Compulsory versus Voluntary Savings as an Incentive Mechanism in Microfinance Programs

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Abstract: *This paper investigates the incentive mechanism of individual microlending contracts focusing particularly on microsavings. We built a model to show the role of compulsory and voluntary microsavings in addressing problems of information asymmetries. Our results are twofold. First, we show that compulsory savings creates incentive conditions required for allowing micro-entrepreneurs to be financed by a Microfinance institution. Second, we show that voluntary savings can serve as a complementary tool to repayment enforcement at the same time inducing borrowers to reveal abilities of their projects. These findings are corroborated with our empirical tests using a dynamic panel model.*

Keywords: *Microfinance; Compulsory microsavings; Voluntary microsavings; Incentive mechanism; Repayment enforcement; Screening*.

JEL*: O16, G21*

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1. Introduction

Microfinance is considered one of various segments in the financial system. Microfinance programs have twofold objectives: to fill the gap left by (larger) conventional institutions in relation to the provision of financial services to disadvantaged sections of society, and to contribute to the social inclusion of these disadvantaged sections. Current microfinance institutions (MFIs) offer a range of financial services that include loans, savings, insurance, remittances, and joint-lending, which are tailored to better meet the needs of poor borrowers. One of the main problems facing MFIs is the vulnerability of their clientele, which typically is unemployed, lacks a documented credit history and pledgeable collateral. Given that, like most financial institutions MFIs operate within a variety of principal-agent relations, they have to cope with some key problems related to imperfect information in the context of credit markets such as adverse selection and moral hazard. They need to find a way to make borrowers demonstrate responsible behavior (i.e. to repay their loans), and to access information required to approve a loan.

Drawing on the major success stories, researchers are attempting to unfold different mechanisms of repayment enforcement and screening. Numerous studies focus on information asymmetry problems related to both group lending and individual microfinance programs in diverse contexts involving different dynamic incentives. Generally, dynamic incentives provide future incentives (e.g. larger or cheaper loans) in exchange for a change in current behavior (e.g. lower moral hazard, greater commitment). Almost all MFIs rely on dynamic incentives. Existing mechanisms are based mainly on joint liability in group lending (see the seminal papers by Stiglitz (1990), Varian (1990), Morduch (1999a) and Ghatak (1999, 2000)) or on the use of social sanctions, collateral, and progressive lending to individuals (Armendáriz and Morduch, 2000; Egli, 2004; Tedeschi, 2006; Bhole and Ogden, 2010).

The objectives of the present paper are in line with the above mentioned literature; we are interested in both repayment enforcement and screening of borrowers. We propose new solutions to the key problems of how to frame and time incentives in microlending contracts in

order that they are socially optimal, and revealing the role of microsavings in these incentive mechanisms.

Accumulated empirical evidence shows the significant role of microsavings in the service portfolios of development finance companies. The huge demand for financial savings, particularly in developing countries, has been demonstrated empirically (Vogel, 1984; Martin, Hulme, and Rutherford, 2002; Robinson, 2001; Dowla and Alamgir, 2003). Recent evidence shows that not only the poor can, but they are also willing to, actively save (Collins et al., 2009). Well-designed savings products can help poor households manage their volatile daily cash flow and smooth their consumption. Access to savings has positive impacts in terms of increased household expenditures (Brune et al., 2016), enhanced possibilities for the poor to cope with health emergencies, improved female business investment (Dupas and Robinson, 2013), and contribute to womenôs empowerment (Ashraf et al., 2010; Guérin, 2006).

Recent studies show that savings instruments play an important role in reducing the financial stress of borrowers and mitigating the risks of over-borrowing (Atkinson et al., 2010; Schicks and Rosenberg, 2011). This saving behavior has been viewed traditionally as an opportunity for MFIs to develop convenient and appropriate savings services in order to meet existing demand and fulfill their social mission.

For MFIs, deposit-taking is often the most stable and affordable source of funding, which also improves their productivity (Hartarska, Parmeter, Nadolnyak and Zhou, 2010; Delgado, Parmeter, Hartarska, and Mersland, 2015; Malikov and Hartarska, 2017) and reduces their dependence on external funds over the long-term (Mata, 2009, Gadway and OôDonnell, 1996; Otero, 1989; Jackelen and Rhyne, 1991). Another study suggests that the poor savers and borrowers may be two different groups and that scope economies arise from sharing physical infrastructure, and not sharing of information from micro-borrowers to improve micro-deposits product design and vice versa (Hartarska, Parmeter and Nadolnyak, 2011). Thus, more underserved clients ï both borrowers and savers - may be reached as a result of MFIs offering both credit and savings services. Cozarenco, Hudon and Szafarz (2016) find that savings may crowd out subsidies because MFIs collecting voluntary savings (not only compulsory savings, which act as collateral for loans) receive fewer subsidies than their credit-only counterparts.

Overall empirical work addresses the issue of MFI savings services provision and its impact (Cozarenco et al., 2016; Delgado, Parmeter, Hatarska and Mersland, 2015; Rossel-Cambier, 2012). However, despite the general consensus on the need for microsavings, MFIs offering savings products are still under-studied.

Our aim in this paper is to demonstrate that attracting microsavings to form joint-lending contracts, by inducing ógood behaviorô of borrowers and allowing MFIs to better screen loan applicants can be a tool for repayment enforcement.

Microsavings fall mostly into the two main types of compulsory or voluntary. Compulsory or forced savings are defined as the minimum savings that condition the borrowerôs access to loans and can be seen as a substitute for collateral imposing a positive inducement for repayment. MFI regulation typically does not allow withdrawal and use of those savings until the loan is repaid. Voluntary or flexible savings allow both borrower and non-borrowers to deposit or withdraw according to their needs (Montgomery, 1996). Voluntary savings imply that savings and credit are integral components of financial intermediation, and that savers already know why and how to save (Robinson, 1994).

Thus, compulsory savings is perceived as savings that is an integral part of a loan; savers learn financial discipline, and qualify for credit on the basis of a convincing saving record. The mobilization of compulsory saving is based on the belief that a process of small, regular payments will contribute to the borrowerôs repayment performance (Wisniwski, 1999; Ledgerwood, 1999; Armendariz and Morduch, 2005). Fiebig, Hannig, and Wisniwski (1999) show that the financial technology of many microcredit programs includes forced saving. However, the other key issue related to MFIs - discriminating among loan applicants ï is not addressed by the compulsory saving mechanism. Several authors argue that this mechanism does not serve as an indicator of the borrowerôs "quality", and potential for successfully undertaking the project. The core argument in our study is whether the inclusion in individual microlending contracts, of voluntary saving could act as a screening and selection device by revealing information about the borrowerôs abilities. This is an important issue for MFIs since the probability of project success generally depends on the borrower's abilities. Thus, our contribution is related to the literature on repayment enforcement and incentive mechanisms. We build particularly on the arguments proposed by Armendáriz and Morduch (2000), which favor the use of saving as deposit mobilization to address adverse selection and moral hazard problems.

We develop a model of asymmetric information with hidden information where microlending is joined with microsavings. We consider a three-period model with two classes of agents ï

micro-entrepreneurs and a MFI, and assume that the population of micro-entrepreneurs consists of two types - "high-ability" and "low-ability" - with two different (high and low) success probabilities for period 2. At period 0, micro-entrepreneurs need external funds in order to invest in a risky project; however, given the poor quality of their characteristics, they do not have access to the conventional financial system and need to apply for financing from a MFI. We assume that the MFI faces two information problems in its relationships with micro-entrepreneurs. On the one hand, the MFI cannot discriminate between "high" and "low" ability micro-entrepreneurs. On the other hand, we assume that micro-entrepreneurs have better information on the profitability of their projects and can divert a part of the cash from the MFI.

First, we design an equilibrium contract between micro-entrepreneurs and the MFI, where the repayment incentive is based on the requirement of compulsory saving. We show that this kind of contract at period 0 allows all projects with positive social value to be financed in period 1. We show also that this contract is not optimal since it does not discriminate between "high" and "lowò ability micro-entrepreneurs, and leads to elimination of certain projects with positive net present values for period 2.

Second, we show that the introduction in our framework of voluntary saving allows the MFI to ascertain the type of micro-entrepreneur and restores optimality. We build a separating equilibrium in which all "high ability" micro-entrepreneurs will choose a loan agreement with voluntary saving, and all "low ability" micro-entrepreneurs will choose a loan agreement with compulsory savings only. This complete enforcement and revealing mechanism can be seen as a novel approach compared to existing incentive methods, which are designed to deal with enforcement and screening issues in individual microfinance lending contracts.

In order to test our theoretical model we design a dynamic panel model that captures the impact of voluntary savings on number of clients in a dynamic panel framework. We utilize moment conditions using lagged differences of endogenous variables, in addition to the moments in Difference GMM. Our results show that the number of clients is positively and significantly associated with voluntary savings.

The rest of the paper is organized as follows. In Section 2 we discuss the emerging importance of microsaving. Section 3 specifies a basic three-period lending model designed for a joint-lending contract. Section 4 derives the equilibrium contract employing compulsory saving as enforcement to reimburse and Section 5 deals with the selection enforcement created by voluntary saving. The empirics testing the model come in Section 6. Section 7 presents some

concluding remarks. Technical details on the proofs of the propositions are presented in the Appendix.

2. Emerging importance of microsavings

The main mission of MFIs is to serve as many untapped poor clients as possible. However, one of the impediments for MFIs not to expand their outreach is their access to limited sources of funds. In overcoming this challenge, also for the sake of covering the high operational costs and remaining competitive, MFIs diversify their product offerings.

For many years, policymakers and bankers have been taught that ***ñ****the poor do not save, cannot save, do not trust in financial institutions and prefer non-financial forms of savings (****é*** *)*ò (Robinson, 2001: 228). This steered microfinance practitioners away from mobilizing the savings of the poor. However, this view was challenged by increased awareness of numerous informal saving schemes which have successfully mobilized savings from low-income individuals.

Additionally, in many countries MFIs offering both saving and credit products have been shown to have more savers than borrowers, and to have higher volumes of savings than loans (Mata, 2009). Consequently, demand of microsavings and the social and financial benefits of their mobilization have been acknowledged. Contrary to the common belief that the poor spend all their income which is insufficient to cover their needs, it has been shown that they are inclined to save in order to face survival uncertainties (see Karlan and Morduch, 2010; Martin, Hulme, and Rutherford, 2002, to name just a few).

Combining credit and savings may improve long term MFI organizational sustainability as savings allow to be less dependent of external loans (Armendariz and Morduch, 2010; Robinson, 2004). While savings could entail various advantages for MFIs (Hirschland, 2005; Delgado et al., 2015), they have a social mission to provide security and stability to clients. The recent literature has documented the positive impact of saving products on clientsô welfare (Karlan et al., 2014).

