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ON THE PROVISION OF MICRO LOANS - MICROFINANCE INSTITUTIONS AND TRADITIONAL BANKS

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This paper employs a utility maximizing model to answer two questions: (i) what are the cost-related factors that determine the supply of a loan by traditional banks and microfinance institutions (MFIs)?; and (ii) why is the supply of micro loan zero under a bank's maximization problem while it is positive under the maximization problem of an MFI? We find that costs associated with default, information asymmetry and liability determine the supply of a loan by a financial institution. Furthermore, we show that under certain conditions (that we derive) a bank may make a loss if it provides micro loan. As a result, it does not supply micro loan.

Keywords: Bank, Group Lending, Microfinance Institutions, Joint Liability, Micro Loans
JEL classification: D24, G21

1. INTRODUCTION

It has now been established in the literature that financial development enhances economic growth (e.g., studies by Alfaro *et al.* (2004) and Levine (2005)). However, most of the less developed countries (LDCs) have thin financial system. For example, domestic credit provided by the banking sector in the less developed countries such as Chad and Tanzania is as low as 17 percent of GDP. This compares with 173 percent for the developed countries, such as the U.S. and Japan (World Bank (2008)). Furthermore, in most LDCs, the poor do not have access to credit from formal financial institutions. There are at least three reasons why banks in LDCs do not provide credit to these domestic residents. First, it is difficult for banks to evaluate the credit worthiness of entrepreneurs - in most LDCs, there are no agencies that track credit history. Second, most of the people live on subsistence and do not have any assets to serve as collateral.

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Third, the size of loan may be so small - it may not cover the cost incurred by the bank in processing the loan.

In response to this "credit problem" a new type of financial institution, known as microfinance institution (MFI) has emerged worldwide. MFIs provide credit to entrepreneurs who do not have access to formal bank credit. The loans are small and known as micro-credit. The World Bank stipulates that there are about 7,000 MFIs operating worldwide. For example, over the last two decades the number of MFIs in Bangladesh has increased from less than 50 to nearly 1,000, an increase of about 1,900% (CDF (2005)). Currently, MFIs in Bangladesh serve about 11 million households. The 2006 Nobel Peace Prize was awarded to Muhammad Yunus for pioneering the idea of microcredit and setting up the Grameen Bank, a microfinance institution of Bangladesh. The importance of microfinance is also evident in the fact that The United Nations declared the year 2005 as the Year of Microcredit.

MFIs engage in both individual lending and group lending in providing loans. However, the mostly used method is group lending; borrowers form groups to obtain loans.[1] The idea is that *within* groups there is no information asymmetry - each member of a group has information about the performance of the project undertaken by the other members of the group as well as the credit worthiness of the other members. Furthermore, within a group all members are jointly liable for each loan and defaulting on a loan can lead to non-refinancing in the future. As a result there is an incentive for members to monitor each other. This reduces the costs of the MFIs associated with lending, such as gathering information, monitoring projects or auditing borrowers. In addition the joint liability feature obviates the need for collateral, because each member serves as collateral for other members.

The growing number of MFIs in LDCs and their success has prompted the professionals, practitioners and researchers to concentrate on the issue of commercialization of microfinance.[2] Countries in Latin America and Africa have developed legal structure and specific regulations for sustainable growth of microfinance industry. Many MFIs have started concentrating on using market-based principles in their operations while maintaining financial self-sufficiency. For example, MFIs in India and Cambodia rely mostly on deposits and commercially priced sources for funding. Experience of MFIs, like, ASA in Bangladesh depicts that it is possible to attain high efficiency (or low cost) while serving poor clients. Given this scenario it is important to conduct a rigorous economic analysis that compares the two types of institutions: traditional banks and MFIs.

This paper provides an analysis of the cost structure of MFIs and traditional commercial banks. There is a vast literature on MFIs (see Brau and Woller (2004), for a literature review). Most of the papers on MFIs, (e.g., Ghatak (1999), Laffont (2003))

[1] For details about group formation see Ghatak (1999).

