{V}}^{JL} + (1-l)U \\
&= \left[\frac{\chi(l,\eta)}{1-\delta} + l(1-\chi(l,\eta))\left(\frac{\eta}{1-\delta p} + \frac{1-\eta}{1-\delta q}\right)\right](pR-\rho)
\end{aligned}$$

The modified framework implies that each lender will face a new IC1 (and IC2

[21] $\chi_l \geq 0$ and $\chi_\eta \geq 0$ follow from the fact that greater scale or a higher proportion of (more frequently defaulting) IL borrowers increase the matching probability and thus welfare of an unmatched borrower. It is straightforward to check that borrower welfare is (weakly) higher under JL for all $\chi$. Also note that as $\chi \to 1$, $\tilde{\tilde{V}}$ and $U$ approach $\frac{pR-\rho}{1-\delta}$, which is the first-best welfare.

under JL). The constraints now reflect the fact that the borrowers' outside option upon default is improved (they become unmatched and may re-borrow in future), and so are tighter than before. As $\chi$, and thus $U$ increases, the tightest of these two constraints becomes tighter. This is the competition effect that constrains existing lenders' interest rates. We derive the constraints in online Appendix A.4.

### 2.2 Equilibrium

In equilibrium, it must not be profitable to open a new branch offering either IL or JL. Two key thresholds in the following analysis are $\tilde{\tilde{S}} \equiv \frac{p-\delta q}{\delta q(1-\delta q)}\rho$, and $\bar{\bar{S}} \equiv \frac{\rho}{\delta q}$. The former is the analog of $\tilde{S}$, representing the level of social capital at which the competitive market switches from IL to JL lending, and the latter is the analog of $\bar{S}$, the level of social capital at which IC1 binds under JL (as opposed to IC2). Note also that $\bar{\bar{S}} > \tilde{\tilde{S}}$.

**PROPOSITION 4** *If $\tilde{\tilde{S}} \leq 0$, the competitive equilibrium is JL-only lending, with market scale strictly increasing in $S$ for $S < \bar{\bar{S}}$, and equal to a constant, $\bar{\bar{l}}$ for $S \geq \bar{\bar{S}}$. If $\tilde{\tilde{S}} > 0$, the equilibrium for $S < \tilde{\tilde{S}}$ is IL-only lending at fixed scale $\underline{l}$. At $\tilde{\tilde{S}}$, all lending switches to JL at scale $\tilde{\tilde{l}} > \underline{l}$, then increases continuously in $S$ to $\bar{\bar{l}}$, at $\bar{\bar{S}}$. Welfare, $Z$, is strictly increasing in scale, $l$, and therefore weakly increasing in $S$.*

The proof and derivations can be found in online Appendix A.4. The intuition of the proof is simple. For a given contract type, lender entry occurs until the tightest repayment constraint (either IC1 or IC2) binds. For low levels of $S$, IC2 under JL is tight so lenders prefer IL. As $S$ increases, the JL IC2 is relaxed to the point that all lending switches to JL. Thereafter, JL is offered and scale increases in $S$ until IC1 binds. Aggregate welfare from microfinance, $Z$, is improved as $S$ increases because this enables a relaxation of credit rationing.

Comparing the key $S$ thresholds, we see that the competitive market is more likely to offer JL than the monopolist, and less likely than the non-profit (i.e. $\hat{S} \leq \tilde{\tilde{S}} \leq \tilde{S}$, with both inequalities strict when $p > \delta q$). This is a corollary of our more general results in de Quidt *et al.* (2017), where we show that non-profits generically decrease, and for-profits increase, their use of JL as borrowers' outside options improve. In this case the improvement comes through the increase in competition.

Note that this finding is not quite enough to argue that the lower use of JL by competitive lenders relative to the non-profit is inefficient. The structure of the market implies that dynamic incentives are somewhat different under competition than in the core model - a defaulting borrower in competition can expect to borrow again in future. In online appendix A.6 we extend the basic model to allow the nonprofit to offer a "stochastic renewal" contract that mimics the competitive market, and show that the competitive market does indeed under-use joint liability.

### *2.3 Comparing market structures*

Lastly, we turn to the question of whether competition is necessarily beneficial for borrower welfare in the presence of weak information sharing as in the framework outlined here:

The following proposition shows that the ranking (by borrower welfare) of the market structures considered in this paper is ambiguous. It is straightforward to see the following result:

**PROPOSITION 5** *The ranking of total borrower welfare under competition and monopoly for-profit lending is ambiguous.*

Under the monopolist, all borrowers receive loans in the first period so total welfare is equal to $\tilde{V} \geq pR$. Under the competitive equilibrium, total welfare is $W$, which depends on the degree of credit rationing in equilibrium. When credit rationing is low ($l$ is close to 1, for example because $\rho$ is small and $S$ is large), $Z$ approaches the first-best welfare $\frac{pR-\rho}{1-\delta}$, and so dominates the monopolist. Meanwhile when credit rationing is high ($l$ is close to zero, for example because $\rho$ is large and $S$ is small), $Z$ approaches zero and is dominated by monopoly lending.

Proposition 5 follows from the observation that when market scale under competition is small, the cost of credit rationing outweighs the benefits of lower interest rates and the potential to borrow again after defaulting. By eliminating the enforcement externality generated by competition, the monopolist solves the credit rationing problem. When scale is large, borrowers are essentially able to borrow every period, so there is no longer the inefficiency generated by dynamic incentives.

Proposition 5 reflects the genuine concern about externalities in uncoordinated competition.[22] A key purpose of the simulations performed in the next section is to

[22] It is also possible in our simple framework that competition might dominate the non-profit, arises because of the assumption that the non-profit must use strict dynamic incentives, while competition mimics a contract with probabilistic termination on default, akin to Bhole and Ogden (2010). We discuss relaxing the assumption of strict dynamic incentives in online Appendix A.6. We assume strict dynamic incentives in the main analysis because this is what lenders seem to use in practice and because the analysis is much simpler. However, if the non-profit chose to use stochastic renewal, he could achieve at least the same welfare as competition. For example by choosing the appropriate renewal probability he can mimic the contract faced by the matched borrowers under competition. However, he can do better by offering this contract to all borrowers. Moreover, sometimes the competitive market offers IL when JL would be better for the borrowers. In online Appendix A.6 we analyse a relaxed dynamic incentive, namely, renewing the group's contracts with certainty following repayment and with probability $\lambda \in [0, 1]$ following default. We find that the monopolist and competitive market always set $\lambda = 0$, while the nonprofit does use stochastic renewal, achieving higher borrower welfare than the competitive market.

understand the scope of this ambiguity - we will rank borrower welfare under our key market structures when we under a reasonable parameterisation of the model.

## 3. Simulation

In this section we carry out a simple simulation exercise to get a sense of the order of magnitude of the effects analysed in the theoretical analysis. We draw on plausible values for the key parameters of the model, mostly estimated using 2009 data from MIXMarket.org (henceforth, MIX), an NGO that collects, validates and publishes financial performance data of MFIs around the world.

The discussion proceeds as follows. First we modify the model to allow for larger group sizes, and also discuss the possibility that the LLC may bind (which we ruled out for the theoretical discussion for simplicity). Next, we describe the estimation of the model parameters and the simulation procedure. Next, we discuss the results using the full global sample of MFIs. Finally, we perform some sensitivity checks and discuss results at the regional level.

### *3.1 Group size and limited liability condition*

We make one modification to the framework, modelling larger groups of size five instead of two.[23] Theoretically, small groups cause problems under JL, since they require very large "guarantee payments" and hence a very tight LLC. This is particularly true in our present framework with only two income realisations, since borrowers must provide the full loan payment for their unsuccessful partners.

[23]Five was the group size first used by Grameen Bank and by other prominent MFIs. An unexplored extension would be to allow the lender to optimally choose the group size. Ahlin (2015) explores the role of group size in an adverse selection model.

For simplicity, we retain the notion of $S$ from the benchmark model - a deviating member loses social capital with the other members worth a total of $S$. In addition to this, we need to allow for the possibility that the LLC might be tighter than IC1. This is straightforward to implement in the simulations.

With a group of size $n$, borrowers will agree to guarantee repayment provided at least some number, $m$, of members are successful, defining a guarantee payment of $\frac{nr}{m}$ per successful member, so for example if $n = 5$ and $m = 4$, each successful member would repay $1.25r$ when one member fails. It is easy to see that the group size does not affect IC1, which simply asks whether it is incentive compatible to repay one loan. $\delta pR \geq r$ is still necessary. However, there will be a different IC2 for each value of $m$, corresponding to the payment that must be made when only $m$ members are successful. In equilibrium, borrowers will repay for every $m \geq m^*$, where $m^*$ is the smallest $m$ such that repayment is incentive compatible. By reducing the interest rate the lender can increase the number of states of the world in which repayment takes place, generating a (binomial) repayment probability of $\pi(n, m, p)$. We discuss the derivation of the constraints in detail in online Appendix A.7.

### 3.2 Data and Parameter values

The model's key parameters are $R$, $p$, $\rho$ and $\delta$. The numeraire throughout is the loan size, assumed to be identical between IL and JL, and the loan term is assumed to be 12 months. We mainly work with data on the financial performance and portfolio structure of 715 microfinance institutions in 2009 collected and organized by the MIX. We use this data to estimate the key parameters and perform extensive sensitivity checks. Each observation is a single MFI, and we use weighted means or regression techniques throughout, weighting by the number of loans outstanding. We use these weights since our unit of analysis is the borrower, so we are essentially estimating parameters for the average borrower, rather than the average MFI (assuming one loan per borrower). Details of the construction of the dataset can be found in online Appendix C. We next discuss how we estimate or calibrate each parameter in turn.

*Estimating $p$ and $m^*$* We estimate $p$ and $m^*$ (the minimum number of successes needed for a group to repay their loans) using cross-sectional data from the MIX on Portfolio At Risk (PAR), the proportion of an MFI's portfolio more than 30 days overdue, which we use as a proxy for the unobserved default probability. This is not an ideal measure for two reasons. Firstly, PAR probably exaggerates final loan losses, as some overdue loans will be recovered. However, MFIs' portfolios are typically growing rapidly (see the discussion of the estimation of $\rho$ below). If loans become delinquent late in the cycle, they will be drowned out by new lending, understating the fraction of a cohort that will subsequently default.

If all loans were IL, we would simply measure $p$ as $1 - PAR$ since the default rate is $1 - p$. However, we need to be mindful of the lending methodology, since the model predicts that JL borrowers will repay more frequently than IL borrowers. The MIX data allow us to separate the loan portfolio by lending methodology. Let $\theta$ denote the IL fraction of the lender's portfolio. Then we have $1 - PAR = \theta p + (1 - \theta)\pi(n, m^*, p)$ where $\pi(.)$ is as defined in the previous section and $n = 5$. We estimate this equation by (weighted) Nonlinear Least Squares, obtaining full sample estimates of $p = 0.921$ and $m^* = 3$, i.e. the estimated success probability is 92% and groups repay whenever at least three of their members are successful. We perform the same analysis at the regional level to obtain region specific estimates.

*Estimating $\rho$* We estimate $\rho$, which is the lender's cost per dollar lent, using data from the MIX on administrative ($x_a$) and financial expenses ($x_f$). To obtain the cost per dollar lent, we need to divide expenses by the total disbursals of that MFI during the year. Since MIX does not report data on disbursals, we hand-collected disbursal data from annual reports of the largest MFIs listed on MIX, for which the (weighted) mean ratio of disbursals to year-end portfolio was 1.91.[24] In other words, for every dollar outstanding at year end, on average MFIs lent 1.91 dollars over the course of the year. We use this factor to convert year end outstanding balances into disbursals for all MFIs. Therefore, for MFI $i$ we estimate $\rho_i = 1 + \frac{x_{a,i}+x_{f,i}}{GrossLoanPortfolio*1.91}$. Our full sample estimate is $\rho = 1.098$.