A number of studies that provide empirical insights into demand for microsavings have been carried out in Bangladesh. Montgomery (1996) conducted case studies of MFIs in Bangladesh and Sri Lanka, providing evidence of how savings among a range of other protective mechanisms, can help and can protect the poor. In contrast to the BRAC approach, SANASA cooperatives in Sri Lanka, instead of excluding poorer members on the basis that they will face repayment problems, have introduced a range of coping mechanisms such as flexible repayment

schedules, open access savings, and instant consumption loans. This approach to adapting savings and credit facilities for the poor has resulted in a more positive perception of individual risk, and encouraged mutual trust and support.

In an analysis of six deposit-taking MFIs, Wisniwski (1998) concludes that individual and voluntary savings have proven to be the most successful savings products in terms of number of accounts and volume of savings.

Referring to a series of studies, Meyer (2001) stresses that a larger number of poor people have need of saving, insurance, leasing, and other financial services apart from loans. Evidence from an experimental project implemented by SafeSave (in Bangladesh) in 1996 demonstrates that there is sizeable demand for voluntary open-access savings among the very poor, and if given the possibility they are motivated to save and capable of saving (Meyer, 2001; Morduch, 1999b).

Dowla and Alamgir (2003) describe how the microfinance industry in Bangladesh evolved from a main focus on standardized loan products and collection of compulsory savings to the development of flexible saving products. The authors argue that poor people are willing to save if they are provided with means to deposit savings. Their study demonstrates how mandatory saving becomes a precondition for microcredit, and how it ensures certain discipline among members. Furthermore, Morduch (2009: 1) states ***ñ****the pattern of borrowing while saving is a regularity in the* ***ó****financial diaries****ô*** *collected over a year in villages and poor urban neighborhoods in India, South Africa, and Bangladesh****ò***. The financial diaries of hundreds of households across Bangladesh, India, and South Africa show that the poor are active savers, and generally exploit several different formal and informal saving devices (Collins et al., 2009). However, they find it difficult to save because ***ñ****the devices are often unreliable (...), inconvenient, inflexible, and inappropriately structured****ò*** (Armendáriz and Morduch, 2010: 183).

More recent studies, such as Glisovic, El-Zoghbi, and Forster (2010: 4), argue that there is evidence of ***ñ****demand for convenient, safe, and affordable savings services****ò*** in the growing number of savers in deposit-taking institutions since the mid 2000s. Glisovic et al. base their argument on MIXMarket data and offer the examples of Grameen Bank and Equity Bank Kenya. Between 2005 and 2008, Grameen Bank added over 2 million new savers, and current deposits amount to 147 percent of its outstanding portfolio. Similarly, Equity Bank Kenya, which had over 3 million savers in 2008, has added an average of 550,000 new deposit clients every year over the past five years. The main and the most essential criteria for poor savers who are willing to save in a financial institution are convenience (easy access to saving services),

liquidity (easy access to savings when needed), and security (safety of the savings and stability of the collecting institution) (Ledgerwood, 1999; Wright, 2003; Deshpande and Glisovic-Mezieres, 2007). Furthermore, existing evidence sheds light on the active capacity of the poor to save using several (formal and informal) saving devices (Collins et al., 2009).

From the perspective of the MFIs, saving represents a long-term financial interest. The evolution of microfinance financing has resulted in a situation where regulated financial institutions can access clientsô savings in most jurisdictions. Client deposits have become a dominant source of funding for traditional financial institutions, and are becoming equally important for MFIs (Fehr and Hishigsuren, 2006). As mentioned earlier, attracting savings requires the MFIs to meet certain conditions related to the services offered. These include a stable macro-economy and a level of political stability, an appropriate regulatory environment, public supervision of MFIs, accountable ownership, effective governance, and consistently good management of their funds, and allocation of high-level management resources to these institutionsô microfinance efforts (Robinson, 2001). Initially, mobilization of highly liquid and small voluntary savings implies increased operational costs, and more sophisticated management skills (Ledgerwood, 1999; Fiebig, Hannig, and Wisniwski, 1999). However, in the long-term deposit taking can be beneficial for MFIs: first, the financial self-sufficiency of the institution is reinforced - savings represent a relatively stable and relatively inexpensive source of funds compared to the cost of debt; second, savings reduce external dependence; third, savings allows the accumulation of clientsô saving records which may later become the basis for borrowing (Mata, 2009; Gadway and OôDonnell, 1996; Otero, 1989; Jackelen and Rhyne, 1991). Rutherford (2000) argues that the essence of microfinance credit contracts is that they provide a clear substitution for imperfect savings vehicles.

One of the few recent studies with regard to the combined microfinance services and MFI performance is Cozarenco, Hudon and Szafarz (2016). The authors study the characteristics of MFIs that collect voluntary savings. Using random-effect probit estimation on a dataset of 722 MFIs active over the 2005-2010 period, the authors find that the MFIs mobilizing savings received fewer subsidies than their credit-only counterparts. This means subsidies crowd-out microsavings products, thus allowing the authors to claim that donors may generate negative externalities on product diversification.

Malikov and Hartarska (2017) suggests that combining credit and savings services is rather justifiable as a means of meeting the needs of poor and does not necessarily serve as a way for

the industry to save costs. They further find that scope economies is mostly observed among smaller MFIs and those targeting the poor.

On the other hand, DôEspallier, Goedecke, Hudon & Mersland (2017) show that institutional transformation of MFIs leads to a cut in their operational expenses and funding costs, and at the same time to an increase in their commercial debt leverage, deposits and average loan size. The latter is often taken as an indicator for mission drift.[2] This allows us to assume that offering deposits might erode MFIs from their dual mission by not targeting less poor clients.

The accumulated empirical evidence constitutes a solid basis from which to argue that the ability to mobilize savings can contribute both to meeting the demands of the poor, and to enhancing the long-term sustainability of MFIs by reducing their dependence on subsidies. Thus, encouraging savings is justified empirically; the challenge lies in designing a financial technology to serve the specific needs of both borrowers and lenders.

The evidence allows a different perspective on microsavings. In our study, we develop a novel approach to the mobilization of microsaving, based on both compulsory and voluntary savings as enforcement and screening mechanisms related to individual microlending contracts. The model shows that compulsory saving which can act as an enforcement mechanism, lacks the means to reveal the borrowerôs potential in the context of individual lending contracts. In our study, voluntary saving is introduced as an incentive mechanism allowing MFIs to discriminate among the abilities of loan applicants. The borrowerôs abilities ultimately condition the probability of project success. Our empirical estimation enables us to test this claim and argue about the robustness of the suggested theoretical model.

3. The Model

We consider two classes of agents ï micro-entrepreneurs and a MFI. and three periods. Micro-entrepreneurs need external funds in order to invest in a risky project at date 0. We assume that, based on their characteristics, they have no access to the capital market or/and bank loans and must obtain financing from the MFI.

[2] DôEspallier, Goedecke, Hudon & Mersland (2017) explore whether MFI business model alters when they transform from NGOs to become regulated and share-holder owned banks. On a sample of 66 transformed MFIs over the period of 1993ï2011 the authors apply an event study methodology and find that institutional transformation results in portfolio yield decrease by 3.9 percentage points indicating that clients get more favorable interest rates. The authors find that MFI profitability in terms of ROA drops in the short term, while ROE is increasing in the medium to long run.

3.1 Micro-entrepreneursô behaviors

The population of micro-entrepreneurs is divided into two types: "high-ability" and "low-ability" micro-entrepreneurs in the respective proportions θ and $(1-\theta)$. We assume that if they decide to invest at date 0, all micro-entrepreneurs (high or low ability) have access to the same risky project, which occurs over two periods and generates at each period a stochastic payoff equal to 0 (in the case of project failure) or $R > 0$ (if the project is successful). The first period (between $t = 0$ and $t = 1$) can be view as the seed stage of the project, which requires α unit of capital (with $\alpha < 1$) at date $t = 0$ in order to be initiated. The second period (between $t = 1$ and $t = 2$) corresponds to the maturity stage of the project, which requires another $\left(1-\alpha\right)$ unit of capital at date $t = 1$ Thus, the total amount required to finance the project is equal to 1.

We assume that at date $t = 0$, micro-entrepreneurs have an initial level of wealth inherited from previous activities, still this wealth is not sufficient to finance their project in either period 1 or period 2. They lack the capital to invest and need to borrow from the financial system. However, because of their poor characteristics and information opacity, micro-entrepreneurs wanting to invest do not have access to traditional financial services and must obtain financing from a MFI in order to obtain a microcredit. Consequently, micro-entrepreneurs need to borrow α unit of capital at date $(t = 0)$ and another $\left(1-\alpha\right)$ unit of capital at date $\left(t = 1\right)$. We assume that financing by the MFI at date $\left(t = 1\right)$ is possible only for projects that were financed previously at date $(t = 0)$.

The probability of project success for period 1 (between $t = 0$ and $t = 1$) is equal to p whatever the level of ability of the micro-entrepreneur. We define $\gamma > 0$ as the opportunity cost of the fund which is defined as the riskless interest rate of the economy.

Assumption 1. We assume that investment projects generate a positive net expected value in period 1, whatever the characteristics of the micro-entrepreneur (high or low ability):

$$pR > \alpha\left(1+\gamma\right) \tag{1}$$

Project success probability for period 2 (between $t = 1$ and $t = 2$) depends on two elements: project success or failure at period 1, and the "quality" of the micro-entrepreneur involved. There are two possibilities. In the case of project success at period 1, the probability of project success at period 2 is equal to p whatever the ability level of the micro-entrepreneur. However, in the case of project failure at period 1, the probability of project success for period 2 is equal to p only for "high-ability" micro-entrepreneurs, and is equal to p_l for "low-ability" micro-entrepreneurs with $\left(p > p_l\right)$. This means that only "high-ability" micro-entrepreneurs are able to bring a project back on track in the case of failure at period 1.

Figure 1 depicts the various possible payoffs of an investment, and the corresponding probabilities.