[2] This necessarily implies the application of market-based principles to microfinance.

attribute the lack of lending to poor entrepreneurs - to a lack of collateral and/or information asymmetry. We however note that banks may be reluctant to lend if the *cost* of processing a loan is very high. This argument is particularly relevant for the poor. The reason is that typically, the amount of loan requests from poor households tend to be small and the costs of processing the loan (which includes information gathering, paper work, etc.) tend to be high. Indeed, the name, ‘micro-credit’ is a clear indication that the loan size is pertinent to any analysis of MFIs. This paper constructs a utility maximizing model to answer two questions. First, what are the cost-related factors that determine the supply of a loan by traditional banks and MFIs? Second, why is the supply of micro loan zero under a bank’s maximization problem while it is positive under the maximization problem of an MFI? We find that costs associated with default, information asymmetry and liability determine the supply of a loan by a financial institution. Furthermore, we show that under certain conditions (that we derive) a bank may make a loss if it provides micro loan. As a result, it does not supply micro loan.

The paper is organized as follows. Section 2 derives the models that capture the behavior of commercial banks and MFIs and Section 3 provides a summary of our findings and conclusion.

2. THE MODEL

There are two general approaches to modeling traditional banks: structural and non-structural. The nonstructural approach focuses on achieved performance and is measured by a variety of financial ratios, such as return-on-asset, return-on-equity, or the ratio of fixed costs to total costs, and the structural approach relies on the economics of cost minimization or profit maximization (Hughes and Mester, 2008). We follow the structural approach, however, we deviate from the literature in this area (e.g., studies by Hughes *et al*., 2000; and Hughes *et al*., 2001) by forgoing the agency problem (bank manager’s behavior) and focusing on bank’s portfolio choice of asset allocation (provision of various loans). One important contribution of this paper is that we extend the existing literature by applying the structural approach in analyzing the behavior of a new type of financial institution: MFIs.

Recall that one of our goals is to determine the optimized portfolio choice of asset allocations of MFI and traditional banks. For the model we assume that both financial institutions have a CES utility function. One advantage of the CES function is that it enhances the modeling process by aggregating the different kinds of assets (or loans) into one equation. We however note that generally, the CES utility function is used to model the behavior of financial institutions in a computable general equilibrium (CGE) model, and is rarely employed in a partial equilibrium analysis of financial institutions.[3]

[3] For example, see Decaluwe and Nsengiyumva (1994) and Naastepad (2002). Unlike these studies our

Thus, one of the contributions of this paper is that it adds to the scant literature that employs CES utility function to study financial institutions in a partial equilibrium setting. Furthermore, to the best of our knowledge, it is the first study to utilize a CES utility function to analyze MFIs.

As pointed out earlier, the inability of poor entrepreneurs to obtain loans from the formal banking system may be partly due to the costs related to providing loans to these borrowers. Therefore, in modeling the optimization problems of commercial banks and MFIs, we will focus on their cost structure. Two aspects of the cost structure are vital for our analysis. First, the transaction cost of processing information about the borrowers, for example, the cost of auditing a borrower. In this case, we follow the "costly state verification" set up given by Townsend (1979).[4] The second aspect pertains to the management cost of providing the financial services. This is represented by a bank's technology.

We assume that financial institutions behave like any other optimizing agent.[5] Usually, loans supplied by a financial institution are considered as its assets while deposits kept by the savers in a financial institution are considered as its liabilities. We assume a competitive financial market where the bank and the MFI earn zero profits.[6] Given this set up, in Section 2.1 we construct a model to analyze the behavior of traditional banks and in Section 2.2 we derive the model of MFIs.

2.1. A Commercial Bank

We assume that, the loans provided by a commercial bank can be divided into two types of loans: short-term loan and long term loan. Short term loans are for the purpose of working capital and can be either large (L) or micro (M) in size. Long-term loans (H) are for the purpose of investment expenditures, consumption, house building, etc. For simplicity we assume that, the commercial bank obtains its resources only from deposits of households. It then uses these funds to provide three different loans.

paper has introduced probability of default and the cost of auditing a defaulted borrower in the optimization problem of a financial institution.

[4] According to Townsend's (1979) "costly state verification", a borrower will be audited when he/she fails to meet contractual obligations.

[5] Our models of the financial institutions evolve around the ideas given by Bernanke *et al*. (1999), Ghatak (1999), Ghatak and Guinnane (1999) and Hughes and Mester (1994).