*Estimating $\delta$* Since the lender's only instrument to enforce repayment is the use of dynamic incentives, the borrowers' time preferences play an important role in the analysis. Unfortunately, it is not obvious what value for $\delta$ to use. Empirical estimates in both developed and developing countries vary widely, and there is little consensus on how best to estimate this parameter (see for example Frederick *et al.* (2002)). Due to this uncertainty, we calibrate $\delta$ as the mid-point of two bounds. We take the upper bound for all regions to be $\delta^U = 0.975$, since in a long-run equilibrium with functioning capital markets $\delta = \frac{1}{1+r^{rf}}$, where $r^{rf}$ is the risk-free

[24] We looked up annual reports, ratings or MFI websites for the 50 largest MFIs by number of outstanding loans. For 26 we were able to obtain data, comprising 60% of the loans in our sample.

real rate of return which we take to be 2.5%, the mean real return on US 10-year sovereign bonds in 1962-2012. For the lower bound we use the model's prediction that $r \leq \delta pR$ by IC1. We estimate the real interest rate charged by MFIs in the MIX data as $r_i = \frac{RealPortfolioYield}{1-PAR}$. To avoid sensitivity to outliers, we then calibrate $\delta^L = \frac{\bar{r}}{pR}$, where $\bar{r}$ is the weighted mean interest rate. Using our calibrated value for $pR$ of 1.6 (see below), we obtain $\delta^L = 0.753$ in the full sample. The midpoint of $\delta^U$ and $\delta^L$ gives us $\delta = 0.864$.

*Estimating R* We draw our full sample value for the returns to capital from de Mel *et al.* (2008). They randomly allocate capital shocks to Sri Lankan micro enterprises, and their study suggests annual expected real returns to capital of around 60%.[25] Since expected returns in our model are $pR$, we use $pR = 1.6$, dividing by our estimate of $p$ to obtain $R = 1.737$.

Table 1 provides a summary of all the parameters in the full sample and across the regions. In addition we report the number of MFIs, number of loans outstanding (million) and the weighted mean interest estimate that was used to calibrate $\delta$. We later compare these interest rate estimates with the non-profit rates predicted by the model. One immediate observation is the extent to which South Asia dominates the sample, comprising 68% of the full sample by number of loans (India comprises 41% of the full sample, and Bangladesh 22%). This observation partly motivates the decision to repeat the exercise by region.

[25]In a similar study in Ghana, they find comparable figures. Udry and Anagol (2006) find returns around 60% in one exercise, and substantially higher in others.

Table 1: Summary Statistics and Parameter Estimates

| | MFIs | Loans (m) | % Full Sample | IL share (num)[a] | IL share (value) | Interest rate | $p$ | $R$ | $\rho$ | $\delta$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Full Sample | 715 | 65.217 | 100.0% | 46.0% | 81.9% | 1.206 | 0.921 | 1.737 | 1.098 | 0.864 |
| Central America | 60 | 1.671 | 2.6% | 93.8% | 98.8% | 1.190 | 0.881 | 1.816 | 1.112 | 0.860 |
| South America | 133 | 6.884 | 10.6% | 97.7% | 99.3% | 1.237 | 0.928 | 1.724 | 1.102 | 0.874 |
| Eastern Africa | 20 | 2.439 | 3.7% | 38.7% | 70.4% | 1.152 | 0.831 | 1.925 | 1.115 | 0.848 |
| Northern Africa | 20 | 1.735 | 2.7% | 37.5% | 59.2% | 1.227 | 0.984 | 1.626 | 1.115 | 0.871 |
| Western Africa | 48 | 1.184 | 1.8% | 60.5% | 89.2% | 1.306 | 0.882 | 1.814 | 1.173 | 0.896 |
| South Asia | 133 | 44.067 | 67.6% | 34.8% | 33.3% | 1.180 | 0.926 | 1.728 | 1.083 | 0.856 |
| South East Asia | 85 | 4.296 | 6.6% | 45.7% | 68.3% | 1.389 | 0.988 | 1.619 | 1.164 | 0.922 |
| South West Asia | 61 | 0.865 | 1.3% | 75.0% | 93.8% | 1.272 | 0.967 | 1.655 | 1.106 | 0.885 |

Notes: IL shares are the fraction of the total number or total value of loans reported as IL loans. The interest rate column reports the weighted mean risk-adjusted portfolio yield, i.e. $r_i = \frac{RealPortfolioYield}{1-PAR}$.
[a]For 10 observations we use the share by value to compute the overall figures in this column.

### 3.3 *Procedure*

The simulation was implemented in Scilab, an open-source alternative to Matlab. We provide details and pseudo-code in web Appendix B, and a full set of replication files on the journal webpage.

For the non-profit and for-profit monopolist the optimisation is very simple, as we do not have to study an entry condition, but just have to evaluate a set of constraints. The optimisation procedure is carried out for each level of social capital, which then gives us the value functions we use for the main plots in the paper. For the competition model, we simulate the entry condition for lenders. At any value of $S$ and $U$ we can check whether an entrant could earn positive profits with some contract (recall that in equilibrium there is always excess demand for credit). This will happen as long as the incentive constraints are slack at the relevant zero-profit interest rate. Hence, for each $S$ we proceed by iteratively increasing $U$ until the most profitable contract breaks even.

### 3.4 *Results*

Using the above estimated model parameters, we compute welfare, interest rates and market scale results for the modeled non-profit, for-profit monopolist and competition cases, while varying the level of $S$ as key independent variable. Of central interest are the different threshold values of $S$ at which lending methods in each of the cases changes, which results in discontinuous jumps in the value functions, interest rate and market scale. Throughout the analysis the numeraire is the loan size, so borrower welfare and social capital are measured in multiples of this. Loan sizes of course vary widely but in South Asia a typical microfinance loan is of the order of \$100-200.

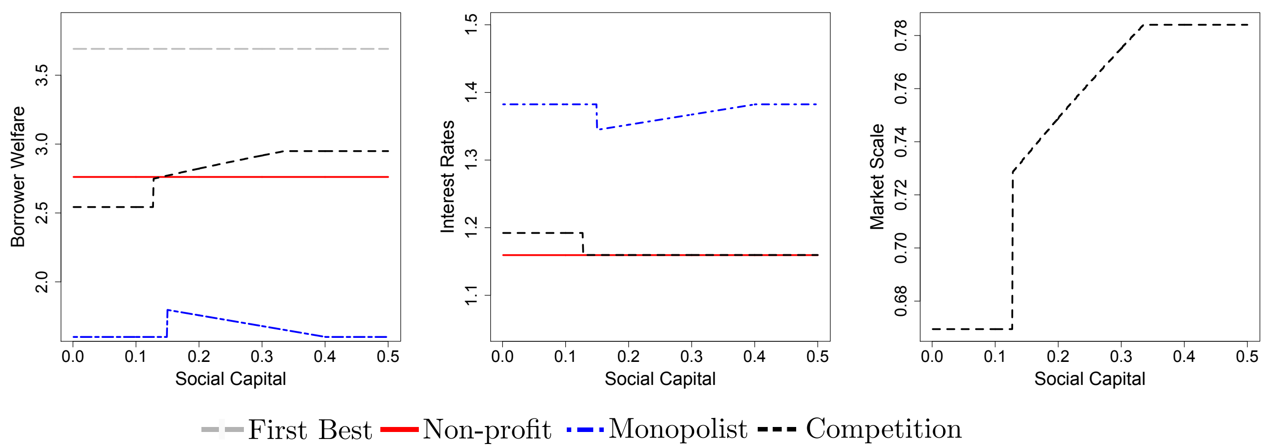


Figure 2: Full Sample Welfare, Interest Rates and Market Scale.

We present our full sample baseline simulation results graphically in Figure 2. It provides a good picture of the basic empirical predictions of the model. The first graph depicts borrower welfare, $\hat{V}$, $\tilde{V}$ and $Z$, and we also indicate the first-best borrower welfare level, $\frac{pR-\rho}{1-\delta}$, which could be obtained in the absence of information asymmetries. At jumps in the graph the contract switches from IL to JL. Borrower utility from access to microfinance, $V$, is 2.76 with a non-profit lender, while the maximum value with a monopolist (at the point of switching from IL to JL) is only 1.80, reducing to 1.60 under IL or when $S$ is large.

The second panel depicts the interest rates offered by the monopolist and non-profit (competitive interest rates are not reported, but correspond to the zero-profit interest rate for the relevant contract and value of $m^*$). A non-profit offers JL to all borrowers at a net interest rate of 15.9%, while the for-profit monopolist's charges a substantially higher interest rate of 38.2% when he offers IL, which occurs for social capital worth less than 0.15 in present discounted value (i.e. 15% of the loan size). When he switches to JL, the interest rate falls to 34.5%, but this difference is eroded as social capital increases, until eventually IC1 binds at social capital worth 0.40 and IL and JL interest rates equalise.

Market scale, plotted in the third panel, varies from 67% of borrowers served under IL, to 78% under JL when S is sufficiently large (note that these predictions should be thought of as local rather than national or regional market penetration). IL is offered for social capital worth less than 0.13 and aggregate welfare from microfinance, $Z$ (which includes matched and unmatched borrowers) is 2.49. This is higher than welfare under a monopolist, so the welfare effect of credit rationing is clearly not too severe. JL is offered, at increasing market scale, for social capital worth more than 0.13, with welfare increasing to a maximum of 2.90 for $S \geq 0.33$, higher even than welfare under the non-profit.

The welfare differences between the different market forms are substantial, with the interesting result that competition and non-profit lending are not strictly ordered. As discussed in section 2, this follows from the assumption that the non-profit uses strict dynamic incentives; in our view the key lesson is that non-profit and competition achieve similar performance despite the externality under competition.

We can now analyse the welfare implications of market power and the lender's choice of contractual form. When the monopolist voluntarily switches from IL to JL at $\tilde{S}$, borrower welfare increases by approximately 12%. If we go further, forcing the monopolist to always use JL the gain is 20% at $S = 0$ (and declining in $S$). Switching to a non-profit lender delivers a minimum gain of 54% (at $\tilde{S}$) and a maximum of 73% for $S < \tilde{S}$ or $S \geq \bar{S}$. Thus our results underline the importance of constraining market power where it exists.

Similarly, we can consider the effect of mandating JL under competitive lending, since for $S < \tilde{\tilde{S}}$ the market equilibrium is IL only. We find that welfare would increase by 2% at $S = 0$, with this gain increasing as $S$ increases, up to 16% at $\tilde{\tilde{S}}$. This illustrates one aspect of the inefficiency of the competitive equilibrium. We graph the welfare effects of mandating JL or IL under monopoly and competition in Figure A1 in the online Appendix.

### *3.5 Sensitivity analysis*

We check the sensitivity of the results by varying each parameter over a reasonable range, while holding the others constant. For simplicity we focus on the results for $S = 0$. The results of these exercises are presented in web Appendix Figure A4. We only plot the parameter regions in which the model predicts any lending. There is no lending predicted (because lenders cannot break even) for $\delta < 0.773$, $p < 0.887$, $\rho > 1.273$ and $R < 1.515$.

Welfare under a monopolist lender is not sensitive to any of the parameters, varying little in comparison with the larger effects under competition or non-profit lending (in particular, naturally the monopolist's contract offer does not depend on $\rho$). For example, as $R$ increases with a non-profit lender, all of the welfare gains are passed on to the borrowers. The monopolist, on the other hand, simply increases his interest rate, extracting almost all of the gains. Borrower welfare under competition typically tracks that under non-profit lending quite closely, so our conclusion that non-profit and competition have similar performance seems robust. The large welfare difference between non-profit and monopolist varies in each parameter, but is reasonably robust in the neighbourhood of our estimates. For low $R$, low $p$, and low $\delta$, welfare may be lower under competition than with a for-profit monopolist, as was theoretically predicted in Proposition 5.