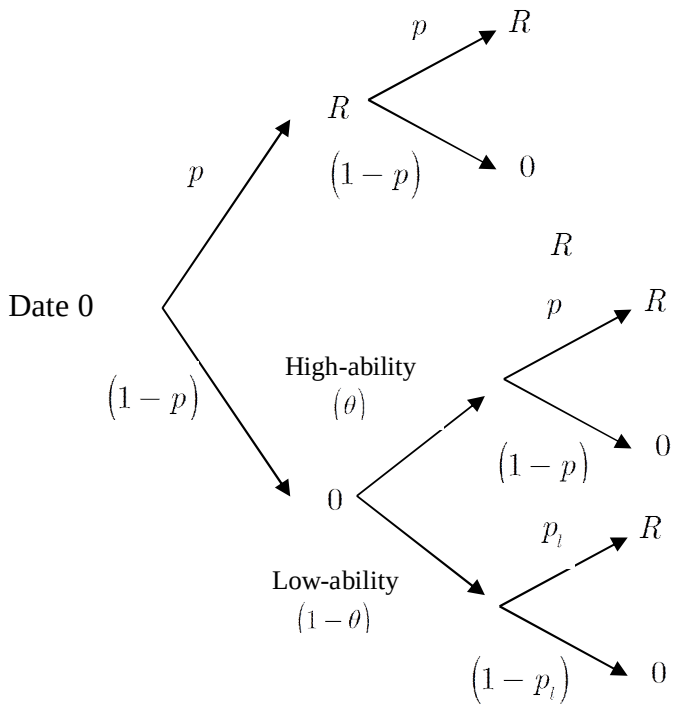

Figure 1: payoff according the various situations

Assumption 2.

a. Successful projects in period 1, or projects that involve "high-ability" micro-entrepreneurs generate a positive net expected value in period 2:

$$pR > \left(1-\alpha\right)\left(1+\gamma\right) \tag{2}$$

b. Projects that fail in period 1 and are conducted by "low-ability" micro-entrepreneurs generate a negative net expected value in period 2:

$$p_l R < \left(1-\alpha\right)\left(1+\gamma\right) \tag{3}$$

Assumption 2 means that a project that fails to generate a payoff at period 1 may have a positive net expected value at period 2 if managed by a "high-ability" micro-entrepreneur. Consequently, allowing "high-ability" micro-entrepreneurs to continue their projects even if they failed to generate a positive payoff at period 1, is efficient from a whole society perspective. This is not the case for projects run by "low-ability" micro-entrepreneurs.

3.2. Microfinance Institution

We assume that the MFI does not have equity capital, and have to raise funds at a riskless interest rate γ per period from local or external financial institutions in order to provide small-scale financial services to the micro-entrepreneur. The interest rate charged by the MFI to all the micro-entrepreneurs it finances is given by r_t with $t = 1,2$.

We assume that the MFI faces two types of informational problems in its relationship with micro-entrepreneurs.

First, the MFI is not capable of discriminating between "high" and "low" ability micro-entrepreneurs. However, since at date 0 all investment projects have a positive net expected value for period 1 (Assumption 1), this *ex-ante* informational problem does not prevent the MFI from financing a micro-entrepreneur who asks for a loan. Nevertheless, problems may occur at date 1 if the financed project fails to generate a positive payoff. In that case, because of Assumption 2, projects run by "low-ability" micro-entrepreneurs must be canceled since their net expected value for period 2 is negative. However, allowing "high-ability" micro-entrepreneurs to continue their projects even if the payoff at period 1 was not positive is efficient from a social point of view. Consequently, at date 1, it is socially efficient to refinance projects that succeed at period 1 and projects that failed at period 1 but are run by "high-ability" micro-entrepreneurs.

In order for inefficient situations to emerge we assume that:

$$\left[\theta p + \left(1-\theta\right) p_l\right] R < \left(1-\alpha\right)\left(1+\gamma\right) \tag{4}$$

Equation (4) means that if the MFI is not able to discriminate between the two types of micro-entrepreneurs, project that fail in period 1 will not be financed at period 2 since their net

expected value is negative. This situation is inefficient since projects conducted by "high-ability" micro-entrepreneurs with net expected value for period 2, will be ended at period 1.

Second, we assume that micro-entrepreneurs are better informed than the MFI about the profitability of their projects, and they can divert a part of the cash derived from the MFI. More precisely, micro-entrepreneurs may announce $\tilde{R} = 0, \forall t = 1,2$ in order not to pay back the MFI, whereas the true value of the payoff is $R > 0$. The literature shows that lenders can conduct a costly deterministic audit that will reveal the value of the current payoff.[3] However, because of the specificity of microcredit (low amount, high opacity) we assume that the verification cost is too high to be profitable for the MFI.

These two informational problems are generally addressed in the literature by exploiting the joint liability in group lending, and the dynamics of incentive mobilization in individual lending. In this paper, we assume that in order to alleviate these informational problems, the MFI proposes compulsory and voluntary saving as enforcement and screening mechanisms in individual micro lending contracts. More specifically, the repayment incentive is based on the requirement of compulsory saving, whereas the use of voluntary saving is introduced in order to allow the MFI to discriminate the abilities of loan applicants. We develop these two kinds of contracts in the next two sections.

4. Financial equilibrium contracts with compulsory savings

At present, the repayment incentive for micro-entrepreneurs is based on the requirement of a compulsory saving $\overline{S}_0$, which serves also as a kind of collateral for the MFI. It means that micro-entrepreneurs must save an amount $\overline{S}_0$ prior to signing the lending contract at date 0. We assume micro-entrepreneurs cannot withdraw this amount until they pay back all of their loan at the end of period 2. In this case, they receive the initial amount of their savings plus the riskless interest rate, which means $\left(1+\gamma\right)^2 \overline{S}_0$. However, if the micro-entrepreneur announces $\tilde{R} = 0$ at period 1 and does not reimburse the MFI, the project will not be financed for period 2 and the MFI keeps its compulsory saving for an amount $\left(1+\gamma\right)\overline{S}_0$. Similarly, if the micro-

[3] See e.g. Townsend (1979).

entrepreneur announces $\tilde{R} = 0$ at period 2 and does not reimburse the MFI, he will lose the initial amount of saving plus the riskless interest rate $\left(1+\gamma\right)^2 \overline{S}_0$.

In the following, we focus first on the main incentive conditions required for the MFI to finance micro-entrepreneurs, and for micro-entrepreneurs to undertake a risky project. Second, we design the financial equilibrium contract combining loan and compulsory savings between micro-entrepreneurs and the MFI, and show that such a contract is not the first best equilibrium from the social point of view since some projects with net expected value for period 2 will be ended at period 1.

4.1. Incentive mechanisms

Let us first begin with an incentive for micro-entrepreneurs (with "high" or "low-ability") to announce the true payoff at each period in the case that they have received a loan. We solve for the incentive constraints using backward induction. Recall that $\tilde{R} = 0$ is defined as the micro-entrepreneurôs payoff announcement to the MFI, and that this announcement may be different from the true payoff R.

Assumption 3.

We assume that in the case of cheating (micro-entrepreneur announces $\tilde{R} = 0$ when the true result is R) micro-entrepreneurs may allocate to themselves only a fraction $\left(1-\varepsilon\right) < 1$ of the true result R. Moreover, in order to prevent self-financing by micro-entrepreneurs at period 2, we assume that $R < \dfrac{\left(1-\alpha\right)}{\left(1-\varepsilon\right)}$.

Assumption 3 means that it is costly for the micro-entrepreneur to cheat, and means that the entrepreneur cannot divert the total amount of the payoff from the project in the case of success. Thus, the cost of cheating is measured as the value of ε. In addition, we exclude the case where a cheating micro-entrepreneur can use the residual value of his successful project at period 1 $\left(\left(1-\varepsilon\right)R\right)$ in order to finance the project for period 2 (which requires an amount of $\left(1-\alpha\right)$).

Lemma 1. If $\bar{S}_0 \geq \dfrac{(1+r_2)(1-\alpha)-\varepsilon R}{(1+\gamma)^2}$*, a micro-entrepreneur that succeeded and announced the true payoff* $\tilde{R}=R$ *at period 1 will, if the project succeeds in period 2, also announce the true payoff* $\tilde{R}=R$ *and pay back* $(1+r_2)(1+\alpha)$ *to the MFI* ***y***

The proof of Lemma 1 is as follows. Recall that micro-entrepreneurs must save an amount $\bar{S}_0$ (compulsory saving) prior to obtaining a loan at date $t=0$. This compulsory savings is invested by the MFI at the riskless interest rate $(1+\gamma)$ and reimbursed at the end of period 2 if the micro-entrepreneur has paid back the interest plus the capital of the loan at period 1 $((1+r_1)\alpha)$ and the interest plus the capital of the loan at period 2 $((1+r_2)(1-\alpha))$. Assume that the project of a micro-entrepreneur succeeded in period 1, and the entrepreneur announced the true payoff $(\tilde{R}=R)$ and paid back $(1+r_1)\alpha$ to the MFI, and thus, was financed for period 2. In period 2, if the project succeeds, this micro-entrepreneur has two choices. First, to announce the true payoff $\tilde{R}=R$, reimburse $(1+r_2)(1-\alpha)$ and receive the initial amount of his savings plus interest $(1+\gamma)^2\bar{S}_0$. Second, he cheats and announces the false payoff $\tilde{R}=0$, retains a fraction $(1-\varepsilon)<1$ of the real payoff R, does not reimburse $(1+r_2)(1-\alpha)$, and loses the amount of his savings. The micro-entrepreneur will always announce the true payoff and reimburse the MFI at period 2 if the gain linked to the "true" declaration $\left(R-(1+r_2)(1-\alpha)+(1+\gamma)^2\bar{S}_0\right)$ is higher or equal to the gain linked to cheating $((1-\varepsilon)R)$ or

$$R-(1+r_2)(1-\alpha)+(1+\gamma)^2\bar{S}_0 \geq (1-\varepsilon)R$$

which leads to $\bar{S}_0 \geq \dfrac{(1+r_2)(1-\alpha)-\varepsilon R}{(1+\gamma)^2}$.

According to Lemma 1, a minimum amount $\bar{S}_0$ of compulsory savings creates an incentive for micro-entrepreneurs to announce the true payoff at period 2.[4]

[4] We will show that micro-entrepreneurs would still have an incentive to undertake a risky project at date 0.

Lemma 2. If $\frac{R}{(1+\gamma)} \geq \frac{(1+r_1)\alpha}{p(1-\varepsilon)+\varepsilon(1+\gamma)}$, *a micro-entrepreneur that is financed and succeeds in period 1 declares* $\tilde{R} = R$, *pays back* $(1+r_1)\alpha$ *to the MFI, and is encouraged to continue the project in period 2* ✓

The proof of Lemma 2 is also straightforward. Similar to the previous case (Lemma 1), a micro-entrepreneur that succeeds in period 1 has two choices.