[6] The zero profits of MFIs are assumed to incorporate the sustainability issue, namely, financial self-sufficiency of MFIs. Moreover, in countries like, Bangladesh and Mexico MFIs operate in competitive framework. Daley-Harris, director of Microcredit Summit Campaign, asserts that, by studying the case of Bangladesh, 'the world's most saturated microfinance market', it would be possible to predict what could happen in other cases if MFIs are constructed with the same care as in Bangladesh (Daley-Harris, Pollin and Montgomery (2007)).

A borrower is characterized by the probability of default. It is assumed, that associated with loan of type i a borrower has a probability of default $p_i \in (0,1)$ where $i = L, M, H$. If the borrower makes repayment, bank gets $(1-p_i)r_i A_i$ where, r_i is the interest rate on loan i and A_i is the amount of loan i. But, if the borrower defaults, the bank audits his/her project and liquidates the project. We assume that the amount liquidated is equal to $p_i \beta_i A_i$, where, β_i is the proportion of defaulted i loan recovered by the commercial bank. At the same time, the bank bears a cost of auditing $\mu_i p_i \beta_i A_i$, where, μ_i is the cost coefficient of auditing defaulted i loan. Therefore, the variable cost of providing loan i is $\mu_i p_i \beta_i A_i$ and the bank receives a return of $p_i \beta_i A_i + (1-p_i)r_i A_i$.

A bank also bears a fixed cost of operation and maintenance, FC_b and costs of liability, namely, interest (r_D) paid on deposits (D).

We assume that, the bank maximizes a constant elasticity of substitution (CES) type of utility function subject to two constraints. The first constraint, given in Equation (1), is the budget constraint or the zero profit function. Profit of the commercial bank is the returns from defaulted and non-defaulted loans minus cost of auditing defaulted loans, interest payments on deposits and fixed costs.

$$\begin{aligned} &p_L \beta_L L + (1-p_L)r_L L + p_M \beta_M M + (1-p_M)r_M M + p_H \beta_H H + (1-p_H)r_H H \\ &- \mu_L p_L \beta_L L - \mu_M p_M \beta_M M - \mu_H p_H \beta_H H - r_D D - FC_b = 0. \end{aligned} \tag{1}$$

The second constraint, Equation (2), represents the cost of processing a small size loan. This includes cost of information gathering, paper work, etc. The administrative cost of a loan, like, book-keeping cost, is an important part of the cost structure of a bank. When making a decision about a micro loan a bank tries to cover the cost of processing the loan by the earning from that loan. The cost of operating the loan should not exceed a threshold level.[7] In our model this level is represented by *K*. This implies:

$$\mu_M p_M \beta_M M \leq K . \tag{2}$$

Given Equations (1) and (2) the bank's objective is to choose the combination of three loans that would maximize its utility:

[7] As there is a maximum, usually, set by the central bank, on the interest rate that could be charged and to maximize the net interest margin, every bank has a minimum loan level below which it would never go. For example, traditional banks would not lend out a small loan of $500 as it would not cover the cost. For such a micro size loan, either the borrower is suggested by commercial banks to use ones credit card or the borrower has to find a non-institutional source, like, relatives, friends and moneylenders.

$$Max\ U_b = \left[\delta_L^b (L)^{-\sigma_b} + \delta_M^b (M)^{-\sigma_b} + \delta_H^b (H)^{-\sigma_b}\right]^{-\frac{1}{\sigma_b}}, \tag{3}$$

where, δ_i^b is the CES distribution parameters in bank's portfolio ($i = L$, M and H) and σ_b is the substitution parameter in bank's utility function.

The problem of the bank can be rewritten as:

$$\begin{aligned} Max\ F = &\left[\delta_L^b (L)^{-\sigma_b} + \delta_M^b (M)^{-\sigma_b} + \delta_H^b (H)^{-\sigma_b}\right]^{-\frac{1}{\sigma_b}} \\ &+ \lambda^b \begin{bmatrix} \mu_L p_L \beta_L L + \mu_M p_M \beta_M M + \mu_H p_H \beta_H H + r_D D + FC_b + p_L \beta_L L \\ -(1-p_L) r_L L - p_M \beta_M M - (1-p_M) r_M M - p_H \beta_H H - (1-p_H) r_H H \end{bmatrix} \\ &+ \rho^b \left[K - \mu_M p_M \beta_M M\right], \end{aligned} \tag{4}$$

where, λ^b is the marginal value of bank's profit, and ρ^b marginal benefit from relaxing the constraint on the variable cost of micro loans or marginal cost from tightening that constraint. The first constraint is a binding constraint and λ^b is therefore, positive. As the second constraint is an inequality constraint, therefore, ρ^b could be either zero or positive.