### 3.6 *Regional analysis*

We next turn to a region-specific analysis. We first observe that our region specific parameter estimates presented in Table 1 always satisfy Assumption 2, so the model predicts at least IL lending in every region. We focus on seven regions with at least 1% of the total number of outstanding loans, comprising 94.2% of the total.[26]

The values of the $S$ thresholds, interest rates, market scale and welfare, are reported in Tables 2 and 3. Table 2 also reports the contracts used by each type of lender, showing that the non-profit exclusively offers JL in the majority of cases, while the monopolist and competitive market typically offer IL for low $S$ and JL for high $S$. Sometimes only IL is offered, corresponding to cases when the JL LLC is tight.

The pattern of contracts offered depends on the market structure. In Eastern Africa, the model predicts only IL lending under all three market structures; the JL LLC is too tight for JL to break even in these regions, primarily since the low success probability requires high interest rates. In Northern Africa, South East Asia and South West Asia, the non-profit would always offer JL, while the monopolist always offers IL. The relatively high success probabilities mean that the guarantee effect of JL is small relative to the cost to the lender of lower interest rates. In these

[26] We graph the predicted borrower welfare functions in Figure A3 in online Appendix A.8.

Table 2: Lending methods and $S$ thresholds across regions

| | Lending Methods | | | S thresholds | | | |
|---|---|---|---|---|---|---|---|
| | M | NP | C | M | | C | |
| | | | | $\tilde{S}$ | $\bar{S}$ | $\tilde{\tilde{S}}$ | $\bar{\bar{S}}$ |
| Full Sample | IL-JL | JL | IL-JL | 0.148 | 0.400 | 0.126 | 0.334 |
| Central America | IL-JL | JL | IL-JL | 0.333 | 0.400 | 0.307 | 0.363 |
| South America | IL-JL | JL | IL-JL | 0.112 | 0.263 | 0.097 | 0.330 |
| Eastern Africa | IL | IL | IL | | | | |
| Northern Africa | IL | JL | IL-JL | | | 0.188 | 0.319 |
| Western Africa | IL-JL | JL | IL-JL | 0.317 | 0.400 | 0.296 | 0.367 |
| South Asia | IL-JL | JL | IL-JL | 0.143 | 0.400 | 0.123 | 0.331 |
| South East Asia | IL | JL | IL-JL | | | 0.146 | 0.315 |
| South West Asia | IL | JL | IL-JL | | | 0.077 | 0.315 |

Notes: M, NP and C denote Monopoly, Non-Profit and Competition, respectively. Lending methods denotes which contract forms are used in equilibrium for some $S$. For example, "IL-JL" means that the lender uses IL for low $S$ and JL for high $S$. "IL" means that JL is never used, and vice versa. $S$ thresholds denote switch points from IL to JL, where a switch occurs. The Non-Profit never switches lending method for our parameter values.

Table 3: Interest Rates, Market Scale and Borrower Welfare

| | Interest Rates | | | Market Scale | | Borrower Welfare | | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | | NP | C | | M | NP | C | |
| | $\tilde{r}^{IL}$ | $\tilde{r}^{JL}(\tilde{S})$ | $\hat{r}$ [a] | $\underline{l}$ | $\bar{l}$ | $\tilde{V}^{JL}(\tilde{S})$ [b] | $\hat{V}$ [a] | $Z(0)$ | $Z(\bar{\bar{S}})$ |
| Full Sample | 1.382 | 1.345 | 1.159 | 0.669 | 0.784 | 1.796 | 2.761 | 2.543 | 2.949 |
| Central America | 1.376 | 1.363 | 1.251 | 0.432 | 0.476 | 1.648 | 2.074 | 1.581 | 1.733 |
| South America | 1.398 | 1.359 | 1.154 | 0.712 | 0.826 | 1.830 | 3.016 | 2.883 | 3.313 |
| Eastern Africa | 1.357 | | 1.342[a] | 0.063 | | | 1.642[a] | 0.217 | |
| Northern Africa | 1.394 | | 1.118 | 0.935 | 0.990 | | 3.698 | 3.535 | 3.725 |
| Western Africa | 1.434 | 1.419 | 1.317 | 0.399 | 0.449 | 1.662 | 2.116 | 1.706 | 1.914 |
| South Asia | 1.370 | 1.331 | 1.137 | 0.698 | 0.813 | 1.800 | 2.803 | 2.573 | 2.967 |
| South East Asia | 1.475 | | 1.166 | 0.955 | 0.995 | | 5.498 | 5.351 | 5.562 |
| South West Asia | 1.416 | | 1.117 | 0.879 | 0.963 | | 3.983 | 3.811 | 4.150 |

Notes: [a] This is the JL interest rate or borrower welfare with a non-profit except where annotated with [a], in which case the values corresponds to the IL case as there is only IL lending in equilibrium. [b] $\tilde{V}^{IL}$ is equal to $pR = 1.6$ in every case, so not reported.

cases, uncoordinated competition delivers IL for low $S$ and JL for high $S$.

In all regions except Central America and Eastern Africa we observe that in welfare terms the non-profit and competition achieve similar outcomes. This observation is highlighted in the sensitivity analysis. In Central America the for-profit monopolist outperforms competition for $S$ sufficiently small. In Eastern Africa, which has a very low success probability rendering repayment guarantees very costly for borrowers, competition performs very poorly, while non-profit and for-profit monopolist are almost identical in welfare terms.

### *3.7 Discussion*

Collecting the simulation results, a picture emerges supporting the discussion in the theoretical analysis. The monopolist for-profit lender does exploit the borrowers' social capital and this has economically meaningful effects on interest rates and welfare. However, these are substantially smaller than the change in interest rates and welfare when switching to a large non-profit lender. As for competition, for our full-sample parameters and for most regions considered, welfare under competition is approximately the same as under non-profit lending. Despite the negative press and industry concerns about competition in microfinance our results suggest a more positive view in which competition is able to mitigate the problems of market power.

A result that emerges from the simulations is that frequently the competitive market dominates the non-profit in welfare terms, despite the enforcement externality that leads to credit rationing. The reason for this is the relatively high repayment probabilities ensure that the population of unmatched borrowers is small, while all borrowers benefit from the ability to re-borrow in future. Under the non-profit this is not available due to the assumption that strict dynamic incentives are used. However, as mentioned in section 2.3, a benevolent non-profit can deliver at least the same welfare as the competitive market, by renewing borrowers' contracts with probability $\lambda$ upon default. A simple way to achieve this would be to choose the renewal probability upon default to mimic the competitive outcome. In this case, the value function of the non-profit would be the envelope of the matched utility. We have computed this example and illustrate it in Figure A2 in online Appendix A.6. The welfare effect is not dramatic; borrower welfare under the non-profit increases from 2.761 with strict dynamic incentives to a maximum of 3.239 with the new contract, a 17% gain. Choosing $\lambda$ optimally, the non-profit can perform even slightly better. We have simulated this as well and observe that the only difference arises because the non-profit would switch to JL for a lower value of $S$.

## 4. Conclusion

Motivated by recent debates about commercialisation and the trade-off between the objectives of making profits and alleviating poverty, this paper studies the consequences of market power in the context of microfinance. We focus on the consequences for borrower welfare going beyond the usual focus on repayment rates and interest rates. The existing literature on microfinance starts with the premise that MFIs are competitive or motivated by borrower welfare and in this paper we showed that there are interesting implications for relaxing this assumption. A lender with market power can extract rents from repayment guarantee agreements between his borrowers, but is ultimately constrained from making those borrowers worse off in the process.

We compare borrower welfare under a for-profit with market power, a benevolent non-profit, and a competitive credit market. One of the interesting trade-offs that emerges is that of rent extraction under monopoly with the enforcement externality under competition. We simulated the model using empirical parameter estimates, and found that the consequences of market power for borrower welfare are significant, while the choice of lending method itself is somewhat less important. Competitive for-profits typically do not perform much worse than our non-profit benchmark, especially when the level of social capital is high.

There are several directions for future work that we believe might be promising. For example, Muhammed Yunus argues that the shift from non-profit to for profit, with some institutions going public, led to aggressive marketing and loan collection practices in the quest for profits to serve the shareholders equity. Our paper does not model coercive loan collection methods by lenders, and allowing this might create an additional channel for for-profit and non-profits to behave differently, in a manner similar to the cost-quality trade-off as in the non-profits literature (see, for example, Glaeser and Shleifer (2001)).

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# Appendix to "Market Structure and Borrower Welfare in Microfinance"

For Online Publication

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This appendix contains proofs omitted from the main text, additional figures from the model simulation, information on the simulation methodology and details of the construction of the dataset used.

## A. Proofs, Derivations and Simulation Results Omitted in the Paper

### A.1 Patient monopolist inefficiently under-uses JL

Proposition 3 points out that the monopolist lender inefficiently under-uses joint liability relative to the non-profit lender. One concern might be that this is due to the fact that the lender is assumed (for simplicity) to be myopic, choosing the contract based only on per-period revenue. JL's relatively high repayment rate makes it relatively more attractive to a patient lender. However this does not overcome the basic inefficiency result as we show here.

Suppose the lender discounts profits from a given borrower with factor $\beta \in$

$[0,1]$. Now the lender's discounted profits per borrower are

$$\Pi = \frac{\pi r - \rho}{1 - \beta\pi}.$$

The only ingredient of the benchmark model that will change is the monopolist lender's contract choice. The constraints and thus interest rates for a given contract as a function of $S$ remain the same. The monopolist now prefers JL whenever $\frac{q\hat{r}^{JL}(S)-\rho}{1-\beta q} \geq \frac{p\hat{r}^{IL}-\rho}{1-\beta p}$. We can solve this condition for a new $\tilde{S}(\beta)$ which is the value of $S$ at which the lender switches from IL to JL. This is:

$$\tilde{S}(\beta) \equiv \max\left\{0, \frac{p^2R(p-\delta q)}{q(1-\delta q)} - \frac{\beta(1-p)(2-\delta q)(\delta p^2 R - \rho)}{\delta(1-\beta p)(2-p)(1-\delta q)}\right\}.$$

$\tilde{S}(\beta)$ is strictly decreasing in $\beta$. Therefore, as intuitively argued above, the monopolist becomes more willing to offer JL as $\beta$ increases. However, this does not reverse the inefficiency result.

When $p < \delta q$, we know that $\hat{S} = \tilde{S} = 0$ and there is no inefficiency, so we focus on the case where $p > \delta q$. We want to show that the monopolist is less willing to offer JL than the nonprofit. Recall that $\hat{S} \equiv \max\left\{0, \frac{(2-\delta q)\rho-(2-p)\delta p^2 R}{\delta q(1-\delta q)}\right\}$. Subtracting the non-zero term in the max in $\hat{S}$ from that in $\tilde{S}(\beta)$ we obtain $\frac{(\delta p^2 R-\rho)(2-\delta q)(1-\beta q)}{\delta q(1-\delta q)(1-\beta p)}$, which is positive for all $\beta$, so we know that $\tilde{S}(\beta) \geq \hat{S}$ for all $\beta$, and that this inequality is strict for $\tilde{S}(\beta) > 0$.[1] Therefore the monopolist is less willing to offer JL than the nonprofit, and thus potentially inefficient, even when fully patient ($\beta = 1$).

[1] I.e. for $\beta < \frac{\delta p^2 R(p-\delta q)(1-\delta q)}{\delta p^2 R q(1-\delta p(1-\delta q))-\rho p(1-p)(2-\delta q)}$.

### *A.2 Heterogeneity*

The analysis so far assumes that social capital $S$ is homogeneous and observable across borrowers. Suppose that this is not the case. To keep things simple, suppose there are two possible values of $S$. A fraction $\theta \in (0, 1)$ of borrowers have $S = 0$, and $1 - \theta$ have $S = S_h > 0$. The lender cannot observe social capital so must screen borrowers by offering an appropriate menu of contracts. We will first characterise the candidate pooling and separating equilibria, then solve for the equilibrium contract offer as a function of $S_h$. Also, to keep things brief, we only consider the monopolist for-profit lender.