First, to announce the true payoff $\tilde{R} = R$, and reimburse $(1+r_1)\alpha$ to the MFI, which gives rise to a net value equal to $\left(R-(1+r_1)\alpha\right)$. In that case, the micro-entrepreneur is refinanced by the MFI and continues to run the project, giving rise to a net expected value of $\frac{p}{(1+\gamma)}\left(R-(1+r_2)(1-\alpha)+\bar{S}_0(1+\gamma)^2\right)$ at period 2. Note that this value is conditional on the announcement of the true payoff at period 2 in the case of project success. It means that, at date $t=0$, the MFI imposes the minimum incentive value for the compulsory saving $\bar{S}_0 = \frac{(1+r_2)(1-\alpha)-\varepsilon R}{(1+\gamma)^2}$ and

$$\frac{p}{(1+\gamma)}\left(R-(1+r_2)(1-\alpha)+\bar{S}_0(1+\gamma)^2\right) = \frac{p}{(1+\gamma)}R(1-\varepsilon)$$

Thus, the net expected value at period 1 of the "true" declaration is given by:

$$\left(R-(1+r_1)\alpha\right)+\frac{p}{(1+\gamma)}R(1-\varepsilon) \tag{5}$$

Second, if the micro-entrepreneur cheats and announces the payoff $\tilde{R}=0$, he retains a fraction $(1-\varepsilon)$ of the total payoff R for himself, does not reimburse $(1+r_1)\alpha$, loses the amount of his savings, and cannot continue the project for period 2. The net value of this action is given by $(1-\varepsilon)R$. Consequently, the micro-entrepreneur will always tend to announce the true payoff and reimburse the MFI at period 1 if

$$\left(R-\left(1+r_1\right)\alpha\right)+\frac{p}{\left(1+\gamma\right)}R\left(1-\varepsilon\right)\geq\left(1-\varepsilon\right)R \text{ or}$$

$$\frac{R}{\left(1+\gamma\right)}\geq\frac{\left(1+r_1\right)\alpha}{p\left(1-\varepsilon\right)+\varepsilon\left(1+\gamma\right)}$$

According to Lemma 2, in order to prevent micro-entrepreneurs from cheating at period 1, the risky projects must generate a sufficient net expected return.

Finally, we must find the condition under which a micro-entrepreneur, no matter the level of his ability, would still have an incentive to undertake a risky project at time 0.

Lemma 3. If $R\geq\frac{\left(1+r_2\right)\left(1+\alpha\right)+p\left(1+\gamma\right)\left(1+r_1\right)\alpha}{\varepsilon+p\left[\left(1+\gamma\right)+p\left(1-\varepsilon\right)\right]}$, *micro-entrepreneurs will still have an incentive to undertake a risky project at time 0* ✓

At time 0, micro-entrepreneurs may decide to do nothing, and the net expected value of this choice is equal to 0.[5] The micro-entrepreneur might also decide to undertake a risky project and borrow from the MFI. In that case, he must provide an amount of compulsory saving of $\bar{S}_0$ (which is a measure of the opportunity cost of the loan in terms of present consumption), whereas the net expected value of this choice is given by

$$\frac{p}{\left(1+\gamma\right)}\left[R-\left(1+r_1\right)\alpha\right]+\left(\frac{p}{\left(1+\gamma\right)}\right)^2\left[R-\left(1+r_2\right)\left(1-\alpha\right)+\bar{S}_0\left(1+\gamma\right)^2\right] \tag{6}$$

Taking account of the fact that according to Lemma 1 we have $\bar{S}_0=\frac{\left(1+r_2\right)\left(1-\alpha\right)-\varepsilon R}{\left(1+\gamma\right)^2}$, a micro-entrepreneur decides to undertake a risky project if

[5] For simplicity we assume that there is no payroll employment for "non-active" micro-entrepreneurs. The introduction of a payroll does not change the reasoning.

$$R \geq \frac{\left(1+r_2\right)\left(1+\alpha\right)+p\left(1+\gamma\right)\left(1+r_1\right)\alpha}{\varepsilon+p\left[\left(1+\gamma\right)+p\left(1-\varepsilon\right)\right]}$$

According to Lemma 3, in order to encourage micro-entrepreneurs to ask for a loan and undertake a risky project at period 0, this project must generate a sufficient payoff compared to the expected value of the reimbursement of the loan and the incentive to cheat.

It is now possible to design a financial equilibrium contract between the micro-entrepreneur and the MFI that combines loan and compulsory saving. We show that such a contract with compulsory savings only, is sub-optimal for the whole economy since it prevents "high-ability" micro-entrepreneurs from continuing their activity in the case of project failure at period 1, even if their project still has a net present value for the economy at period 2.

4.2. Financial equilibrium contracts with compulsory savings

We assume that the MFI objective is to maximize micro-entrepreneursô access to micro-credit, since all projects have a positive net expected value at date 0. Since the MFI must also ensure its financial equilibrium, we assume that it behaves competitively and fixes r_1 and r_2 according to a nonprofit condition. The equilibrium contract between micro-entrepreneurs and the MFI must fulfill the conditions stated in Lemma 1 to 3, and the non-profit conditions of the MFI for periods 1 and 2.

The MFI's gross expected profit for period 1 is equal to $\pi_1 = p\left(1+r_1\right)\alpha + \left(1-p\right)\overline{S}_0\left(1+\gamma\right)$, where the first part of the equation represents the MFIôs expected revenue in the case of project success (and assuming that micro-entrepreneurs pay back the MFI), and the second part represents the MFIôs expected revenue in the case of project failure (the MFI will retain the level of compulsory saving that is deposited by defaulting micro-entrepreneurs).

The MFI's gross expected profit for period 2 is equal to $p\left(1+r_2\right)\left(1-\alpha\right)+\left(1-p\right)\overline{S}_0\left(1+\gamma\right)^2$ where the first part of the equation still represents the MFIôs expected revenue in the case of

project success, and the second part represents the MFIôs expected revenue in the case of project failure.[6]

Consequently, non-profit conditions for period 1 and 2 are respectively equal to:

$$p\left(1+r_1\right)\alpha+\left(1-p\right)\overline{S}_0\left(1+\gamma\right)=\left(1+\gamma\right)\alpha \tag{7}$$

$$p\left(1+r_2\right)\left(1-\alpha\right)+\left(1-p\right)\overline{S}_0\left(1+\gamma\right)^2=\left(1+\gamma\right)\left(1-\alpha\right) \tag{8}$$

where $\left(1+\gamma\right)\alpha$ and $\left(1+\gamma\right)\left(1-\alpha\right)$ respectively measure the cost of capital for the MFI at periods 1 and 2.

Proposition 1 gives the main characteristic of the equilibrium contract of financing with compulsory saving.

PROPOSITION 1. *Given the conditions exposed in Lemma 1 to 3, and assuming the following parameter restrictions:* $\varepsilon<\frac{\left(1+\gamma\right)}{pR};1>\alpha>\frac{1}{\left(1+\gamma\right)+1}\left[1-\frac{p\varepsilon R}{\left(1+\gamma\right)}\right]>0$ *, there is an equilibrium contract* $\left[\overline{S}_0^*,\left(1+r_1^*\right),\left(1+r_2^*\right)\right]$ *between micro-entrepreneurs and the MFI with:*

$\overline{S}_0^*=\frac{\left(1-\alpha\right)}{\left(1+\gamma\right)}-\frac{p\varepsilon R}{\left(1+\gamma\right)^2}\leq\alpha,\qquad\left(1+r_1^*\right)=\frac{\left(1+\gamma\right)}{p}-\frac{\left(1-p\right)}{p\alpha}\left[\left(1-\alpha\right)-\frac{p\varepsilon R}{\left(1+\gamma\right)}\right]\geq 1$ *and*

$\left(1+r_2^*\right)=\left(1+\gamma\right)+\frac{\varepsilon R\left(1-p\right)}{\left(1-\alpha\right)}\geq 1$

Such that:

a. All micro-entrepreneurs ask for a loan at date 0 and are financed;

b. Projects that give rise to a positive payoff at period 1 are refinanced at date 1 for period 2;

[6] Recall that only successful projects at period 1 are financed in period 2, and that the probability of success of such projects is equal to p.

c. Projects that fail to generate a positive payoff at period 1 are not refinanced at date 1 for period 2;

d. Micro-entrepreneurs that succeed at period 1 have an incentive to continue their project and ask for a loan at period 2;

e. The MFI is at equilibrium and fulfills the nonprofit condition. y

Proof: see appendix A.

Proposition 1 states that compulsory savings can create the incentive condition required to allow all micro-entrepreneurs to be financed by the MFI at period 1. Moreover, this equilibrium contract maximizes the net expected payoff of micro-entrepreneurs since the MFI has received the minimum payoffs $\left(\left(1+r_1^*\right),\left(1+r_2^*\right)\right)$ to ensure financial equilibrium and the realization of the incentive conditions for micro-entrepreneurs. Nevertheless, this equilibrium contract does not solve the *ex-ante* informational problem faced by the MFI. Hence, identifying "high" and "low-ability" micro-entrepreneurs still remains a challenge for the MFI. Consequently, it is always optimal for the MFI not to refinance a project that fails to generate a positive payoff at period 1. It is possible to show that such a situation is not optimal from a social perspective.

PROPOSITION 2. *The equilibrium contract* $\left[\overline{S}_0^*,\left(1+r_1^*\right),\left(1+r_2^*\right)\right]$ *is socially sub-optimal since a fraction* $\theta\left(1-p\right)$ *of projects fail at period 1 and are not refinanced for period 2 even if their social value is positive for period 2. The social value of the net expected loss is equal to* $\theta\left(1-p\right)\left(pR-\left(1+\gamma\right)\right)>0$ y

Proof of Proposition 2 is obvious since there is a proportion θ of "high-ability" micro-entrepreneurs that is financed in the initial period and that fails to reimburse $\left(1+r_1^*\right)$ at period 1 with a probability $\left(1-p\right)$. According to proposition 1.c, these micro-entrepreneursô projects are not refinanced by the MFI at period 2 even if their social value is positive. Consequently, there is a net expected loss of $\theta\left(1-p\right)\left(pR-\left(1+\gamma\right)\right)>0$ to the whole society.

Propositions 1 and 2 allow us to derive two main results. Firstly, an equilibrium contract with joint loan and compulsory saving provides equal access to all types of loan applicants ("low"

and "high" ability micro-entrepreneurs). This contract is based on compulsory saving as an equilibrium solution for the lender to induce repayment by the borrower when allocating the loan. This equilibrium contract also maximizes, at date 0, the number of financed projects emphasizing the social outreach of micro lending. Secondly, we show that this kind of contract is sub-optimal, since it cannot prevent the MFI from not refinancing an efficient project at date 1. Consequently, we need to ask: What kind of mechanism could be put in place to help to discriminate borrowersô abilities and ensure continued financing of "promising" projects? We demonstrate further that in order to reestablish optimality we can introduce voluntary savings to incentivize "high-ability" micro-entrepreneurs to declare their abilities. These more complete lending contracts that include voluntary saving need an adjustment to the interest rate in order to create a positive social value and relieve "high-ability" micro-entrepreneurs from the burden of "low-ability" borrowers.