We now turn our attention to the micro loan. Note that under the bank's problem, the supply of micro loan, M, will be zero if the first order condition with respect to M is negative:[8]

$$\begin{aligned} &F_M : \lambda^b \left[\mu_M p_M \beta_M - p_M \beta_M - (1-p_M) r_M\right] - \rho^b \left[\mu_M p_M \beta_M\right] < 0, \\ &\text{or,}\ \ \lambda^b (MC_M - MR_M) - \rho^b (MC_M) < 0, \end{aligned} \tag{5}$$

where, $MR_M = p_M \beta_M + (1-p_M) r_M$ is the marginal revenue earned by the bank from micro loan, $MC_M = \mu_M p_M \beta_M$ is the marginal cost born by the bank on micro loan and $M\pi_M = MR_M - MC_M$ is the marginal profit of the bank on micro loan. Two scenarios can arise from Equation (5).

Scenario 1. *If marginal value of the bank's profit is positive and the marginal benefit of relaxing the constraint on the variable cost of micro loans is also positive then the marginal revenue from micro loan could be either greater than or equal to or less than the marginal cost of micro loan*.

Proof. See Appendix A.

[8] The Kuhn-Tucker conditions for the problem of the bank are $F_M < 0, M = 0$ and $MF_M = 0$.

Scenario 1 implies that there is a possibility that the marginal cost of micro loan could exceed the marginal benefit of micro loan. Therefore, according to this cost-benefit analysis the possibility of negative marginal profit prohibits the bank from supplying micro loan. As a utility optimizer, it is economically rational for a bank not to supply a product, namely, micro loan, as there is a possibility of making a loss by doing so.

Scenario 2. *If marginal value of the bank's profit is positive and the marginal benefit of relaxing the constraint on the variable cost of micro loans is zero then the marginal revenue from micro loan would be greater than the marginal cost of providing that loan.*

Proof. See Appendix A.

Positive marginal profit obtained from micro loan does not justify why commercial banks do not supply this loan. Therefore, we ignore this possibility.

Solution to the bank's problem yields (see Appendix A for details):

$$L = \frac{1}{T_b}\left[r_D D + FC_b\right], \tag{6}$$

$$M = 0, \tag{7}$$

$$H = B^{\psi_b} X^{\psi_b} L, \tag{8}$$

where, $T_b = [p_L\beta_L + (1-p_L)r_L - \mu_L p_L \beta_L] + [p_H\beta_H + (1-p_H)r_H - \mu_H p_H \beta_H] B^{\psi_b} X^{\psi_b}$, $B = \frac{\left[p_L\beta_L + (1-p_L)r_L - \mu_L p_L \beta_L\right]}{\left[p_H\beta_H + (1-p_H)r_H - \mu_H p_H \beta_H\right]}$, $X = \frac{\delta_H^b}{\delta_L^b}$ and, $\psi_b = \frac{1}{1+\sigma_b}$ is the elasticity of substitution in bank's utility function.

Our results may be summarized as follows:

Result 1. The supply of bank loans depends on the interest rates charged on different loans (r_i), cost coefficient of auditing defaulted loans (μ_i), borrower's default probability (p_i), proportion of defaulted loans recovered (β_i), fixed cost (FC_b) and liability cost ($r_D D$).