In a pooling equilibrium, the monopolist offers a single interest rate $r$, and either IL or JL. There are three possible pooling equilibria. Equilibrium A uses IL and the interest rate will be $\tilde{r}^{IL} = r_{IC1}$. Equilibrium B uses JL with interest rate $\tilde{r}^{JL}(0)$, in which case all groups are able to guarantee one another's loans. Equilibrium C uses JL and interest rate $\tilde{r}^{JL}(S_h)$, in which case only the high $S$ groups can do so, (in this case, the low $S$ groups will only repay when both are successful, with probability $p^2$). We show that these are the only possible pooling equilibria below.

Now we turn to the separating equilibrium. We use the following notational convention. Where the interest rate corresponds to that from the basic model, we retain the same $\tilde{r}$ notation. Where the interest rate function differs, it is denoted by subscript "sep", as in $\tilde{r}_{sep}$. In a separating equilibrium the lender offers the following menu of contracts: one JL contract at interest rate $\tilde{r}^{JL}(S_h)$, and one IL contract at interest rate $\tilde{r}^{IL}_{sep}(S_h)$. Note that the IL interest rate depends upon the social capital of the high $S$ types. High $S$ borrowers take the JL contract and low $S$

borrowers take the IL contract. When $S_h \geq \bar{S}$, the lender charges the same interest rate under both contracts, namely $\tilde{r}^{JL}(S_h) = \tilde{r}^{IL}_{sep}(S_h) = \tilde{r}^{IL}$, i.e. all borrowers are charged the "maximum" interest rate $\tilde{r}^{IL} = r_{IC1}$. When $S_h < \bar{S}$, we find that $\tilde{r}^{JL}(S_h) < \tilde{r}^{IL}_{sep}(S_h) < \tilde{r}^{IL}$. The lender cannot charge the maximum interest rate to the JL borrowers any more as they do not have sufficient social capital to guarantee one another. In addition, the truth-telling constraint that induces low-$S$ borrowers to choose IL rather than JL constrains the lender from charging the maximum interest rate to IL borrowers either.

Below, we derive the $r^{IL}_{sep}(S_h)$ function, obtaining the following: $\tilde{r}^{IL}_{sep}(S_h) \equiv \phi\tilde{r}^{IL} + (1-\phi)\tilde{r}^{JL}(S_h)$, where $\phi \equiv \frac{1-p}{1-\delta p^2} < 1$. Note that $r^{IL}_{sep}(S_h)$ is increasing in $S_h$. The higher is $S_h$, the higher the interest rate the lender can charge under JL and thus the higher he can charge under IL as well. This gives us an observation analogous to the "exploitation" results earlier:

**OBSERVATION 2** *In a separating equilibrium with heterogeneous social capital, the interest rate faced by the individual liability borrowers (who have low social capital) is increasing in the social capital of the joint liability borrowers (who have high social capital).*

The main addition to the benchmark model is that now more social capital among one type of borrowers has spillover effects on the other type, enabling the lender to exploit them more as well.

Now we derive the equilibrium contract. As before, the lender maximises per-period profits, which is equivalent to choosing the contract or menu that yields the highest per-period revenue. When $S_h$ is high, the lender will have a strong incentive to separate borrowers by type, so the separating equilibrium prevails. When $S_h$ is low, we need to check which of the pooling equilibria (A, B or C) will be chosen.

We can immediately rule out pooling equilibrium C (JL with interest rate $\tilde{r}^{JL}(S_h)$). This yields revenue of $(\theta p^2 + (1-\theta)q)\tilde{r}^{JL}(S_h)$, while the separating menu yields strictly larger revenue of $\theta p \tilde{r}^{IL}_{sep}(S_h) + (1-\theta)q\tilde{r}^{JL}(S_h)$, using the fact that $\tilde{r}^{IL}_{sep}(S_h) > \tilde{r}^{JL}(S_h)$. Intuitively, pooling equilibrium C is unattractive as it leads the low $S$ borrowers to default very frequently.

Now note that revenue does not depend on $S_h$ in either of the remaining two pooling equilibria (A or B), so these can be ranked based on model parameters only. Determining which the lender prefers (IL at $\tilde{r}^{IL}$, or JL at $\tilde{r}^{JL}(0)$) is equivalent to determining whether $\tilde{S} \gtrless 0$, which reduces to our usual condition (2) or $p \gtrless \delta q$. Essentially, when $p \geq \delta q$, JL is always attractive so the lender will offer JL in the pooling equilibrium (B), otherwise he offers IL (A). For brevity, we analyse the $p \geq \delta q$ case here, the other is similar and is discussed separately below.[2]

If $p > \delta q$, then the IL pooling equilibrium (A) is more profitable than the JL one (B). It is easy to check that for any $\theta$, there exists a threshold $S_h^{p>\delta q}$ for $S_h$ above which the lender offers the separating contracts and below which he offers the pooling contract.[3] We have the following result:

[2]The key qualitative difference between the two cases is that when $p \geq \delta q$, the lender offers IL when $S_h$ is low, and welfare discontinuously increases when he switches to the separating equilibrium. When $p < \delta q$ he offers the most favourable JL contract when $S_h$ is low, and therefore welfare for both types discontinuously *decreases* when he switches to the separating contract, and then further decreases in $S_h$ thereafter, by Observation 2. Furthermore, when $p < \delta q$ the lender may always prefer the pooling equilibrium.

[3]For $S_h = 0$ and $p > \delta q$ the lender earns earns strictly lower per-borrower revenue from each type in the separating equilibrium than under the IL pooling contract. For $S_h \geq \bar{S}$, $\tilde{r}^{IL}_{sep}(S_h) = \tilde{r}^{JL}(S_h) = \tilde{r}^{IL} = \delta p R$, so the interest rate is the same under both pooling and separating equilibrium, but the repayment probability is higher under the separating equilibrium, (formally revenue under the separating contract is $[\theta p + (1-\theta)q]\delta p R$ which is superior to pooling IL). The existence of the threshold $S_h^{p>\delta q}$ then follows by continuity.

**PROPOSITION 6** *When $p > \delta q$, for $S_h < S_h^{p>\delta q}$, the lender offers IL at interest rate $\tilde{r}^{IL}$. For $S_h \geq S_h^{p>\delta q}$ he offers IL at $\tilde{r}^{IL}_{sep}(S_h)$ and JL at $\tilde{r}^{JL}(S_h)$, low S borrowers take the IL contract and high S borrowers take JL. Welfare of both types of borrowers increases discontinuously at $S_h^{p>\delta q}$, and decreases in S thereafter.*

Low $S$ types initially have IL contracts and utility $V = pR$ as usual. When the lender switches to the separating contract, they continue to receive IL loans but their interest rate decreases from $\tilde{r}^{IL}$ to $\tilde{r}^{IL}_{sep}(S_h)$, so they are discontinuously better off. Then, as noted in observation 2, this interest rate increases in $S_h$ thereafter, reducing their welfare. High $S$ types exactly mirror the borrowers in the homogeneous model: they receive IL up to $S^{p>\delta q}$ (as opposed to $\tilde{S}$), then switch to JL with a lower interest rate, making them better off, but this interest rate subsequently increases in $S_h$.

Proposition 6 is closely analogous to our earlier results. Enough social capital to induce the lender to offer JL is beneficial: the high $S$ borrowers receive a more efficient JL contract at a lower interest rate, while the low $S$ borrowers continue to receive IL but also benefit from a lower interest rate. However, above $S_h^{p>\delta q}$, Observation 2 kicks in and more social capital makes borrowers worse off.

We see the results in this section as broadly supporting the main conclusion that understanding market structure is critical for how we think about the role of social capital in influencing borrower welfare. With heterogeneity, there are also spillovers: the more social capital held by the high types, the higher the interest rate faced by the low types.

### A.3 Derivation of pooling contract

Under IL it is obvious that charging $\tilde{r}^{IL} = r_{IC1}$ is optimal from the lender's perspective.

Under JL, if he charges less than $\tilde{r}^{JL}(0)$, repayment will not increase but revenue will be lower than charging $\tilde{r}^{JL}(0)$. If he charges between $\tilde{r}^{JL}(0)$ and $\tilde{r}^{JL}(S_h)$, the low $S$ borrowers will still only repay with probability $p^2$ and the high $S$ with probability $q$, and revenue will be lower than charging $\tilde{r}^{JL}(S_h)$. Lastly, charging more than $\tilde{r}^{JL}(S_h)$ results in a repayment probability of $p^2$ from all borrowers and revenue lower than that attainable under IL.

#### A.3.1 Derivation of separating contract

In a separating equilibrium, it must be that the lender offers one IL and one JL contract.[4] Define the interest rates as $\tilde{r}^{IL}_{sep}(S_h)$ and $\tilde{r}^{JL}_{sep}(S_h)$ where $S_h$ is the social capital of the high $S$ group.

By IC1, the lender will never charge more than $\delta pR$ under either contract. If he did so under both, all borrowers would default, and if he did so under only one, then all borrowers would take the other contract.

Since a borrower's utility from a *given* JL contract (i.e. when holding *r constant*) is increasing in $S$, the high $S$ types must choose JL and the low $S$ types choose IL in equilibrium. Furthermore, since utility from a *given* IL contract does not depend on $S$, both types value IL equally. Denoting the utility in separating equilibrium of

[4]Note that there can be no "screen-out" equilibrium, since the borrowers' participation constraints are slack: a borrower can always obtain utility $pR$ by taking a loan and defaulting. Thus the separating equilibrium must involve a contract offer for both types.

a borrower with social capital $S$ under contract $j$ by $V^j_{sep}(S)$, we have:

$$V^{IL}_{sep}(S_h) = V^{IL}_{sep}(0) \equiv V^{IL}_{sep}$$
$$V^{JL}_{sep}(S_h) \geq V^{JL}_{sep}(0)$$

the truth-telling constraints are:

$$V^{JL}_{sep}(0) \leq V^{IL}_{sep} \tag{3}$$
$$V^{JL}_{sep}(S_h) \geq V^{IL}_{sep}. \tag{4}$$

with one strict. These reduce to $V^{JL}_{sep}(S_h) > V^{JL}_{sep}(0)$ and either $V^{JL}_{sep}(S_h) = V^{IL}_{sep}$ or $V^{JL}_{sep}(0) = V^{IL}_{sep}$.

$V^{JL}_{sep}(S_h) > V^{JL}_{sep}(0)$ requires that $\tilde{r}^{JL}_{sep}(S_h) \leq \tilde{r}^{JL}(S_h)$. Otherwise, the high types would not be able to guarantee one another under JL, so all types would repay with probability $p^2$ in which case $V^{JL}_{sep}(S_h) = V^{JL}_{sep}(0)$. Similarly, $\tilde{r}^{JL}_{sep}(S_h) > \tilde{r}^{JL}(0)$ since otherwise low types would be able to guarantee under JL which would again mean that $V^{JL}_{sep}(S_h) = V^{JL}_{sep}(0)$. Clearly, then, the lender wants to charge the highest possible interest rate under IL and JL subject to these constraints. This is easy to find. Under JL he charges $\tilde{r}^{JL}_{sep}(S_h) \leq \tilde{r}^{JL}(S_h)$. This minimises $V^{JL}_{sep}(S_h)$ and $V^{JL}_{sep}(0)$. Then he charges the highest possible interest rate under IL, such that $V^{JL}_{sep}(0) = V^{IL}_{sep}$.

Solving (3), we obtain the following expression for $r^{IL}_{sep}(S_h)$:

$$\tilde{r}^{IL}_{sep}(S_h) = \frac{\delta p R(1-p)}{1-\delta p^2} + \frac{p(1-\delta p)}{1-\delta p^2}\tilde{r}^{JL}_{sep}(S_h)$$

substituting for $\tilde{r}^{JL}_{sep}(S_h) = \tilde{r}^{JL}(S_h)$, $\delta pR = \tilde{r}^{IL}$ and $\phi \equiv \frac{1-p}{1-\delta p^2} < 1$, we obtain

$$\tilde{r}^{IL}_{sep}(S_h) \equiv \phi \tilde{r}^{IL} + (1-\phi)\tilde{r}^{JL}(S_h).$$

This concludes the derivation.