5. Financial equilibrium contracts with compulsory and voluntary savings

We now consider equilibrium contracts with compulsory and voluntary savings. We assume that the MFI offers two different contracts to micro-entrepreneurs: one with compulsory saving only (hereafter CSC for Compulsory Savings Contract) and one with compulsory and voluntary savings (hereafter VSC for Voluntary Savings Contract). We build on arguments that favor a *separating contract*, which typically is considered the optimal contract (Rothschild and Stiglitz, 1976). In the separating contract the principal offers different contracts to different types of agents and each type finds it optimal to choose the contract that has been predesigned for its risk type.

An important question which arises when considering the different characteristics of voluntary and compulsory savings, is: ñCan the institution mobilize compulsory and voluntary saving simultaneously?ò Hirschland (2005, p.146) argues that many MFIs, especially credit unions, mobilize large volumes of voluntary as well as mandatory deposits. In fact, those institutions allow clients to make a voluntary deposit along with ï and into the same account as ï their mandatory minimum (for instance, ASA and VYCCU). For example, in Guinea, the Yete-Mail cooperativeôs required collateral saving represents just 5 percent of total deposits, and the rest is voluntary. Another well-known example is the practice of the Grameen II Pension funds. Among the new collection of products that have replaced the classic version of Grameen, in all its branches, the new savings products are the most popular in Grameen II. As Stuart Rutherford (in Hirschland, 2005, p.143) shows, members like the new weekly savings, which accepts

voluntary in addition to compulsory deposits, and allows almost unlimited withdrawals on demand.

In fact, many different saving mechanisms have evolved directly in the field. First, we retain compulsory savings as the integral part of the credit which is required as part of the loan terms. Second, following the literature on the savings services for the poor (Glisovic, El-Zoghbi, and Forster, 2010; Hirschland, 2005), we define voluntary savings as a time/certificate deposit, practiced in particular by regulated MFIs such as credit unions or savings banks. This saving service allows micro-entrepreneurs to decide on voluntary basis to make a single deposit that cannot be withdrawn for a specific period of time. At the appointed time, the micro-entrepreneur can withdraw the saved amount.

5.1. Structure of the contracts

The two contracts (CSC and VSC) have the following characteristics. The nature of the contract with compulsory savings is similar to the one previously described. Thus, if a micro-entrepreneur chooses a CSC, he must provide an amount $\overline{S}_0$ of compulsory savings in order to be financed at period 0 and he will be liquidated if he fails to reimburse the MFI at period 1. However, if the micro-entrepreneur pays back at period 1, he can continue the project for period 2. At that period, he pays back the MFI in the case of success or loses the amount of his compulsory savings.

If the micro-entrepreneur chooses a VSC, he must provide an amount $\overline{S}_0 + S_v$ of savings composed respectively of compulsory and voluntary savings, in order to be financed at period 0. If the project succeeds in period 1, the micro-entrepreneur withdraws the voluntary part of his savings plus interest, and continues the project in period 2. However, in the case that the micro-entrepreneur does not pay back the MFI at period 1 (project failure), the MFI will retain the voluntary part of his savings (S_v) at that period but the micro-entrepreneur can continue the project in period 2. At that period, he pays back to the MFI in case of success, or loses the amount of his compulsory savings. Consequently, the voluntary savings contract allows micro-entrepreneurs to pursue their activities even in the case of failure at period 1.

On the one hand, regardless of the nature of the contract (CSC or VSC), the compulsory part of the savings is used by the MFI in order to encourage micro-entrepreneurs to reimburse their loans plus interest at the end of period 2, and the conditions stated in Lemma 1 still hold.
On the other hand, in order to discriminate, contracts should be designed in such a way that CSC will be chosen by "low-ability" micro-entrepreneurs (whose projects have a negative expected value for period 2 if they fail at period 1), whereas VSC will be chosen by "high-ability" micro-entrepreneurs (whose projects have a positive expected value for period 2 even if they fail at period 1). Lemma 3 provides the condition for the amount of voluntary saving that allows such discrimination.

Lemma 4. If $p_l \frac{(1-\varepsilon)R}{(1+\gamma)^2} < S_v < p\frac{(1-\varepsilon)R}{(1+\gamma)^2}$*, at period 0 "high-ability" micro-entrepreneurs will choose VSC and "low-ability" micro-entrepreneurs will choose CSC contract.*

Proof of Lemma 4, see appendix B.

Finally, as the CSC is similar to the previously described contract, the incentive to repay the MFI at period 1 does not change for "low-ability" micro-entrepreneurs who choose such a contract, and the conditions set in Lemma 2 and Lemma 3 still hold. However, we have to define a new condition in order to give an incentive for "high-ability" micro-entrepreneurs, who chose VSC, to reimburse the MFI at period 1 in case of success.

Lemma 5. If $S_v \geq \frac{(1+r_1)\alpha - \varepsilon R}{(1+\gamma)}$*, a "high-ability" micro-entrepreneur that is financed via a VSC and succeeds in period 1 declares* $\tilde{R} = R$*, pays back* $(1+r_1)\alpha$ *to the MFI and he is encouraged to continue the project in period 2.*

Proof of Lemma 5, see appendix C.

In the last part of the paper, we define the optimal design of financial equilibrium contracts between micro-entrepreneurs and the MFI combining loan, and compulsory and voluntary savings. We show that there is a separating equilibrium which leads to an optimal situation for

the whole economy: all projects with positive expected present value for period 2 are refinanced at period 1.

5.2. Financial equilibrium with compulsory and voluntary savings contracts

As already shown, we assume that the objective of the MFI is to maximize micro-entrepreneursô access to microcredit, and that the MFI behaves competitively and fixes the various interest rates according to a non-profit condition. Proposition 3 gives the main characteristic of the two equilibrium contracts between micro-entrepreneurs and the MFI.

PROPOSITION 3. *Given the conditions exposed in Lemma 1 to 5, and assuming the following parameter restrictions:*

$$\frac{(1-\alpha)(1+\gamma)}{R(2+\gamma)} < \varepsilon < \frac{(1+\gamma)}{pR} < 1\,;\, 1 > \alpha > \frac{1}{(1+\gamma)+1}\left[1-\frac{p\varepsilon R}{(1+\gamma)}\right] > 0$$

; $p > \dfrac{(1-\alpha)(1+\gamma)}{\varepsilon R(2+\gamma)}$ *,* $p_l < \dfrac{(1+\gamma)\left[\alpha(1+\gamma)-p\varepsilon R\right]}{(1-\varepsilon)R} > 0$ *; there is a separating equilibrium contract between micro-entrepreneurs and the MFI.*

1. Low ability entrepreneurs will choose a CSC, $\left[\bar{S}_0^*,(1+r_1^*),(1+r_2^*)\right]$ *with:*

$$\bar{S}_0^* = \frac{(1-\alpha)}{(1+\gamma)} - \frac{p\varepsilon R}{(1+\gamma)^2} \le \alpha, \qquad (1+r_1^*) = \frac{(1+\gamma)}{p} - \frac{(1-p)}{p\alpha}\left[(1-\alpha)-\frac{p\varepsilon R}{(1+\gamma)}\right] \ge 1 \qquad \textit{and}$$

$$(1+r_2^*) = (1+\gamma) + \frac{\varepsilon R(1-p)}{(1-\alpha)} \ge 1$$

2. High ability entrepreneurs will choose a VSC, $\left[\bar{S}_0^*,S_v^*,(1+r_1^*),(1+r_2^*)\right]$ *with*

$$\bar{S}_0^* = \frac{(1-\alpha)}{(1+\gamma)} - \frac{p\varepsilon R}{(1+\gamma)^2},\ S_v^* = \alpha - \frac{p\varepsilon R}{(1+\gamma)},\ (1+r_1^*) = (1+\gamma) + \frac{(1-p)\varepsilon R}{\alpha} \ge 1,$$

$$(1+r_2^*) = (1+\gamma) + \frac{\varepsilon R(1-p)}{(1-\alpha)} \ge 1 \ \textit{and}\ \bar{S}_0^* + S_v^* < \alpha\,.$$

Such that:

a. All micro-entrepreneurs ask for a loan at date 0 and are financed;

b. Projects run by "low-ability" micro-entrepreneurs, which engender a positive payoff at period 1, are refinanced at date 1 for period 2;

c. Projects run by "low-ability" micro-entrepreneurs, which fail to generate a positive payoff at period 1, are not refinanced at date 1 for period 2;

d. "Low-ability" micro-entrepreneurs that succeed at period 1 have an incentive to continue their project and ask for loan at period 2;

e. Projects run by "high-ability" micro-entrepreneurs are refinanced at date 1 for period 2 whatever their payoff at period 1;

f. "High-ability" micro-entrepreneurs always have an incentive to continue their project and ask for loan at period 2.

g. The MFI is at equilibrium and fulfills the nonprofit condition for each contract. ɣ

Proof: appendix D.

On the one hand, in such a separating equilibrium "high-ability" micro-entrepreneurs will choose the VSC. They are encouraged to repay the MFI in the case of project success, and are always financed in period 2, even in case of failure at period 1 (in that case, the MFI just keeps the voluntary part of the saving at the end of period 1). Consequently, projects undertaken by "high-ability" micro-entrepreneurs, with a positive net expected value at periods 1 and 2, are always financed for the second period. Note that, since the MFI can discriminate between micro-entrepreneurs, this equilibrium contract is less costly for "high-ability" micro-entrepreneurs than the equilibrium contract with compulsory savings only.

On the other hand, "low-ability" micro-entrepreneurs will choose the CSC. If they fail to repay the MFI at period 1, they are not financed for period 2. However, if their projects succeed in period 1, they are financed for period 2 and reimburse the MFI at period 2 in the case of project success. In all cases, the MFI will keep the compulsory part of the project in case of failure at period 2.

Consequently, one of the main result of proposition 3 is that a separating equilibrium increases the welfare of "high-ability" micro-entrepreneurs (the value of the interest rate they will pay at period 1 is lower than in the previous situation) without impairing the welfare of "low-ability" micro-entrepreneurs (the nature of their contract with the MFI remains unchanged).