Result 2. It is not always optimal for a bank, using its traditional framework, to provide a certain type of loan, in this case the micro loan.[9]

[9] In recent time period some traditional banks are active in the microcredit market. However, they usually

2.2. A Microfinance Institution

Behavior of a MFI can be explained under a similar setup as that of a commercial bank. We assume that the loans supplied by a MFI can be divided into two types of loans: micro loan (M) for the purpose of working capital and small housing loan (S).[10] Similar to the commercial bank, for simplicity we assume that, the MFI obtains its funds through deposits of households only.[11]

We assume that, MFIs use group-lending method to provide loans. For simplicity, we assume a group size of two and that the group members are alike.[12] However, two members receive two separate but identical loans. Group members are characterized by their probability of default. For example, in case of loan i, each member in a group has a probability of default of $p_{ij} \in (0,1)$ where $i = M, S$ and $j = 1,2$. Whenever one member of the group defaults, the non-defaulting partner has to make a payment of c where $0 < c < 1$. It is a fraction of A_i, the amount of loan i. If the member decides to repay the loan then he/she has to pay the following two amounts: payment for own loan, $(1 - p_{i1}) r_i A_i$ where, r_i is the interest rate charged on loan i and payment for joint liability $cp_{i2}(1 - p_{i1})A_i$ if his/her partner defaults. When both members default, the MFI audits the project and liquidates the project. We assume that the amount liquidated is equal to $p_{i1} p_{i2} \beta_i A_i$, where, β_i is the proportion of defaulted loan i recovered by the MFI. Note that under this scenario, the frequency of auditing a loan (or a borrower) decreases relative to the bank's problem.[13] As a consequence, the overall cost of auditing is less under the problem of MFI. Nevertheless, the MFI may still incur some auditing cost, which is $\mu_i p_{i1} p_{i2} \beta_i A_i$ where, μ_i is the cost coefficient of auditing defaulted i loan. Therefore, the variable cost of providing loan i to one member of the group is $\mu_i p_{i1} p_{i2} \beta_i A_i$ and the MFI gets a return of $p_{i1} p_{i2} \beta_i A_i + (1 - p_{i1}) r_i A_i + cp_{i2}(1 - p_{i1}) A_i$.

Similar to the bank, the MFI also incurs some general costs such as fixed costs of

have separate sections or branches that operate in this market. These branches have similar structure as the MFIs.

[10] Though not all, but many of the MFIs provide loans, other than micro loan, for different purposes to their customers. Small housing loan is used as a representative of these different purposed loans.

[11] Many of the MFIs have started concentrating on deposits by savers, equities sold, loans from other financial institutions as their sources of funds. According to MicroBanking Bulletin (MicroFinance Information Exchange (2007)), even though some funds are subsidized, by the end of 2006 almost 70 percent of the funding of a MFI came through commercial borrowing and deposits.

[12] This small size of the group would capture the main essence of the model. Larger group size would mainly, make computations complex rather than changing any results.

[13] The reason is that under the MFI auditing occurs only when all the members of a group defaults. In contrast, the bank audits each borrower that defaults.

operation and maintenance, FC_{mf} and liability costs, namely, interest (r_{DM}) paid on deposits (D_M).

The MFI maximizes a CES utility function subject to its budget constraint. The zero profit function is the budget constraint of the MFI. Profit of the MFI is the returns from defaulted and non-defaulted loans plus joint liability payment minus cost of auditing defaulted borrowers, interest payments on deposits and fixed costs. It is given in Equation (9).

$$\begin{aligned} & p_{M1}p_{M2}\beta_M M + (1-p_{M1})r_M M + cp_{M2}(1-p_{M1})M + p_{S1}p_{S2}\beta_S S + (1-p_{S1})r_S S \\ & + cp_{S2}(1-p_{S1})S - \mu_M p_{M1}p_{M2}\beta_M M - \mu_S p_{S1}p_{S2}\beta_S S - r_{DM}D_M - FC_{mf} = 0. \end{aligned} \tag{9}$$

Unlike the traditional commercial bank, the MFI does not face any additional constraint on the variable cost of micro loan. Specifically, one of the main functions of MFIs is the provision of micro loans. Rather than one large loan MFIs provide a number of small loans, in this case two micro loans.

Given Equation (9) the MFI chooses the combination of the two loans that would maximize its utility:[14]

$$\text{Max } U_{mf} = \left[\delta_{mf} M^{-\sigma_{mf}} + (1-\delta_{mf})S^{-\sigma_{mf}}\right]^{-\frac{1}{\sigma_{mf}}}, \tag{10}$$

where, δ_{mf} is the share of micro loan in the portfolio of the MFI and σ_{mf} is the substitution parameter in the CES utility function of the MFI.