#### A.3.2 Equilibrium with heterogeneous social capital and $p \leq \delta q$

If $p \leq \delta q$, the lender prefers the JL pooling contract to the IL one. Moreover, it is not guaranteed that he will ever choose the separating contract. To see this, note that if $S_h > \bar{S}$, revenue in the separating equilibrium is equal to $(\theta p + (1-\theta)q)\delta pR$. This is only greater than revenue in the pooling equilibrium, $\frac{\delta pqR}{2-\delta q}$, if $\theta < \frac{(2-p)(1-\delta q)}{(2-\delta q)(1-p)}$, a threshold strictly smaller than one when $p < \delta q$. Hence when the fraction of low $S$ types is large, the lender may never offer the separating contract. Intuitively, in the pooling contract these borrowers receive a JL contract at interest rate $\tilde{r}^{JL}(0)$, while in the separating contract they receive IL, and we know that the former earns higher revenue than the latter when $p \leq \delta q$.

For simplicity, suppose $\theta < \frac{(2-p)(1-\delta q)}{(2-\delta q)(1-p)}$, so that by an analogous argument to that given above (footnote 3) there exists a threshold, $S_h^{p \leq \delta q}$, such that for $S_h$ above the threshold the lender offers the separating contract. We have the following:

**PROPOSITION 7** *When $p \leq \delta q$, for $S_h < S_h^{p \leq \delta q}$, the lender offers JL at interest rate $\tilde{r}^{JL}(0)$. For $S_h \geq S_h^{p \leq \delta q}$ he offers IL at $\tilde{r}^{IL}_{sep}(S_h)$ and JL at $\tilde{r}^{JL}(S_h)$, low S borrowers take the IL contract and high S borrowers take JL. Welfare of both types decreases discontinuously at $S_h^{p > \delta q}$. Welfare of both types of borrowers further decreases in S thereafter.*

To see why welfare now *decreases* at the switching threshold, simply note that the pooling equilibrium in this case is the most favourable contract the monopolist ever offers the borrowers - it achieves the highest possible repayment probability, $q$, at the lowest interest rate the lender will ever charge. At the switching point, the low types switch to IL (lower repayment probability) at a higher interest rate, and the high types keep JL but at a higher interest rate. Thereafter, Observation 2 applies as before. Now, higher social capital among high $S$ borrowers is doubly bad for borrower welfare.

### *A.4 Competition*

Consider a repayment probability $\pi$. IC1 requires that the value of future access to credit from the current lender, less the repayment amount, exceeds the borrower's outside option which is to return to the pool of unmatched borrowers. At the zero profit interest rate the condition is:

$$\delta V - \frac{\rho}{\pi} \geq \delta U.$$

Simplifying, we obtain

$$\delta p R \frac{1-\chi(l,\eta)}{1-\delta\pi\chi(l,\eta)} \geq \frac{\rho}{\pi}.$$

We denote the left hand side by $r_{IC1}^{IL}(\chi)$ under IL (when $\pi = p$) and $r_{IC1}^{JL}(\chi)$ under JL ($\pi = q$).

Unlike the single-lender case, we have a different IC1 for IL and JL. Note that $r_{IC1}^{JL}(\chi) > r_{IC1}^{IL}(\chi)$, so it is not possible for both IC1s to bind simultaneously. Also note that for all $\chi > 0$, $\frac{dr_{IC1}(\chi)}{d\chi} < 0$ for IL and JL. This is the competition effect through improvements in the borrowers' outside option. Also note that, as before, provided IC1 holds JL borrowers will always be willing to repay their own loans provided their partner is also repaying.

The IC2 under JL requires that repayment of both loans is preferred to losing access to the current lender (rejoining the unmatched pool) and losing the social capital shared with the current partner. The condition is

$$\delta(V+S) - 2\frac{\rho}{\pi} \geq \delta U,$$

which simplifies to

$$\frac{\delta[(1-\chi(l,\eta))pR + (1-\delta q)S]}{2-\delta q - \delta q\chi(l,\eta)} \geq \frac{\rho}{q}.$$

We denote the left hand side by $r_{IC2}(S,\chi)$. $r_{IC2} \leq r^{JL}_{IC1}$ for $S \leq \frac{1-\chi(l,\eta)}{1-\delta q\chi(l,\eta)}pR$ (we compute the equilibrium value of this threshold below). $\frac{dr_{IC2}(S,\chi)}{d\chi} < 0$ whenever $\chi > 0$ and IC2 is tighter than IC1.

Therefore, in conclusion, the tighter of $r_{IC2}(S,\chi)$ and $r^{JL}_{IC1}$ is downward sloping in $\chi$. This is the effect of competition on the repayment incentive constraints.

Recall now the two key thresholds, stated in the text and derived below: $\tilde{\tilde{S}} \equiv \frac{p-\delta q}{\delta q(1-\delta q)}\rho$, the analog of $\tilde{S}$, representing the level of social capital at which the competitive market switches from IL to JL lending; and $\bar{\bar{S}} \equiv \frac{\rho}{\delta q}$, the analog of $\bar{S}$, the level of social capital at which IC1 binds under JL (as opposed to IC2). Note also that $\bar{\bar{S}} > \tilde{\tilde{S}}$.

*PROPOSITION 4 (restated)* If $\tilde{\tilde{S}} \leq 0$, the competitive equilibrium is JL-only lending, with market scale strictly increasing in $S$ for $S < \bar{\bar{S}}$, and equal to a constant, $\bar{\bar{l}}$ for $S \geq \bar{\bar{S}}$. If $\tilde{\tilde{S}} > 0$, the equilibrium for $S < \tilde{\tilde{S}}$ is IL-only lending at fixed scale $\underline{l}$. At

$\tilde{\tilde{S}}$, all lending switches to JL at scale $\tilde{\tilde{l}} > \underline{l}$, then increases continuously in $S$ to $\bar{\bar{l}}$, at $\bar{\bar{S}}$. Welfare, $Z$, is strictly increasing in scale, $l$, and therefore weakly increasing in $S$.

*Proof.* In equilibrium, at most one of IL and JL breaks even (except for at the switching threshold as discussed below). So for a lender, who takes $\chi$ as given, the following condition will hold:

$$\rho = \max\{pr^{IL}_{IC1}(\chi), \min\{qr^{JL}_{IC1}(\chi), qr^{JL}_{IC2}(S,\chi)\}\}.$$

Next note that $pr^{IL}_{IC1}(\chi) < qr^{JL}_{IC1}(\chi)$, so to determine the equilibrium contract, we only need to compare $pr^{IL}_{IC1}(\chi)$ with $qr^{JL}_{IC2}(\chi, S)$. If $\rho = pr^{IL}_{IC1}(\chi) > qr^{JL}_{IC2}(S,\chi)$, only IL will be used in equilibrium, and if $\rho = qr^{JL}_{IC2}(S,\chi) \geq pr^{IL}_{IC1}(\chi)$ only JL will be used (we assume that JL will be offered when both IL and JL break even).

Solving $\rho = pr^{IL}_{IC1}(\chi)$, for $\chi$ we obtain the equilibrium value of $\chi$ under IL:

$$\tilde{\tilde{\chi}} = \frac{\delta p^2 R - \rho}{\delta p^2 R - \delta p \rho}.$$

Next we solve $pr^{IL}_{IC1}(\tilde{\tilde{\chi}}) = qr^{JL}_{IC2}(\tilde{\tilde{\chi}}, S)$ to find $\tilde{\tilde{S}}$, the switching threshold value of $S$ at which both IL and JL break even:

$$\tilde{\tilde{S}} = \frac{p - \delta q}{\delta q(1-\delta q)}\rho \gtreqless 0.$$

Lastly, we solve $\rho = qr_{IC2}(S,\chi)$ to find the equilibrium value of $\chi$ under JL when

IC2 is binding. This is $\chi = \psi(S)$ where we define $\psi(S)$ as:

$$\psi(S) \equiv \tilde{\tilde{\chi}} + \frac{1-\delta q}{pR-\rho}(S - \tilde{\tilde{S}}).$$

There is no equilibrium with JL lending for $S < \tilde{\tilde{S}}$, since then $\chi(S) < \tilde{\tilde{\chi}}$, in which case the IL IC1 would be slack and new lenders would enter offering IL. By a symmetric argument there is no equilibrium with IL lending for $S > \tilde{\tilde{S}}$. At $\tilde{\tilde{S}}$, lending switches from IL to JL, so $\eta$ changes discontinuously from 1 to 0. This enables us to solve for market scale, using $\chi(\underline{l}, 1) = \chi(\tilde{\tilde{l}}, 0) = \tilde{\tilde{\chi}}$. We obtain the market scale under IL, equal to

$$\underline{l} = \frac{\delta p^2 R - \rho}{\delta p^2 R - p\rho},$$

and the market scale after the switch to JL, equal to

$$\tilde{\tilde{l}} = \frac{(\delta p^2 R - \rho)(1-\delta q)}{(\delta p^2 R - p\rho)(1-\delta q) + p(1-p)(1-\delta)\rho}.$$

Given that by the definition of $\underline{l}$ and $\tilde{\tilde{l}}$, the following condition holds (as shown above): $\chi(\underline{l}, 1) = \chi(\tilde{\tilde{l}}, 0) = \tilde{\tilde{\chi}}$, and that $\chi_l > 0$ and $\chi_\eta > 0$ for all $l > 0$, it follows that $\tilde{\tilde{l}} > \underline{l}$.[5] Intuitively, in a JL equilibrium, borrowers default less frequently, so for a given market scale it is less likely that a "slot" will come available at a lender for a currently unmatched borrower. As a result, for a given value of $\chi$, a higher level of $l$ can be sustained under JL than under IL.

[5] The interested reader may note that there are many mixed equilibria at $\tilde{\tilde{S}}$, defined by a one-to-one function $l(\eta)$, $\eta \in [0,1]$, of which $l = \tilde{\tilde{l}}$, $\eta = 0$ is the welfare-maximising case.

Lastly note that if $\tilde{\tilde{S}} < 0$, there is never IL lending in equilibrium. Even for $S = 0$, the JL IC2 is more slack than the IL IC1 and therefore $\chi = \psi(0) > \tilde{\tilde{\chi}}$. Thus, market scale at $S = 0$ exceeds $\tilde{\tilde{l}}$.

Now consider $S > \tilde{\tilde{S}}$. Lending is JL-only (i.e. $\eta = 0$). Since IC2 is relaxed as $S$ increases, entry will occur to compensate, so $l$ and hence $\chi$ are strictly increasing in $S$ as long as IC1 is slack. IC2 must then intersect IC1 at some $\bar{\bar{S}} > \tilde{\tilde{S}}$, where $\chi$ reaches a maximum $\bar{\bar{\chi}}$. For $S \geq \bar{\bar{S}}$, IC1 is tighter than IC2, and therefore market scale has reached its maximum.

To find $\bar{\bar{S}}$ and $\bar{\bar{\chi}}$ we simply need to solve for the values at which IC1 intersects IC2 in competitive equilibrium. In other words, we solve the following condition

$$\rho = qr^{JL}_{IC1}(\bar{\bar{\chi}}) = qr^{JL}_{IC2}(\bar{\bar{S}}, \bar{\bar{\chi}})$$

obtaining:

$$\begin{aligned} \bar{\bar{S}} &= \frac{\rho}{\delta q} \\ \bar{\bar{\chi}} &= \frac{\delta pqR - \rho}{\delta pqR - \delta q\rho}. \end{aligned}$$

Lastly, to obtain the maximum scale, $\bar{\bar{l}}$, we solve $\chi(\bar{l}, 0) = \bar{\bar{\chi}}$ yielding $\bar{l} = \frac{\delta pqR-\rho}{\delta pqR-q\rho}$.