Finally, note that the VSC enables MFIs to discriminate types of micro-entrepreneurs, and consequently, "high-ability" micro-entrepreneursô projects with positive net expected value at period 1 for period 2 are no longer liquidated. Hence, these new contracts solve the inefficiency of the incentive mechanisms offered in contracts with compulsory savings only. The reason for that inefficiency is explained by the fact that in the case of repayment default at period 1 the projects of "high-ability" micro-entrepreneurs which potentially could have a profitable outcome, are not financed for period 2. Thus, the results of this section show that the new agreements based on both compulsory and voluntary microsavings go hand in hand with the dual mission of MFIs. Firstly, the poor are provided with equal access to financial intermediation, and secondly and more importantly, the social value of lending from the perspective of the entire society is increased.

6. Empirical model

In our theoretical model we show that voluntary savings, on top of compulsory savings, create incentives for micro-entrepreneurs (MFI clients, borrowers) to disclose their type (low versus high ability). *Low ability borrowers opt only for compulsory savings and high ability borrowers opt for both compulsory and voluntary savings, when borrowing funds from an MFI with stochastic outcomes.* We claim that high ability borrowers, those who failed their projects in the first period, are able to get additional funding by MFI if only they hold voluntary savings, in addition to compulsory. *While compulsory savings governs incentives for debt repayment, voluntary savings help high ability borrowers to disclose their type so that MFIs differentiate them from low ability borrowers.*

This is the outcome of the equilibrium contract, when an MFI maximizes the number of borrowers. The empirical model aims to capture the impact of voluntary savings on number of clients in a dynamic panel framework. The generic form of the model is:

$$y_{it} = \alpha_i + \beta y_{i,t-1} + \gamma_1 x_{it} + \gamma_2 z_{it} + \gamma_3 w_{it} + \gamma_4 v_{it} + \gamma_5 \varepsilon_{it},$$

where y_{it} is the number of clients of the i-th MFI, z_{it} the proportion of clients in MFI holding voluntary saving, x_{it} is the vector of predetermined variables (other than number of clients), w_{it} is the vector of strictly exogenous variables, α_i is the fixed effect and ε_{it} is the error term. For technical reasons, we take the natural logarithm of total number of clients. We discuss this point later. The impact of voluntary saving on total number clients is captured by γ_2. The

indicator capturing the impact of voluntary saving is endogenous, and explained by MFI specific (internal factors) and institutional variables (external factors). In order to be safe from the reverse causality, we take all relevant MFI specific variables with lag. Instead, variables capturing intuitional (financial) development are strictly exogenous by nature and values at time t are included in the model. That is, the vector X involves MFI specific variables, while Z involves country level variables.

The vector of MFI controls includes specific MFI characteristics such as capital structure, organization age, size, number of branch offices, risk characteristics and efficiency measures.

In microfinance studies the elements of the capital structure are captured by capital-to-asset, debt-to-asset or debt-to-equity ratios. In our dataset, debt-to-equity ratio is available and we use it to assess the impact of capital structure on the number of clients. However, it shows insignificant effect in our model.

Asset quality and risk taking are controlled for with the standard measure of nonperforming loan (NPL) ratio of loans overdue more than thirty days (PAR30). Lower asset quality (e.g., higher NPL ratio) requires more resources to manage the higher risk (Hartarska, Nadolnyak, and Shen 2012) and makes the MFI outreach harder.

In our model this credit risk measure is significant, and it enters the model with one (year) lag, which is the adjustment period, needed for the causal impact from the change of the credit risk and the upgraded credit policy.

Controlling for the firm size is important, as the increase of the number of clients is expected to lead a larger volume of loans or assets. In order to retrieve the net impact of the voluntary savings on the on the pool of clients, we should control for the change in the size of the MFI.

The empirical evidence shows that larger MFIs have cost savings due to the advantages driven by potential economies of scale and scope between deposits and loans (Hartarska, Shen, and Mersland 2013).We take the logarithm of total assets, another endogenous variable in the model (the first one ratio of the number of clients with voluntary savings to the total number, the main variable of interest).

Other variables indicating MFI characteristics such as age, legal status and number of branch offices are included in our estimation. However, all of them are insignificant in our model. The reason is that we estimate a fixed effect dynamic panel model, in which all time invariant characteristics, MFI-, country- and regional levels, are embedded into fixed effects.

Efficiency measures of MFI can refer to productivity or cost efficiency. To capture productivity, we use personnel productivity (pers_prod), the number of credit clients per employee in the

MFI.[7] Alternatively, we can use Loan officer productivity (Credoff_prod), the number of credit clients per loan officer in the MFI.

For cost efficiency measures, we may use personnel costs ratio related to total assets (erscost_assets), operating expense ratio related to portfolio (operexp_portf), operating expense ratio related to assets (operexp_assets), cost of funds ratio (cost_bor_funds). Out of the rich list of variables, we are constraint to choose one efficiency related variable, which is operating expense ratio related to portfolio, which is most significant, though fails to be even marginally significant. The main costs of the loan granting activity of MFIs include the financial costs of accessing funds, the fixed costs of supporting the MFI and the administrative costs of maintaining a relationship with borrowers for the provision of loans and other services. Given the loan methodologies in microfinance, the relationship with borrowers (including the gathering of information, the monitoring of borrowers or the collection of late payments) is the main component of the cost structure, occupying the bulk of the staff time and cost. As highlighted by Hudon and Traca (2011), in theory, this cost should depend on the actual number of borrowers, the numbers of loans provided to each, and the value of each loan. However, experience from microfinance organizations suggests that once a relationship with a client is established, the marginal costs of providing additional or larger loans amount only to the financial cost of the funds lent, while the marginal administrative cost is small. Hence, we find the productivity variable defined in terms of the number of borrowers per loan officer as a suitable measure that captures MFI efficiency. Moreover, given the importance of client relationships for MFI efficiency, we would expect more efficient MFIs to have larger number of borrower.

The second group of independent variables represented by the vector of Z variables includes country-level macroeconomic indicators. We look at a countryôs GDP or GNI per capita and, inflation and foreign exchange rate. For instance, GDP per capita could affect borrowersô purchasing power and be associated with their risk of default. However, in our estimation and for this sample of MFIs neither of the specified macroeconomic indicators are significant. Thus, we remove them from the final specification.

We estimate our dynamic model by System GMM (Blundell and Bond, 1998), where covariates in the right side generate a large collection of instruments making the estimation output

[7] As argued by Christen (2000), measuring efficiency using resources per borrower has the additional benefit of neutralizing the effect of loan size. The alternative of using the cost per dollar of loan, institutions serving the low-end market are likely to be, on average, more efficient than broad and high-end programs.

sensitive to the number of covariates. For this reason, we abstain from keeping variables in the model, which are potentially interesting, but turn to be insignificant.

Our dynamic panel model utilizes moment conditions using lagged differences of endogenous variables, in addition to the moments in Difference GMM (Arellano and Bond, 1991).[8] System GMM generate numerous instruments and easily overfit the endogenous variable(s) resulting in the coefficient bias (see e.g. Rodman 2009). Windmeijer (2005) shows that reducing the number of instruments more than twice, from 28 to 13, the bias decreases by 40 percent. Also, the bias rises when using instruments in deeper lags (Tauchen, 1986; Ziliak, 1997). For this reason, we limit number of instruments in two ways. First, we collapse the matrix is instruments into one column for the lagged dependent variable and the endogenous variable of the main interest (the ratio of number of voluntary savers and total clients). Second, we put lag limit for all collapsed instruments to 6. Collapsing the instrument matrices reduces the number of instruments down to 144. The lag limit for non-collapsed instruments, constructed from pre-determined variables, is taken 3, in order to have a control on the total number of instruments. We apply Windmeijer (2005) finite-sample correction to the reported standard errors in the two-step estimation. Windmeijer (2005) finite-sample correction is needed to account for the downward bias in standard errors in the two step estimator, the latter being asymptotically efficient and robust to any form of heteroskedasticity and cross-correlation. The estimated covariance of the two-step estimator, however, is sensitive to a small sample size and may result in the singular form of the covariance matrix. Generalized inverse is still feasible and as long as the number of instruments falls short from the number of groups (N, microfinance enterprises in our case). In our model, N=344 and we ensure that the number of instruments are less than N through the choice of lag limits and collapsing matrices of instruments. In our case, the estimated two-step covariance matrix is singular, unless we collapse all matrices of instruments, which yields insignificant results, suggesting that the number of instruments is too small. We estimate the same specification with one-step, in which case finite sample correction is not needed (second column in Table 2). Both the magnitudes and the significance of coefficients remain stable.

The P-value of Hansen J test (overidentification) is in the acceptable range for dynamic panel models not to reject the null hypothesis that instruments are orthogonal to errors. Difference in

[8] Additional moments proposed by Blundell and Bond (1998) require certain stationarity conditions of the initial observation, as suggested by Arellano and Bover (1995). These conditions are embedded in these additional moment conditions (Rodman, 2009), making System GMM estimator perform better than Difference GMM in terms of bias and the root mean squared error (Blundell and Bond, 1998; Blundell, Bond and Windmeijer, 2000).

Hansen test for levels, as already mentioned, are also in the non-rejection region for all instrumented variables. There is no second order autocorrelation, which allows to use instruments in the second lag for differenced equations.

6.1. Data

Our dataset includes MFIs from different regions for the period of 1999-2014.

Summary statistics are presented in Table 1. It shows

Table1. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
tot_clients	1357	24793.63	49042.95	92	813210
log_tot_cl	1357	9.159702	1.431269	4.521789	13.60874
TotLoans	1357	1.13E+07	2.21E+07	30353	2.65E+08
log_tot_lo~s	1357	15.27854	1.396499	10.32065	19.3939
sav_clients	1357	8731.779	40243.84	0	813210
ratio_sav_~1	1357	0.164801	0.361481	0	1
operexp_po~f	1354	0.28436	0.209734	0.0293	2.95
par30	1355	0.052962	0.076668	0	0.973

6.2. Estimation results

In Table 2, we report estimation output from 4 models, which differ from each other in certain aspect. We estimate the benchmark model by System GMM (Model 1), in which the proportion of voluntary savers and (the log of) the volume of loans enters with a contemporaneous lag, as endogenous variables. Operating expenses-to-loan portfolio ratio and the credit risk measure (PAR 30) enter with a lag, presuming that some time is needed until these variables affect the client size. From the benchmark model, we learn that 1 percent increase in the proportion of voluntary savers leads to 0.356 percent increase in the number of total clients. The response of the client size to the change in the proportion of voluntary savers is fairly high. This is strong evidence supporting the main theoretical result of the paper. Interestingly, the impact is large and significant within the same time period, relative to the lagged impact (Model 3). The lagged ratio has still a positive impact, but it suffers in significance (P-value is 0.17).

As for the other variables, the impact directions are with expectations. Loan volume elasticity of the client size is given by the coefficient, 0.208, which is around 70 percent of the voluntary savers proportion elasticity (0.356). This overemphasizes the importance of the voluntary

savings in reaching out more clients, rather than reaching them with the purpose of allocating larger volumes of loans.