Solution to the MFI's problem yields (see Appendix B for details):

$$M = \frac{1}{T_{mf}}\left[r_{DM}D_M + FC_{mf}\right], \tag{11}$$

$$S = J^{\psi_{mf}} V^{\psi_{mf}} M, \tag{12}$$

where,

$$\begin{aligned} T_{mf} = & \left[p_{M1}p_{M2}\beta_M + (1-p_{M1})r_M + cp_{M2}(1-p_{M1}) - \mu_M p_{M1}p_{M2}\beta_M\right] \\ & + \left[p_{S1}p_{S2}\beta_S + (1-p_{S1})r_S + cp_{S2}(1-p_{S1}) - \mu_S p_{S1}p_{S2}\beta_S\right]J^{\psi_{mf}} V^{\psi_{mf}}, \end{aligned}$$

[14] Usually, outreach, reaching the maximum number of borrowers, is regarded as one of the goals of MFIs. We tried to capture that aspect through loans instead of clients.

$$J=\frac{\left[p_{M1}p_{M2}\beta_M+(1-p_{M1})r_M+cp_{M2}(1-p_{M1})-\mu_M p_{M1}p_{M2}\beta_M\right]}{\left[p_{S1}p_{S2}\beta_S+(1-p_{S1})r_S+cp_{S2}(1-p_{S1})-\mu_S p_{S1}p_{S2}\beta_S\right]}\;,\quad V=\frac{(1-\delta_{mf})}{\delta_{mf}}$$ and,

$\psi_{mf}=\dfrac{1}{1+\sigma_{mf}}$ is the elasticity of substitution in MFI's utility function.

Our results may be summarized as follows:

Result 3. The supply of loans by a MFI depends on the interest rates charged on different loans (r_i), cost coefficient of auditing defaulted loans (μ_i), borrower's own default probability (p_{i1}), default probability of other member of the same group (p_{i2}), proportion of defaulted loan recovered (β_i), joint liability payment (c), fixed cost (FC_{mf}) and liability cost ($r_{DM}D_M$).

Result 4. Unlike a traditional bank it is optimal for a MFI to provide micro loan to its borrowers. As a utility optimizer, it is economically rational for a MFI to supply micro loan, as it is possible to make positive marginal profit by doing so.

2.3. Discussion of Results

Our results show that supply of each type of loan is determined by the returns from the loan as well as the costs of providing the loan. Note that Results 1 and 3 highlight the difference between traditional banks and MFIs. Specifically, MFIs differ from commercial banks with respect to the cost of default (default probability of other member of the group and joint liability payment) and the cost of information (frequency of auditing the defaulted loan and cost of processing micro loan). All other costs, namely, fixed costs, interest payment on deposits, interest charged on different loans and borrower's own probability of default exist for both commercial banks and MFIs. Thus our results indicate that the cost structure of a financial institution plays an important role in the supply of the various types of loans.

Our results also suggest that one reason why traditional banks do not provide loans to micro entrepreneurs is that they want to minimize risk and cost. A natural question that arises is this: why don't traditional banks adopt joint liability lending to mitigate the cost and risk associated with micro lending?[15] A plausible explanation is that among other factors the organizational structure of a bank depends on the environment under which it operates, namely, property rights, legal set up, chartering rules and government

[15] Sometimes when collateral is insufficient to avoid risk or costs, banks use co-signing principle which is different from the joint liability lending. Under the joint liability lending all the group members are jointly liable for all loans while under co-signer method only the co-signer is liable for the loan applicant but the loan applicant is not liable for the co-signer (Gangopadhyay and Lensink (2009)).

regulations (Hughes and Mester (2008)).[16] Adoption of joint liability lending by the traditional banks requires some change in the existing environment. Initiating a change of the above-mentioned factors is highly costly and outside the scope of a traditional bank. Evidently, banks do not attempt to serve the micro loan borrowers (through joint liability lending) as the relative contributions such a movement will make to profit are smaller than if they serve the large loan borrowers.