For $S \in (\tilde{\tilde{S}}, \bar{\bar{S}})$, we find the market scale by setting $\chi(l, 0) = \psi(S)$, obtaining equilibrium $l$ equal to $\frac{(1-\delta q)\psi(S)}{(1-q)+q(1-\delta)\psi(S)}$ which is strictly increasing in $S$. Collecting results, we can write the equilibrium market scale as the following function of $S$:

$$l(S) \equiv \max\left\{\underline{l}, \min\left\{\frac{(1-\delta q)\psi(S)}{(1-q)+q(1-\delta)\psi(S)}, \bar{\bar{l}}\right\}\right\}.$$

Where there is IL-only lending for $S < \tilde{\tilde{S}}$ and JL-only for $S \geq \tilde{\tilde{S}}$.

$\square$

### A.5 Mandating JL or IL

In section 3.4 we discussed the welfare effects of mandating JL or IL under monopoly or competitive lending. These are illustrated in Figure A1.

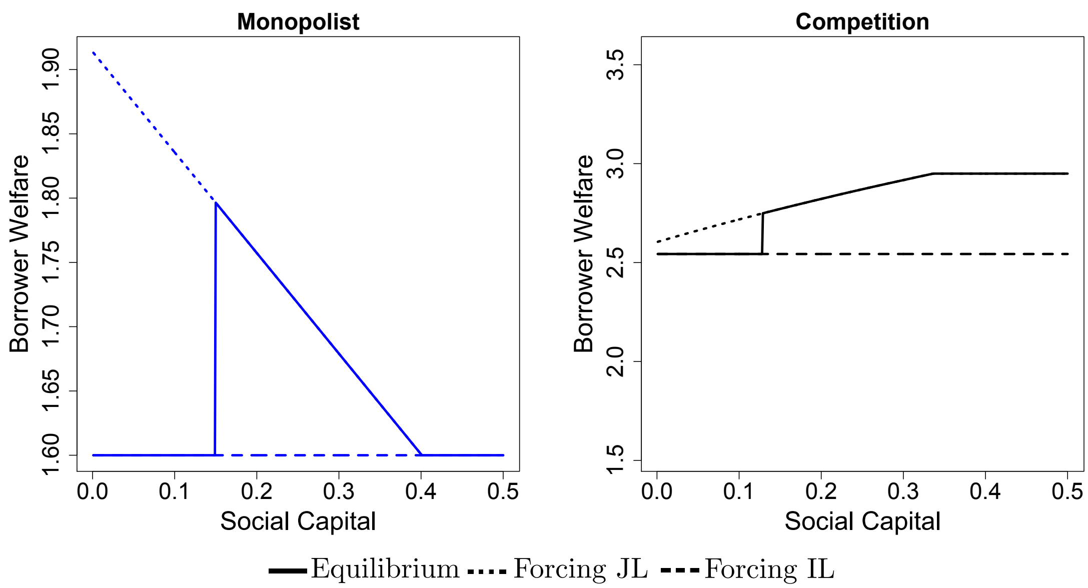


Figure A1: Mandating contractual form. Social capital ranges on horizontal axes, borrower welfare on vertical axes.

### A.6 Stochastic Renewal

Suppose the lender offers either JL or IL, but renews the group's contracts with certainty following repayment and with probability $\lambda \in [0,1]$ following default. One complication immediately arises. Suppose the state is $(R,0)$ and the interest rate is $r$. If borrower 1 defaults, her social capital is lost but the group might survive, so her IC2 is $\delta(V(S,r) + S) - 2r \geq \delta\lambda V(0,r)$. For a given interest rate $r$,

$V(S,r) \geq V(0,r)$, since without social capital repayment guarantees may not be possible. This may be a key reason why such flexible penalties are not widely used - the borrowing group dynamic may be too badly damaged following a default. To retain the basic structure of our benchmark model, we make the simplifying assumption that if the borrowers' contracts are renewed following a default, the group is dissolved and members matched up with new partners with whom they share the same value of social capital. Default is still costly, since it destroys the social capital of the existing group, but does not adversely affect the dynamic of the group if it survives. This assumption is the analogue of the group reformation assumption in the competition framework.

It is easy to see that the stochastic renewal setup closely mirrors the competition framework. Specifically, for a given $S$, a single lender could offer a the same contract (IL or JL and the same interest rate) as offered under competition, that renews with probability $\lambda = \frac{U(S)}{\tilde{\tilde{V}}(S)}$ following default. The tightest of IC2 and IC1 would bind, and all borrowers would receive utility $\tilde{\tilde{V}}(S)$.[6] However, the contracts that emerge in equilibrium are quite different, as shown in the following proposition.

**PROPOSITION 8** *Consider the following modification to the contracting setup: the lender renews the borrowers' contracts with certainty after repayment, and probability $\lambda$ following default. Equilibrium contracts are as follows:*

1. *Neither the monopolist nor competitive lenders use stochastic renewal: $\lambda = 0$.*

[6]To see this, note that for repayment probability $\pi$ and $r = \frac{\rho}{\pi}$, $\tilde{\tilde{V}} = pR - \rho + \delta(\pi V + (1-\pi)U)$, while the stochastic renewal contract yields $V = pR - \rho + \delta(\pi + (1-\pi)\lambda)V$.

2. (a) *If* $\frac{\delta p^2 r}{\rho} \leq \frac{1-\delta p}{1-p}$, *the nonprofit offers JL for all* $S \geq \hat{S}$ *as before, and* $\lambda > 0$ *for all* $S$ *(unless the JL IC2 binds at* $S = \hat{S}$*, in which case* $\lambda = 0$ *at* $\hat{S}$*).*

   (b) *If* $\frac{\delta p^2 r}{\rho} > \frac{1-\delta p}{1-p}$, *there is an* $\hat{\hat{S}} \in (\hat{S}, \frac{\rho}{\delta q})$ *such that the nonprofit offers IL for all* $S < \hat{\hat{S}}$*, JL otherwise, and* $\lambda > 0$ *for all* $S$*.*

   (c) *When JL is used,* $\lambda$ *and thus borrower welfare* $V$ *is strictly increasing in* $S$ *for all* $S < \frac{\rho}{\delta q}$*.*

3. *Borrower welfare is always higher with the nonprofit lender than under competition.*

*Proof.* The key relationship to check is the effect of $\lambda$ on IC1 and IC2. For a given $V$, higher $\lambda$ implies weaker penalty for default. However, higher $\lambda$ increases $V$ by improving the borrower or group's renewal probability. It turns out that the former effect dominates; the constraints are strictly tighter as $\lambda$ increases.

First consider the single (non-profit or for-profit) lender case. Borrower utility with stochastic renewal and repayment probability $\pi$ is

$$V = \frac{pR - \pi r}{1 - \delta(\pi + (1-\pi)\lambda)}.$$

The LLC is unchanged. The IC1 is $\delta(1-\lambda)V \geq r$ or

$$\frac{1-\lambda}{1-\delta\lambda}\delta pR \geq r.$$

The IC2 under JL is $\delta[(1-\lambda)V + S] \geq 2r$ or

$$\frac{\delta[(1-\lambda)pR + (1-\delta(q+(1-q)\lambda))S]}{2-\delta(q+\lambda(2-q))} \geq r.$$

Both are strictly tighter as $\lambda$ increases. To see this for IC2, suppose IC2 binds. Rearranging, we obtain $\frac{dr}{d\lambda} = \frac{pR-\pi r}{2+\pi a(\lambda)} a'(\lambda)$ where $a(\lambda) = \frac{\delta(1-\lambda)}{1-\delta(q+(1-q)\lambda)} > 0$, $a'(\lambda) < 0$. Thus the monopolist always sets $\lambda = 0$, since increasing $\lambda$ forces him to decrease the interest rate.

With competition, the corresponding constraints are

$$\delta(1-\lambda)(V-U) \geq r \tag{IC1}$$

$$\delta[(1-\lambda)(V-U)+S] \geq 2r \tag{IC2}$$

$U$ is exogenous from the lender's perspective, and $V-U>0$ in equilibrium. Using $V = pR - \pi r + \delta[(\pi + (1-\pi)\lambda)V + (1-\pi)(1-\lambda)U]$, we obtain $\delta(1-\lambda)(V-U) = a(\lambda)(pR - \pi r - (1-\delta)U)$, from which it is straightforward to check that both IC1 and IC2 are strictly tighter as $\lambda$ increases. Thus stochastic renewal is never used in competition. To see this, consider an equilibrium with $U = U^*$ where some lender offers IL with $\lambda^* > 0$ and breaks even. This implies that, for his borrowers, $\delta(1-\lambda^*)(V(\lambda^*) - U^*) = \frac{\rho}{p}$. But then an entrant could offer IL with $\lambda' < \lambda^*$ and earn positive profits since $\delta(1-\lambda')(V(\lambda') - U^*) > \frac{\rho}{p}$. An analogous argument rules out equilibria with stochastic renewal and JL, and rules out entry by lenders using stochastic renewal in an equilibrium with no stochastic renewal.

The non-profit lender will use stochastic renewal whenever the tightest repayment constraint is slack at the zero-profit interest rate, since increasing $\lambda$ improves borrower welfare without violating the constraint. We first analyse contract choice under IL and JL, then the choice of contract type.

Under IL, the lender chooses $\lambda$ to bind IC1. The solution to $\frac{1-\lambda}{1-\delta\lambda}\delta pR = \frac{\rho}{p}$ is $\hat{\lambda}^{IL} \equiv \frac{\delta p^2 R-\rho}{\delta p^2 R-\delta\rho}$, which is strictly positive by Assumption 2.

Under JL, the lender chooses $\lambda$ to bind the tighter of IC1 and IC2. Just as in the competition setup, IC1 and IC2 intersect at $S = \frac{\rho}{\delta q}$. If IC1 is binding, $\hat{\lambda}^{JL}(S) = \frac{\delta pqR-\rho}{\delta pqR-\delta\rho}$. If IC2 is binding, $\hat{\lambda}^{JL}(S) = \frac{\delta q[pR+(1-\delta q)S]-(2-\delta q)\rho}{\delta q[pR+\delta(1-q)S]-\delta(2-q)\rho}$. $\lambda$ is strictly increasing in $S$ until $S = \frac{\rho}{\delta q}$. However, note that if $S < \hat{S}$, JL is not usable even with $\lambda = 0$, and for $S > \hat{S}$, $\hat{\lambda}^{JL}(S) > 0$. Therefore, we have:

$$\hat{\lambda}^{JL}(S) = \begin{cases} 0 & S < \hat{S} \\ \frac{\delta q[pR+(1-\delta q)S]-(2-\delta q)\rho}{\delta q[pR+\delta(1-q)S]-\delta(2-q)\rho} & S \in [\hat{S}, \frac{\rho}{\delta q}) \\ \frac{\delta pqR-\rho}{\delta pqR-\delta\rho} & S \geq \frac{\rho}{\delta q} \end{cases}$$

The nonprofit chooses JL whenever

$$\hat{V}^{JL}(S, \hat{\lambda}^{JL}(S)) \geq \hat{V}^{IL}(\hat{\lambda}^{IL}).$$

Since the numerator is $pR - \rho$ in both cases, JL is used if and only if

$$1 - \delta(q + (1-q)\hat{\lambda}^{JL}(S)) \leq 1 - \delta(p + (1-p)\hat{\lambda}^{IL})$$

or

$$\hat{\lambda}^{JL}(S) \geq \frac{\hat{\lambda}^{IL} - p}{1-p}.$$

At $\hat{S}$ (i.e. $\hat{\lambda}^{JL}(S) = 0$) this reduces to $\frac{\delta p^2 R}{\rho} \leq \frac{1-\delta p}{1-p}$. If this condition holds, the lender offers JL for all $S \geq \hat{S}$, just as before. Otherwise, he offers JL for $S \geq \hat{\hat{S}}$, with

$\hat{S} < \hat{\hat{S}} < \frac{\rho}{\delta q}$, defined implicitly by $\hat{\lambda}^{JL}(\hat{\hat{S}}) = \frac{\hat{\lambda}^{IL} - p}{1-p}$.