An increase in operating expenses ratio leads to an increase in number of clients with elasticity 0.163, though the magnitude is not significant. Still, the P-value is high enough, 0.191, to keep the efficiency measure in the regression. The credit risk elasticity of the client size is the highest in the absolute value, 1.033 in the benchmark model. The interpretation is that if in the current year, the proportion of outstanding loans increase by 1 percent, it leads to a decrease in the client pool in the next year by 1.033 percent. Elasticity remains fairly high in Model 2 and Model 3. The current client size is explained by its previous year value by the factor 0.675, which is not high and suggests that much of the current variation is explained by endogenous and predetermined variables.

In Model 2, we estimate the same specification as in Model 1, but apply to one-step GMM estimator. The reason is technical and discussed below. The good news is that results are preserved in a qualitative sense. In Model 3, we use the lagged value of the main variable of interest and the coefficient is insignificant (briefly discussed above). Finally, we estimate the model with Difference GMM, and we do not obtain significant coefficient for endogenous variables. System GMM brings additional set of instrument to the model and in our case it makes difference. Difference-Hansen tests for levels confirm that moment conditions for levels do a good job and justify the use of System GMM.

Table 2. Results of GMM Regression of Savings on Number of Clients

	Model 1	Model 2	Model 3	Model 4
VARIABLES	(System GMM)	(System GMM, one-step)	(System GMM, Ratio lagged	(Difference GMM)
Lagged log of Total clients	0.675***	0.704***	0.791***	0.215***
	(0.0803)	(0.0744)	(0.0844)	(0.0620)
Proportion of voluntary savers	0.356**	0.361**		0.166
	(0.148)	(0.141)		(0.721)
Lagged proportion of voluntary savers			0.221	
			(0.161)	
Log of Total loans	0.208***	0.186***	0.125**	0.503***
	(0.0529)	(0.0505)	(0.0632)	(0.0840)
Lagged ratio of Operating expenses to loan portfolio	0.163	0.131	0.119	0.0286
	(0.125)	(0.0981)	(0.108)	(0.0297)
PAR30	-1.033***	-0.878***	-1.006***	-0.494**

	(0.282)	(0.309)	(0.295)	(0.233)
P-value of Hansen J test	0.236	0.231	0.306	0.266
Observations	1,357	1,357	1,346	978
Number of ID	344	344	344	312

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

7. Concluding remarks

The evolution of microfinance has led to the emergence of novel lending methods for poor households and small-scale entrepreneurs. The usual incentive mechanisms are mainly expressed by the joint liability in group lending, progressive lending, and regular repayment schedules in individual lending contracts. In both practice and academic writing, saving is attracting increased interest in relation to microfinance programs, and is becoming a significant pillar of MFIsô service portfolios (Collins et al., 2009; Dowla and Alamgir, 2003; MaRtin, Hulme, and Rutherford, 2002). The acknowledged success of informal ROSCAs and commitment savings products in developing countries is signaling the importance of commitment mechanisms for overcoming time inconsistencies and problems of self-control (Gugerty, 2007; Ambec and Treich, 2007). This study suggests a more complete incentive mechanism based on coupled lending contracts that include compulsory and voluntary saving.

Our model shows that the introduction of voluntary savings in the incentive mechanism identifies borrowers' abilities, and addresses the screening problems in microfinance programs. Voluntary saving allows borrowers the possibility of revealing the potential of their projects and allows them to continue the project even if they have not paid at the end of the first period. The advantage of our model is that it gives all borrowers an equal chance of obtaining a loan once they have agreed to compulsory saving in the initial stage. This serves as high certainty about the enforceability of repayments. The disadvantage of our model is that it brings this mechanism closer to those employed in traditional bank loans, which require collateral. Also, the model does not allow MFIs to control for the probability of project success.

On the top of our theoretical model we design a dynamic panel model to capture the impact of voluntary savings on number of clients. It is based on moment conditions using lagged differences of endogenous variables, in addition to the moments in Difference GMM. Our results show that the number of clients is positively and significantly associated with voluntary savings.

Related to this is the question of what can be considered the optimal microlending contract? For instance, how can the borrower be induced to reveal its ability after the first installment has or has not been paid? Our model shows shown that an equilibrium contract is feasible if borrowers are required to invest compulsory savings in order to access their loan. As mentioned above, this guarantee is not optimal since it does not allow discrimination among borrowersô abilities. We have shown that voluntary savings can fill this gap, and together with compulsory savings, can serve as an effective approach for MFIs to deal with the issues of adverse selection and moral hazard.

By acknowledging certain limits of requiring savings, we argue that the model raises several questions such as how to cope with national regulation, provision of both convenience and security, identification of profitable reinvestment opportunities, etc. (Morduch, 1999b).
To conclude, theoretical work on individual lending incentive mechanisms to which this paper contributes, proposes many different ways in which those mechanisms can enable MFIs to solve enforcement and screening issues. Researchers are increasingly interested in exploring savings as dynamic incentives. However, empirical work testing the effect of specific instruments, combining compulsory and voluntary savings in a microlending contract, has lagged behind theoretical work on the topic. Apart from pure academic interest, empirical evidence could help us to understand the significance of and necessity of using savings to develop enhanced incentive mechanisms to help to achieve the promise of microfinance programs. An interesting implication of our model is that by employing both compulsory and voluntary savings as an incentive mechanism, MFIs could generate positive social value even when carrying out projects that do not initially perform to a sufficient level.

Future research should investigate to what type of MFI ownership structure such enforcement and screening mechanisms would best contribute. Since our model is outside the framework of credit-only programs, further research could collect more data to allow a careful quantification of the roles of these two types of savings in risk and liquidity management and MFIsô internal control mechanisms.

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APPENDIX

Appendix A. Proof of Proposition 1

Parts a., b. c. and d. of proposition 1 are obvious.

Concerning part a. of Proposition 1, recall that given the incentive conditions stated in Lemma 1 to 3, all micro-entrepreneurs decide to ask for a microcredit at date 0 and are financed by the MFI since their projects have a positive net expected value for period 1.

Concerning part b. of Proposition 1, according to assumption 2.a, all successful projects in period 1 have a positive net expected value for period 2. Consequently, based on the incentive conditions stated in Lemma 1 to 3, these projects are financed by the MFI at date 1 for period 2.

Concerning part c. of Proposition 1, according to assumption 2.b, all projects that fail in period 1 that are conducted by "low-ability" micro-entrepreneurs have a negative net expected value for period 2. Since the MFI is not capable of discriminating between "high" and "low" ability micro-entrepreneurs, the net expected value for period 2 of a failing project at period 1 is given by $\left[\theta p + \left(1-\theta\right) p_l\right] R < \left(1-\alpha\right)\left(1+\gamma\right)$. Consequently, projects that fail in period 1 will not be financed at period 2, since their net expected values are negative.

Concerning part d. of Proposition 1, given the condition stated in Lemma 2, a micro-entrepreneur that is financed and succeeds in period 1, always repays its loan to the MFI and is encouraged to continue his project in period 2.

Proof of part e.

Considering the conditions stated in Lemma 1 to 3, the MFI will choose $\left(1+r_1\right)$ and $\left(1+r_2\right)$ in order to ensure its financial equilibrium (nonprofit condition) and

$$p\left(1+r_1\right)\alpha + \left(1-p\right)\bar{S}_0\left(1+\gamma\right) = \left(1+\gamma\right)\alpha \tag{7}$$

$$p\left(1+r_2\right)\left(1-\alpha\right) + \left(1-p\right)\bar{S}_0\left(1+\gamma\right)^2 = \left(1+\gamma\right)\left(1-\alpha\right) \tag{8}$$

where $\bar{S}_0 = \dfrac{(1+r_2)(1-\alpha)-\varepsilon R}{(1+\gamma)^2}$.

Let us begin by solving equation (8). Substituting the value of $\bar{S}_0$ into equation (8) we obtain

$$(1+r_2)(1-\alpha)-\varepsilon R(1-p)=(1+\gamma)(1-\alpha) \quad \text{and} \quad (1+r_2^*)=(1+\gamma)+\frac{\varepsilon R(1-p)}{(1-\alpha)}\geq 1$$

since $(1+\gamma)>1$ and $\dfrac{\varepsilon R(1-p)}{(1-\alpha)}>0$.

Using this equilibrium value of the interest rate charged by the MFI for period 2, it is possible to compute the equilibrium value of the compulsory saving required at date 0 by the MFI in order to finance a loan. We obtain $\bar{S}_0^* = \dfrac{(1-\alpha)}{(1+\gamma)}-\dfrac{p\varepsilon R}{(1+\gamma)^2}$.

In order for micro-entrepreneurs to ask for a loan, we must have $\bar{S}_0^* = \dfrac{(1-\alpha)}{(1+\gamma)}-\dfrac{p\varepsilon R}{(1+\gamma)^2}<\alpha$, which means that the amount of the compulsory saving is lower than the value of the loan at date 0. This condition is completed for $1>\alpha>\dfrac{1}{(1+\gamma)+1}\left[1-\dfrac{p\varepsilon R}{(1+\gamma)}\right]>0$ with $\varepsilon<\dfrac{(1+\gamma)}{pR}$.

Finally, substituting the equilibrium value of the compulsory saving into equation (7), we obtain the equilibrium rate of interest charged by the MFI at period 1.

$$p(1+r_1)\alpha+(1-p)(1+\gamma)\left[\frac{(1-\alpha)}{(1+\gamma)}-\frac{p\varepsilon R}{(1+\gamma)^2}\right]=(1+\gamma)\alpha \text{ and}$$

$$(1+r_1^*)=\frac{(1+\gamma)}{p}-\frac{(1-p)}{p\alpha}\left[(1-\alpha)-\frac{p\varepsilon R}{(1+\gamma)}\right].$$

We have $(1+r_1^*)\geq 1$ for $\alpha\geq\dfrac{(1-p)}{2(1-p)+\gamma}\left[1-\dfrac{p\varepsilon R}{(1+\gamma)}\right]$.

This condition is always realized if $1 > \alpha > \frac{1}{(1+\gamma)+1}\left[1 - \frac{p\varepsilon R}{(1+\gamma)}\right] > 0$, since we have

$$\frac{(1-p)}{2(1-p)+\gamma}\left[1 - \frac{p\varepsilon R}{(1+\gamma)}\right] < \frac{1}{(1+\gamma)+1}\left[1 - \frac{p\varepsilon R}{(1+\gamma)}\right].$$

The proof of Proposition 1 is complete. ▪

Appendix B. Proof of Lemma 4.