3. CONCLUSION

Microfinance institutions (MFIs) have become increasingly important in LDCs. An important difference between MFIs and commercial banks is that MFIs provide micro credit, but banks, under the traditional framework, generally do not. This paper constructs a utility maximization model to analyze the cost structure of MFIs and traditional commercial banks. It also derives the conditions under which a bank will not issue micro loans. First, we find that the costs associated with default, information asymmetry and liability determine the supply of a loan by a financial institution. Second, if the marginal value of the bank's profit is positive and the marginal benefit of relaxing the constraint on the variable cost of micro loans is also positive then there is a possibility that the marginal revenue from micro loan could be less than the marginal cost of micro loan. As a consequence no micro loan is issued.

Appendix

A. Model of a Commercial Bank

The problem of the bank can be rewritten as:

$$
\begin{aligned}
Max\ F = &\left[\delta_L^b (L)^{-\sigma_b} + \delta_M^b (M)^{-\sigma_b} + \delta_H^b (H)^{-\sigma_b}\right]^{-\frac{1}{\sigma_b}} \\
&+ \lambda^b \begin{bmatrix} \mu_L p_L \beta_L L + \mu_M p_M \beta_M M + \mu_H p_H \beta_H H + r_D D + FC_b - p_L \beta_L L \\ -(1-p_L) r_L L - p_M \beta_M M - (1-p_M) r_M M - p_H \beta_H H - (1-p_H) r_H H \end{bmatrix} \\
&+ \rho^b \left[K - \mu_M p_M \beta_M M\right].
\end{aligned} \tag{A.1}
$$

Our aim is to find out the conditions, under which a commercial bank supplies positive amounts of *L* and *H* and zero amount of *M*. Setting the first order conditions

[16] Discussions on these issues are beyond the scope of this paper.

with respect to *L* and *H* equal to zero, we have:

$$Z^{-\left(1+\frac{1}{\sigma_b}\right)}\left[\delta_i^b\left(A_i\right)^{-(1+\sigma_b)}\right]=\lambda^b\left[p_i\beta_i+\left(1-p_i\right)r_i-\mu_i p_i\beta_i\right],$$
$$\text{or,}\quad MU_i=\lambda^b\left(MR_i-MC_i\right)=\lambda^b M\pi_i\,, \qquad \text{(A.2)}$$

where, $Z=\delta_L^b(L)^{-\sigma_b}+\delta_M^b(M)^{-\sigma_b}+\delta_H^b(H)^{-\sigma_b}$, $MU_i=(Z)^{-\left(1+\frac{1}{\sigma_b}\right)}\left[\delta_i^b\left(A_i\right)^{-(1+\sigma_b)}\right]$ is the marginal utility derived by the bank from loan type i , $MR_i=p_i\beta_i+(1-p_i)r_i$ is the marginal revenue earned by the bank from loan type i , $MC_i=\mu_i p_i\beta_i$ is the marginal cost born by the bank on loan type i and $M\pi_i=MR_i-MC_i$ is the marginal profit of the bank on loan type i ($i=L$ and *H*). We assume that, MU_i , MR_i , MC_i and $M\pi_i$ are positive.

Given positive marginal utility and a positive λ^b , Eequation (A.2) implies that, the bank would choose to supply positive amount of *L* (or *H*) if the marginal revenue from *L* (or *H*) were greater than the marginal cost of providing *L* (or *H*).

Now for the supply of micro loan to be zero, first order condition with respect to *M* needs to be negative. The first order condition would then change to the following form:

$$F_M:\lambda^b\left[\mu_M p_M\beta_M-p_M\beta_M-\left(1-p_M\right)r_M\right]-\rho^b\left[\mu_M p_M\beta_M\right]<0\,,$$
$$\text{or,}\quad \lambda^b\left(MC_M-MR_M\right)-\rho^b\left(MC_M\right)<0\,. \qquad \text{(A.3)}$$

Scenario 1. *If marginal value of the bank's profit is positive and the marginal benefit of relaxing the constraint on the variable cost of micro loans is also positive then the marginal revenue from micro loan could be either greater than or equal to or less than the marginal cost of micro loan.*

Proof of Scenario 1. If both the Lagrange multipliers λ^b and ρ^b , and marginal cost and marginal revenue of micro loan are positive then the second term of Equation (A.3), $\rho^b\left(MC_M\right)$ will be positive. The first term $\lambda^b\left(MC_M-MR_M\right)$ can be either positive, zero or negative depending on whether MC_M is greater than, equal to or less than MR_M .