To see the last part of the proposition, we have already noted that by mimicking the competitive market the nonprofit can give utility $\tilde{\tilde{V}}$ to each borrower. However, as he is unconstrained by the market equilibrium conditions, he may be able to offer an alternative contract that yields higher borrower welfare. Secondly, since he uses stochastic renewal instead of credit rationing as a motivating device, this contract can be offered to all borrowers, instead of just the matched borrowers as under competition. □

Stochastic renewal is more efficient than strict dynamic incentives. Nevertheless we find that the for-profit monopolist and competitive lenders will never use it. As a result, the nonprofit organisational form achieves the highest borrower welfare.[7] Figure A2 shows borrower welfare and $\lambda$ under the simulated stochastic renewal contract.

### *A.7 Group size and binding limited liability condition*

Consider a group of size $n$, and suppose the group's loans are repaid whenever at least $m$ members are successful. Then the repayment probability is

$$\pi(n,m) = \sum_{i=m}^{n} \binom{n}{i} p^i (1-p)^{n-i},$$

so

$$V = \frac{pR - \pi(n,m)r}{1 - \delta\pi(n,m)}.$$

[7] If the monopolist also valued future profits from a given borrower (non-myopic), he *would* use stochastic renewal, since there is now a tradeoff between higher interest rates and increasing the renewal probability. The result for the competitive market only relies on free entry and zero-profit equilibrium and therefore does not depend on the lenders' time horizon.

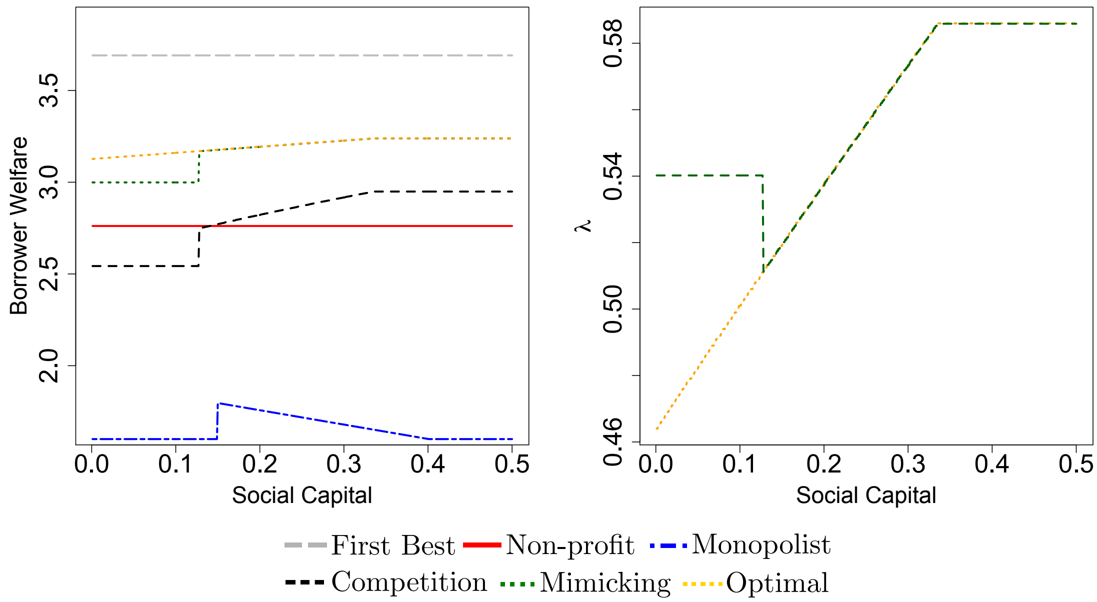


Figure A2: Simulating the stochastic renewal contract. Social capital ranges on horizontal axes, borrower welfare on vertical axes.

IC1 is unchanged: $r_{IC1} = \delta p R$. For the successful borrowers to be willing to repay when exactly $m$ are successful, each repaying $\frac{nr}{m}$, we must have $r \leq r_{IC2}(S, n, m)$, which we can derive as:

$$r_{IC2}(S, n, m) \equiv \frac{\delta m[pR + (1 - \delta\pi(n, m))S]}{n - (n - m)\delta\pi(n, m)}.$$

The LLC requires that the $m$ successful borrowers can afford to repay all 5 loans, i.e. $nr \leq mR$ yielding

$$r_{LLC}(n, m) \equiv \frac{mR}{n}.$$

For a given $r \leq r_{IC1}$, borrowers will choose the lowest $m$ such that to IC2 and LLC are satisfied, so equilibrium $m^*$ is determined by

$$\min\{r_{LLC}(n, m^*), r_{IC2}(S, n, m^*)\} \geq r > \min\{r_{LLC}(n, m^* - 1), r_{IC2}(S, n, m^* - 1)\}.$$

This $m^*$ then defines the repayment probability function $\pi^*(S, n, r)$.

The non-profit lender chooses the lowest $r$ such that $\pi^*(S, n, r)r = \rho$. The for-profit chooses $r$ to maximise $\pi^*(S, n, r)r$.

Despite this modification, it may be that LLC at $m^*$ is tighter than IC1, in which case the highest interest rate the lender can charge under JL will now be dictated by the LLC and smaller than $r_{IC1}$. If this is the case and the lender is a for-profit monopolist, borrowers will be *strictly* better off under JL than IL. However, if the LLC is very tight, JL may never be offered. This has three implications for the simulations. Firstly, the value of $\bar{S}$, obtained from the point at which the lender can no longer leverage social capital, depends on whether IC1 or LLC are tightest. Formally, with the group size modification,

$$\bar{S} = \min\left\{\frac{(n-m)pR}{m}, \frac{[n(1-\delta p) - (n-m)\delta\pi^*]R}{\delta n(1-\delta\pi^*)}\right\}.$$

Secondly, the interest rate and borrower welfare at $\bar{S}$ are be lower and higher respectively than the corresponding values under IL, when $r_{LLC} < r_{IC1}$. Thirdly, if $r_{LLC}$ is very tight for every $m$ there may be no value $\tilde{S}$ at which the lender is willing to offer JL.

### *A.8 Additional figures*

Figure A3 plots the predicted borrower welfare in each of the regions considered in the simulations, as was discussed in section 3.4. Figure A4 plots the sensitivity checks.

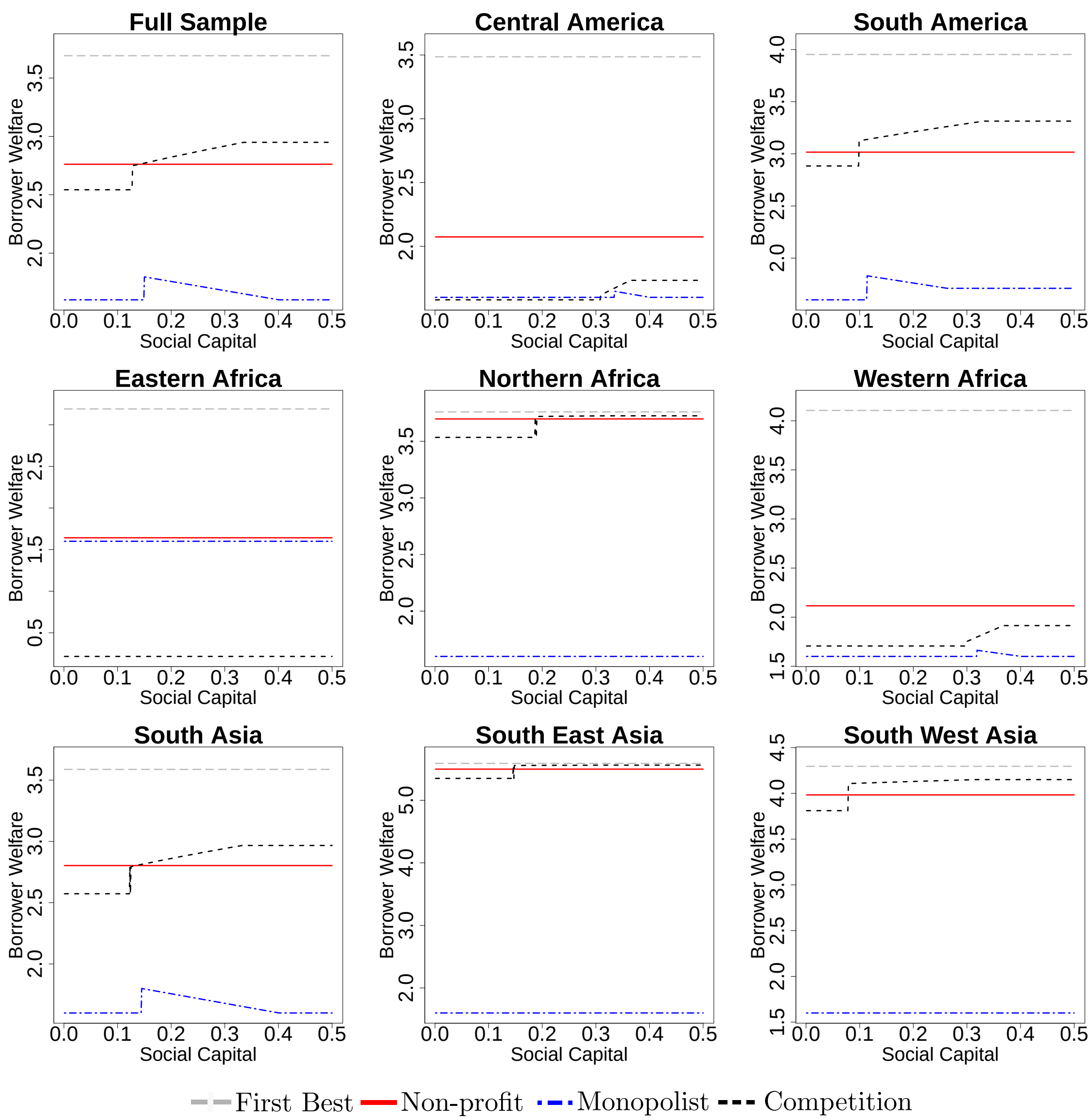


Figure A3: Borrower Welfare: Regional Differences. Social capital ranges on horizontal axes, borrower welfare on vertical axes.

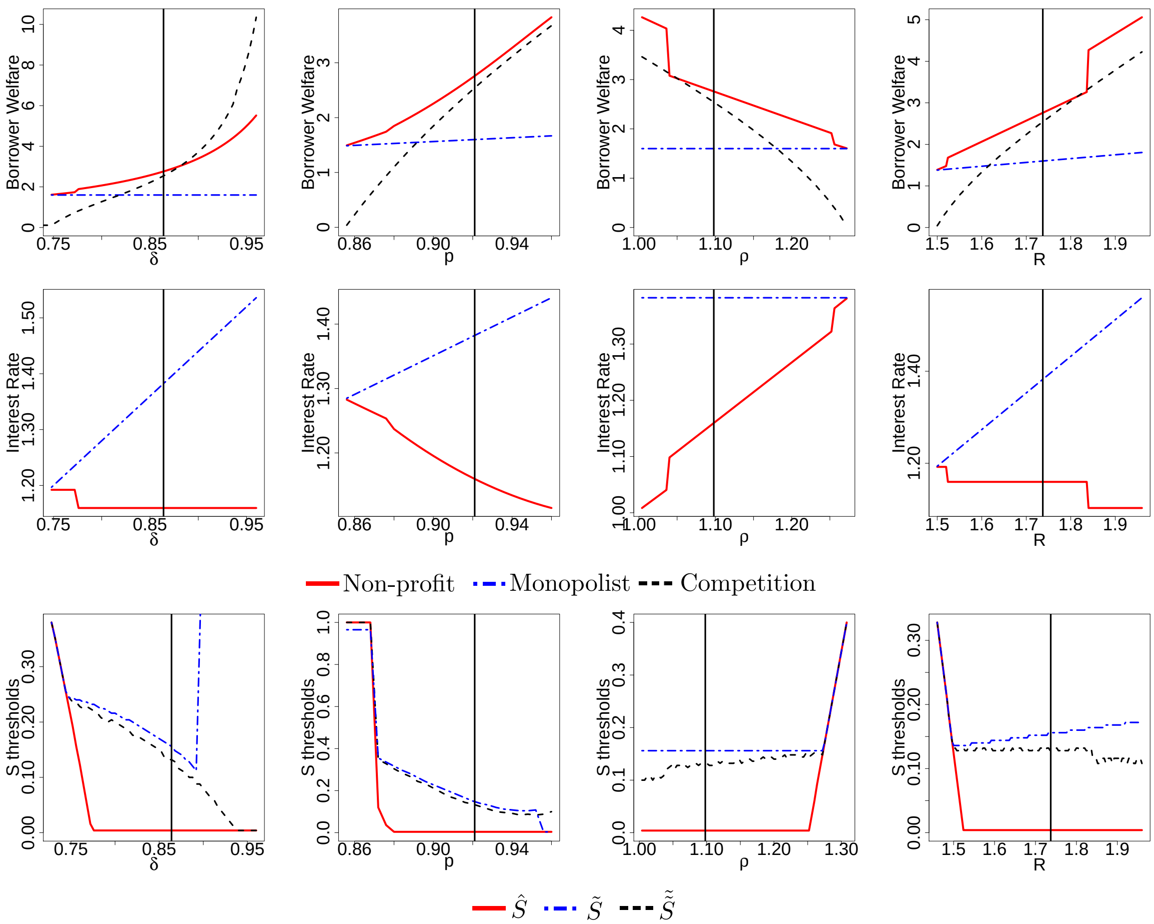


Figure A4: Sensitivity Analysis. Vertical lines indicate full sample parameter estimates.