At period 0, "high-ability" micro-entrepreneurs will choose VSC rather than CSC if the net present expected value of their project associated with VSC is higher than that associated with CSC.

U_{VSC} is the net present expected value of the micro-entrepreneur project associated with VSC and U_{CSC} is the net present expected value of a micro-entrepreneur project associated with CSC.

For a "high-ability" micro-entrepreneur we have that:

$$U_{VSC} = \frac{p}{(1+\gamma)}\left[R - (1+r_1)\alpha + S_v(1+\gamma)\right] + \frac{p}{(1+\gamma)^2}\left[R - (1+r_2)(1-\alpha) + \bar{S}_0(1+\gamma)^2\right] - (\bar{S}_0 + S_v)$$

$$U_{CSC} = \frac{p}{(1+\gamma)}\left[R - (1+r_1)\alpha + S_v(1+\gamma)\right] + \left(\frac{p}{(1+\gamma)}\right)^2\left[R - (1+r_2)(1-\alpha) + \bar{S}_0(1+\gamma)^2\right] - \bar{S}_0$$

The main difference between the two equations is that the probability of being financed at period 1 for period 2 is not conditioned by the success of the project in period 1 for VSC but is dependent on the probability of project success at period 1 for CSC.

Thus, we have $U_{VSC} > U_{CSC}$ if $S_v < p\frac{(1-\varepsilon)R}{(1+\gamma)^2}$.

Similarly, at period 0, "low-ability" micro-entrepreneurs will choose CSC rather the VSC if the net present expected value of their project associated with CSC is higher than the value associated with VSC. U_{VSC} denotes the net present expected value of the low-ability" micro-entrepreneursôproject associated with VSC, while U_{CSC} is the net present expected value of the low-ability" micro-entrepreneurs project associated with CSC.

Thus, for a "low-ability" micro-entrepreneur we have:

$$U_{VSC} = \frac{p}{(1+\gamma)}\left[R-(1+r_1)\alpha + S_v(1+\gamma)\right] + (1-p)\frac{p_l}{(1+\gamma)^2}\left[R-(1+r_2)(1-\alpha)+\bar{S}_0(1+\gamma)^2\right]$$
$$+\left(\frac{p}{(1+\gamma)}\right)^2\left[R-(1+r_2)(1-\alpha)+\bar{S}_0(1+\gamma)^2\right]-(\bar{S}_0+S_v)$$

$$U_{CSC} = \frac{p}{(1+\gamma)}\left[R-(1+r_1)\alpha + S_v(1+\gamma)\right] + \left(\frac{p}{(1+\gamma)}\right)^2\left[R-(1+r_2)(1-\alpha)+\bar{S}_0(1+\gamma)^2\right]-\bar{S}_0$$

The "low-ability" of micro-entrepreneurs means that the probability of success of the project at period 2 depends on its success or failure at period 1, even if micro-entrepreneur is sure of being financed at period 1 for period 2.

It is evident that we have $U_{VSC} < U_{CSC}$ if $S_v > p_l \frac{(1-\varepsilon)R}{(1+\gamma)^2}$.

Consequently, for $p_l \frac{(1-\varepsilon)R}{(1+\gamma)^2} < S_v < p\frac{(1-\varepsilon)R}{(1+\gamma)^2}$ "high-ability" micro-entrepreneurs will find it profitable at period 0 to subscribe to a VSC, while "low-ability" micro-entrepreneurs will choose a CSC ▪

Appendix C. Proof of Lemma 5.

A micro-entrepreneur financed with VSC in the case of success in period 1 has two choices.

First, he announces the true payoff $\tilde{R} = R$, reimburses $(1+r_1)\alpha$ to the MFI, withdraws the amount of his voluntary saving plus interest, and is refinanced by the MFI to continue to run the project. This choice gives rise to a net expected value equal to $\left(R-(1+r_1)\alpha + S_v(1+\gamma)\right) + \frac{p}{(1+\gamma)}\left(R-(1+r_2)(1-\alpha)+\bar{S}_0(1+\gamma)^2\right)$. Again, note that this value is dependent on the announcement of the true payoff at period 2 in the case of a successful project.

Second, if the micro-entrepreneur cheats and announces the payoff $\tilde{R} = 0$, he retains a fraction $(1-\varepsilon)$ of the total payoff R, does not reimburse $(1+r_1)\alpha$, loses the amount of his voluntary saving but since he has chosen a VSC, the micro-entrepreneur will be refinanced by the MFI

for period 2. The net value of this action is given by $\left(1-\varepsilon\right)R+\frac{p}{\left(1+\gamma\right)}\left(R-\left(1+r_2\right)\left(1-\alpha\right)+\bar{S}_0\left(1+\gamma\right)^2\right)$. Consequently, the micro-entrepreneur will always tend to announce the true payoff and reimburse the MFI at period 1 if $\left(R-\left(1+r_1\right)\alpha+S_v\left(1+\gamma\right)\right)\geq\left(1-\varepsilon\right)R$ which lead to $S_v\geq\frac{\left(1+r_1\right)\alpha-\varepsilon R}{\left(1+\gamma\right)}$ ▪

Appendix D. Proof of Proposition 3.

Considering the conditions stated in Lemma 1 to 5:

1. Let us begin with the CSC. The MFI will choose $\left(1+r_1\right)$ and $\left(1+r_2\right)$ in order to ensure its financial equilibrium (nonprofit condition) and

$$p\left(1+r_1\right)\alpha+\left(1-p\right)\bar{S}_0\left(1+\gamma\right)=\left(1+\gamma\right)\alpha \tag{7}$$

$$p\left(1+r_2\right)\left(1-\alpha\right)+\left(1-p\right)\bar{S}_0\left(1+\gamma\right)^2=\left(1+\gamma\right)\left(1-\alpha\right) \tag{8}$$

where $\bar{S}_0=\frac{\left(1+r_2\right)\left(1-\alpha\right)-\varepsilon R}{\left(1+\gamma\right)^2}$.

As these conditions are similar to those in proposition 1 above, CSC is identical to the contract previously computed.

2. Let us now consider the VSC. The MFI will always choose $\left(1+r_1\right)$ and $\left(1+r_2\right)$ in order to ensure its financial equilibrium (nonprofit condition) and

$$p\left(1+r_1\right)\alpha+\left(1-p\right)S_v\left(1+\gamma\right)=\left(1+\gamma\right)\alpha \tag{9}$$

$$p\left(1+r_2\right)\left(1-\alpha\right)+\left(1-p\right)\bar{S}_0\left(1+\gamma\right)^2=\left(1+\gamma\right)\left(1-\alpha\right) \tag{10}$$

where $S_v=\frac{\left(1+r_1\right)\alpha-\varepsilon R}{\left(1+\gamma\right)}$; $\bar{S}_0=\frac{\left(1+r_2\right)\left(1-\alpha\right)-\varepsilon R}{\left(1+\gamma\right)^2}$.

Recall that in the case of project failure at period 1, the MFI will retain the voluntary part of the saving; in case of project failure at period 2, it is the compulsory part of the saving that is retained.

Substituting the value of $\bar{S}_0$ into equation (10) we obtain

$$\left(1+r_2\right)\left(1-\alpha\right)-\varepsilon R\left(1-p\right)=\left(1+\gamma\right)\left(1-\alpha\right) \quad \text{and} \quad \left(1+r_2^*\right)=\left(1+\gamma\right)+\frac{\left(1-p\right)\varepsilon R}{\left(1-\alpha\right)}\geq 1$$

since $\left(1+\gamma\right)>1$ and $\frac{\varepsilon R\left(1-p\right)}{\left(1-\alpha\right)}>0$.

Substituting the value of S_v into equation (9) we obtain

$$p\left(1+r_1\right)\alpha+\left(1-p\right)\left[\left(1+r_1\right)\alpha-\varepsilon R\right]=\left(1+\gamma\right)\alpha \text{ and } \left(1+r_1\right)=\left(1+\gamma\right)+\frac{\left(1-p\right)\varepsilon R}{\alpha}$$

Using these new equilibrium values of the interest rate charged by the MFI on VSC for periods 1 and 2, it is possible to compute the equilibrium value of the voluntary and the compulsory saving required at date 0 by the MFI to finance a loan. We obtain $S_v^*=\alpha-\frac{p\varepsilon R}{\left(1+\gamma\right)}$; $\overline{S}_0^*=\frac{\left(1-\alpha\right)}{\left(1+\gamma\right)}-\frac{p\varepsilon R}{\left(1+\gamma\right)^2}$.

In order for the "low-ability" micro-entrepreneurs not to choose the VSC we must have $S_v^*>p_l\frac{\left(1-\varepsilon\right)R}{\left(1+\gamma\right)^2}$, which leads to $p_l<\frac{\left(1+\gamma\right)\left[\alpha\left(1+\gamma\right)-p\varepsilon R\right]}{\left(1-\varepsilon\right)R}>0$. Similarly, in order for the "high-ability" micro-entrepreneurs to choose the VSC we must have $S_v^*<p\frac{\left(1-\varepsilon\right)R}{\left(1+\gamma\right)^2}$, which leads to $p>\frac{\alpha\left(1+\gamma\right)^2}{R\left(1+\varepsilon\gamma\right)}$.

Finally, in order for "high-ability" micro-entrepreneurs to ask for a loan and accept the VSC, we must have $S_v^*+\overline{S}_0^*<\alpha$, which means that the amount of the voluntary and the compulsory saving is lower than the value of the loan at date 0. This condition is completed for $p>\frac{\left(1-\alpha\right)\left(1+\gamma\right)}{\varepsilon R\left(2+\gamma\right)}<1$.

We have $\frac{(1-\alpha)(1+\gamma)}{\varepsilon R(2+\gamma)} < 1$ if $\varepsilon > \frac{(1-\alpha)(1+\gamma)}{R(2+\gamma)} > 0$. Moreover, we must have $\varepsilon < \frac{(1+\gamma)}{pR} < 1$, which is compatible with the previous condition since $\frac{(1-\alpha)(1+\gamma)}{R(2+\gamma)} < \frac{(1+\gamma)}{pR}$ for $p < \frac{(2+\gamma)}{(1-\alpha)}$, a condition that is always realized as $\frac{(2+\gamma)}{(1-\alpha)} > 1$

.

Note that as $\frac{(1-\alpha)(1+\gamma)}{\varepsilon R(2+\gamma)} > \frac{\alpha(1+\gamma)^2}{R(1+\varepsilon\gamma)}$, it is sufficient to have $p > \frac{(1-\alpha)(1+\gamma)}{\varepsilon R(2+\gamma)}$ in order for the "high-ability" entrepreneurs to choose the VSC.

The proof of Proposition 3 is complete. ▪