Now, Equation (A.3), $[\lambda^b\left(MC_M-MR_M\right)-\rho^b\left(MC_M\right)]$ will be negative, if $[\rho^b\left(MC_M\right)]$ is positive and,

If $MC_M<MR_M$ so that $[\lambda^b\left(MC_M-MR_M\right)]$ is negative or,

If $MC_M=MR_M$ so that $[\lambda^b\left(MC_M-MR_M\right)]$ is zero or,

If $MC_M>MR_M$ so that $[\lambda^b\left(MC_M-MR_M\right)]$ is positive.

The third option implies that, there is a possibility that the marginal cost of micro loan could exceed the marginal benefit of micro loan. ■

Scenario 2. *If marginal value of the bank's profit is positive and marginal benefit of relaxing the constraint on the variable cost of micro loans is zero then the marginal revenue from micro loan would be greater than the marginal cost of providing that loan.*

Proof of Scenario 2. If $\rho^b = 0$ then the second term in Equation (A.3), $\rho^b(MC_M)$ becomes zero. With $\lambda^b > 0$ the only way $\lambda^b(MC_M - MR_M)$ can be negative is if $MR_M > MC_M$. ■

B. Model of a MFI

The problem of the MFI can be rewritten as:

$$
\begin{aligned}
&Max\ F = \left[\delta_{mf} M^{-\sigma_{mf}} + (1-\delta_{mf})S^{-\sigma_{mf}}\right]^{-\frac{1}{\sigma_{mf}}} \\
&+ \lambda^{mf}\begin{bmatrix} \mu_M p_{M1}p_{M2}\beta_M M + \mu_S p_{S1}p_{S2}\beta_S S + r_{DM}D_M + FC_{mf} \\ - p_{M1}p_{M2}\beta_M M - (1-p_{M1})r_M M - cp_{M2}(1-p_{M1})M - p_{S1}p_{S2}\beta_S S \\ -(1-p_{S1})r_S S - cp_{S2}(1-p_{S1})S \end{bmatrix}
\end{aligned}
\tag{B.1}
$$

As the MFI faces a binding constraint, λ^{mf} is positive. To find out the conditions under which the MFI provides positive amount of *M* and *S* we set the first order conditions with respect to *M* and *S* equal to zero.

$$
Z^{-\left(1+\frac{1}{\sigma_{mf}}\right)}\left[\delta_{mf}(A_i)^{-(1+\sigma_{mf})}\right] = \lambda^{mf}\left[p_{i1}p_{i2}\beta_i + (1-p_{i1})r_i + cp_{i2}(1-p_{i1}) - \mu_i p_{i1}p_{i2}\beta_i\right],^{17}
$$

$$
\text{or,}\quad MU_i = \lambda^{mf}(MR_i - MC_i) = \lambda^{mf} M\pi_i, \tag{B.2}
$$

where, $Z = \delta_{mf} M^{-\sigma_{mf}} + (1-\delta_{mf})S^{-\sigma_{mf}}$, $MU_i = (Z)^{-\left(1+\frac{1}{\sigma_{mf}}\right)}\left[\delta_{mf}(A_i)^{-(1+\sigma_{mf})}\right]$ is the marginal utility derived by the MFI from loan type i, $MR_i = p_{i1}p_{i2}\beta_i + (1-p_{i1})r_i + cp_{i2}(1-p_{i1})$ is the marginal revenue earned by the MFI from loan type i, $MC_i = \mu_i p_{i1}p_{i2}\beta_i$ is the marginal cost born by the MFI on loan type i and $M\pi_i = MR_i - MC_i$ is the marginal profit of the MFI on loan type i ($i = M$ and *S*). We

[17] In case of *S*, δ_{mf} is replaced by $(1-\delta_{mf})$.

assume that, MU_i, MR_i, MC_i and $M\pi_i$ are positive.

Therefore, given the positive marginal utility and a positive λ^{mf} Equation (B.2) implies that, the MFI would supply positive amount of loan *M* (or *S*), if marginal revenue from *M* (or *S*) were greater than marginal cost of providing *M* (or *S*).

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