## B. Simulation Methodology

This Appendix outlines the algorithm used to simulate the core model. The simulation was implemented in Scilab, an open-source alternative to Matlab. Rather than solving the model explicitly, which becomes increasingly complicated with larger groups, we chose to simulate the optimisation problem numerically. As the objective functions are all linear, this is a computationally tractable and simple task.

The simulation consists of two parts. The first part computes the optimal contracts of a non-profit and a monopolist lender, while varying the level of social capital $S$. The second part computes the competition section.

The section proceeds by presenting annotated pseudo-codes, that illustrates how the code proceeds to arrive at the optimal contracts.

*Non-Profit and Monopolist*

Here the optimisation is very simple, as we do not have to study an entry condition, but just have to evaluate a set of constraints. The optimisation procedure is carried out for each level of social capital, which then gives us the value functions we use for the main plots in the paper. Since $n = 5$ throughout we drop the $n$ notation.

For each value of $S$:

*Non-Profit*

1. JL: find the set $M_{JL}^{ZP}$ of values for $m$ that satisfy $r_{LLC}(m) \geq \rho/\pi(m)$ and the associated functions $\hat{V}^{JL}(m)$.

2. IL: Find, if it exists, the IL zero-profit equilibrium and the associated $\hat{V}^{IL}$.

3. Choose the contract (IL/JL), value of $m$ and corresponding interest rate that gives borrowers maximal utility.

*Monopolist*

1. JL: For each $m \in M_{JL}^{ZP}$ find the maximal interest rate $\tilde{r}(m)$ such that $\tilde{r}_{JL}(m) = \min\{r_{IC2}(m), r_{LLC}(m), r_{IC1}\}$ and compute the associated profits $\tilde{\Pi}(m)^{JL} = \pi(m)\tilde{r}^{JL}(m) - \rho$.

2. IL: Compute the maximal interest rate $\min\{r^{IC1}, r^{LLC}\}$ and compute the associated profits $\tilde{\Pi}^{IL} = p\tilde{r}^{IL} - \rho$.

3. Choose the contract that maximises profits.

*Competition*

For the competition model, we simulate the entry condition for lenders. For each value of $S$ and $U$ we check whether an entrant could earn positive profits with some contract (recall that in equilibrium there is always excess demand for credit). This will happen as long as the relevant constraints (see below) are slack at the relevant zero-profit interest rate. Hence, for each $S$ we proceed by iteratively increasing $U$ until the most profitable contract breaks even. The details are provided in the following pseudo-code:

For each value of $S$:

1. Initialise $U = 0$.

2. JL: for all $m = 1, ..., n$, check that all three constraints (LLC, IC2, IC1) are satisfied at the zero-profit interest rate.

3. IL: check that IC1 is satisfied at the zero-profit interest rate.

4. If there exists at least one contract such that all relevant constraints are satisfied, increase U by one unit and repeat from step 2. Otherwise, we have found the equilibrium value of $U$. The equilibrium contract (either IL or JL and the appropriate value of $m$) is the one for which all three constraints were satisfied in the previous round of iteration. If two or more contracts are feasible, pick the one that delivers the highest borrower welfare.

5. Given the equilibrium contract, solve $U$ for the equilibrium market scale, and thus find $Z$.

*Optimal Contract with Stochastic Renewal*

The algorithm to determine the optimal level of $\lambda$ is very similar to the one that determines the level of $U$ in the competition simulation. The idea is, that a non-profit adjusts $\lambda$ as long as the relevant constraints are slack. The key difference is that the non-profit finds the binding level of $\lambda$ for for all different levels of $m$ and then choses the level of $m$ that provides borrowers with maximal utility. Free-entry competition may not yield the welfare-maximising level of $m$. The reason is that entry continues until the slackest constraints eventually binds, which gives a single value for $U$. Under the optimal stochastic renewal contract, we find the optimal $\lambda$ for each level of $m$ respectively and then let the non-profit chose the welfare-maximising contract. The details are provided in the following pseudo-code:

For each value of $S$:

1. Initialise $\lambda = 0$.
2. JL: for all $m = 1, ..., n$, check that all three constraints (LLC, IC2, IC1) are satisfied at the zero-profit interest rate.
   (a) if for any $m$, a constraint is violated, we record the current $\lambda$ as the optimal one for that particular $m$.
3. IL: check that IC1 is satisfied at the zero-profit interest rate.

(a) if the constraint is violated, we record the current $\lambda$ as the optimal one for IL.

4. As long as there exists at least one contract such that all relevant constraints are satisfied (either IL or all JL), increase $\lambda$ by one unit and repeat from step 2.

5. Evaluate the value functions at the respective optimal $\lambda$ and chose the contract that maximises utility.

## C. Data Appendix

The dataset we work with comes from MIXMarket.org, an organisation that collects, validates and publishes financial performance data of MFIs around the world. The MIX provides a set of reports and financial statements for each MFI reporting to it. The financial statements and reports were downloaded in March 2011, the relevant data was then extracted into a database using an automated script. The variables we use in this paper come from the MFIs' Overall Financial Indicators, the Income Statement, the Balance Sheet and the Products and Clients report. The Balance sheet and the Income statements are regular financial statements, while the Financial Indicators report variables such as Portfolio at Risk and the Products and Clients report include the number of loans by methodology.

The variables we use from the Balance Sheet are Value of IL Loans, Value of Solidarity Group Loans and overall Gross Loan Portfolio. From the Income statement we use the Operating Expense and the Financial Expense to compute the expense per dollar lent as described in the main text. From the Financial Indicators report, we use the Portfolio at Risk numbers, along with the Real Portfolio Yield to compute the risk adjusted real yields. From the Products and Clients report, we extract the Number of IL Loans and Number of Solidarity Group Loans, which we refer to in the main table and the text.

We work with a sample of 715 institutions for the year 2009. We chose the year 2009 as that is the year for which we have the largest number of institutions reporting lending methodology.[8]

The MIX data does not give us information whether JL is used, but they state that "loans are considered to be of the Solidarity Group methodology when some aspect of loan consideration depends on the group, including credit analysis, liability, guarantee, collateral, and loan size and conditions." We will refer to the share of loans falling into this category as JL share loans.

Sometimes the data on lending methodology by number of loans or by volume does not correspond exactly to the reported total portfolio or number of loans outstanding because of data entry errors, missing data or number of borrowers rather than number of loans reported. In these cases we assume that the errors are not biased toward either IL or JL, so we compute the share from the data we have. For example, if a lender reports \$1m of loans, but \$450k IL and \$450k solidarity group lending, we compute an IL share of 50% and apply this to the whole portfolio. Of the 715 institutions in the sample, 143 have such incompleteness in the value data, 16.7% of the total Gross Portfolio is unaccounted for. As for the number of loans

[8] In 2009, 911 (out of a total of 1106) provide some data on lending methodology by volume coming from the Balance Sheets. Of these, we exclude 154 "village banks" for which lending methodology is unclear. Furthermore, we lose 41 observations due to missing data on the key variables used for the simulation: Portfolio at Risk, Operating Expense, Financial Expense and Real Portfolio Yield. Lastly, we drop one MFI that reports PAR greater than 100%.

(which are not used in the estimation), 10 have no data so we use the value shares as a proxy, and 222 institutions have incomplete data; a total of 11.4% of the number of loans are unaccounted for. In total 304 institutions have some incompleteness in these data.

The relationship between the two is illustrated in Figure C1. Points lying on the 45 degree line correspond to lenders where the IL share by value is the same as the IL share by number. Each point corresponds to an MFI, with those in red, the "portfolio data incomplete", corresponding to the observations where the methodology breakdown does not exactly match the portfolio figures as discussed in the previous paragraph. From this graph we learn three things. Firstly, the pattern of the data is very similar when we compare "complete" and "incomplete" observations, which suggests we need not be concerned about the incomplete cases. Secondly, most points lie to the north west of the 45 degree line, indicating that IL loans tend to be larger than JL loans (an issue we do not explore in this paper). This has been previously observed in Cull *et al.* (2007). Thirdly, although we do observe some lenders offering both IL and JL, the majority of lenders use predominantly one or the other. 72% of lenders (accounting for 68% of loans by number and 84% by value) have 95% of their portfolio in either IL or solidarity lending.

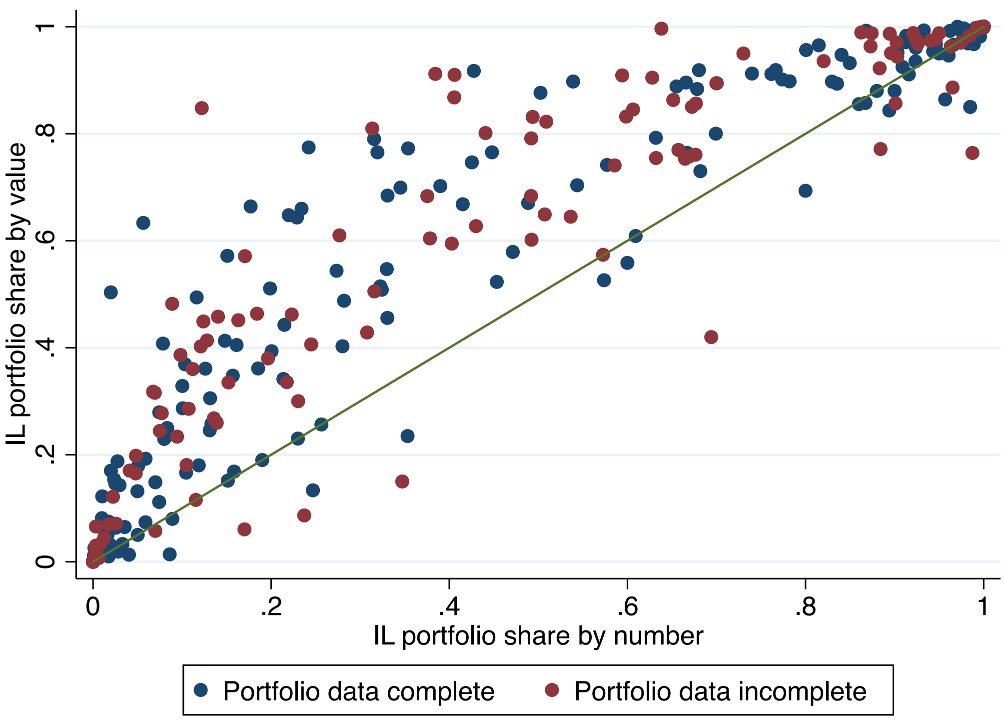


Figure C1: IL Share by Value and by Number