

CREDIT FOR THE POOR: MICROLENDING TECHNOLOGIES
AND CONTRACT DESIGN IN BOLIVIA

DISSERTATION

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ABSTRACT

This dissertation develops models to represent alternative lending technologies and the resulting loan contracts when the lender simultaneously faces moral hazard and adverse selection in markets where collateral is scarce. These models are used to predict who gets loans and in what conditions, when the lender must overcome collateral imperfections, high fixed costs, and increasing competition from lenders offering different contracts. The model correctly predicts borrower types for two Bolivian microfinance organizations.

Access to credit for the poor has dramatically improved in Bolivia due to new microlending technologies that significantly differ from collateral-based technologies and among themselves. A benchmark model is developed to compare technologies when lenders simultaneously address information asymmetries about actions (diligence) and type (productivity). Depending on the lender's stock of information and lending technology and the borrower's collateral, different contracts are offered that match different borrower classes. Comparative statics results about imperfect collateral, equity contributions, and fixed and monitoring costs are examined.

Both portfolio quality and size matter, because microlenders must cover substantial fixed handling costs related to lending to the poor. A tradeoff emerges as the

interest rate increases, augmenting individual repayment promises, but the total number of borrowers and portfolio quality decline.

The different technologies of the two largest Bolivian microfinance organizations, BancoSol and Caja Los Andes, are studied. An important difference is the degree of standardization of loan contracts. Andes offers personalized (separating) contracts after intensive screening, pledging of imperfect collateral (assets with high consumption but low resale value), and monitoring to ameliorate moral hazard. BancoSol offers standardized (pooling) contracts to all takers and screening and monitoring are delegated to joint liability credit groups.

Matching is determined by the lending technology. Low-productivity borrowers prefer standard contracts due to the possibility of cross-subsidization. High-productivity borrowers prefer personalized contracts to avoid cross-subsidizing others. Competition may improve access for the poor through lower monopoly rents but it may deteriorate the quality and size of the portfolio of poverty-oriented lenders. Non-parametric statistics show that lower-productivity and poorer borrowers are more likely to borrow from BancoSol.

To my parents

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CHAPTER 1

INTRODUCTION

Financial markets have attracted the economists' attention because they represent a challenge to the usual understanding of a market. In a standard market, say the wheat market, the seller is not interested in the characteristics (type) of the buyer; the seller just cares about receiving the right amount of money for her product. This happens because this is a spot transaction and because both parties possess perfect information about the quality and the price of the homogeneous good being traded. Lenders, in contrast, sell a product (loan contract) for which they do not receive the price (principal plus interest) immediately. They only receive a promise of (uncertain) future payment. This is why lenders care about the future behavior of their customers.

The lenders' ability to correctly predict repayment is crucial for their success. The probability of repayment is determined not only by the the intrinsic risk of the project to be financed, but also by the behavior of the borrowers. Borrowers may influence repayment by engaging in opportunistic behavior and thereby increasing lender losses from default. Borrowing behavior is influenced, in turn, by the incentives embedded in the terms of the loan contract.

Lenders must address asymmetric information. Indeed, when a potential borrower goes to a bank and applies for a loan, he knows the distribution of the possible outcomes of his venture better than the bank does and he knows about his own character (willingness to pay the loan) better than the lender does.

It is well known, at least by bankers, that alternative lending technologies can be successfully used to partially overcome these information asymmetries.

The adoption of different lending technologies has a number of implications:

- (a) it influences the structure and level of costs of the lenders, therefore influencing their profitability;
- (b) it influences the utility of borrowers through its impact on the quality of financial products and on the costs levied on the borrowers; and
- (c) it influences the welfare of society as a whole, through the level and optimal allocation of investment.

To understand the advantages and disadvantages of adopting specific lending technologies and their effects on lenders, borrowers, and society at large is important.

A. Motivation

It has been estimated that 90 percent of the Bolivian population does not have access to loans from formal financial organizations (FONDESIF, 1997). It has also been estimated that 70 percent of this population is poor (Ministerio de Desarrollo Humano, 1995). Numerous non-traditional financial organizations have emerged to meet this demand. The first generation were specialized government-owned development banks. These organizations failed, and their failure along with the general domestic and

international mistrust of government intervention unlocked the opportunities for non-government organizations (NGOs) to enter this field (Monje, 1995).

Literally, hundreds of NGOs invaded the Bolivian financial market in the mid-1980s. Their clients had truly not been reached by traditional commercial banks, while development banks had already disappeared at that time. The absence of commercial banks in this market niche reflected the lack of a profitable technology to overcome the information problems involved (Gonzalez-Vega, 1998a). Commercial banks did not know how to deal with small and, in most cases, unsecured loans.

NGOs, however, were not the definitive answer to the lack of access to credit, in view of their weak institutional design. They served, however, as a means for intensive experimentation in new lending technologies. As a result of this domestic experimentation and of lessons transferred from international experience, various new successful microlenders emerged in Bolivia.

Different criteria have been recommended to measure the success of these microcredit organizations. Yaron (1994), for example, proposed a dual test: outreach and sustainability. Outreach is the social value of the output of a microfinance organization in terms of depth, worth to users, cost to users, breadth, length and scope of the financial services offered (Navajas *et al.*, 1998). Sustainability is permanence (Schreiner, 1997). It means meeting goals (outreach) now and in the long run. Judged by these criteria, several Bolivian microfinance organizations have been quite successful (Gonzalez-Vega *et al.*, 1997a).

Important ingredients in the success of these new financial organizations have been the introduction of appropriate lending technologies and the achievement of

economies of scale. The emergence of these lending technologies has attracted private investors and now even commercial banks have begun to provide credit to poor people. The most successful of the non-profit-driven organizations have understood that profitability is important in pursuing their altruistic goal because subsidies are not likely to flow for ever. In turn, banks have realized that, with the proper lending technology, profit maximization is compatible with lending to the poor.

B. Objectives and Hypotheses

This dissertation has both theoretical and empirical objectives. Most credit market models have analyzed the effects on the level of investment of just one type of imperfection due to information asymmetries (adverse selection or moral hazard) for a lender with a *given* lending technology. The approach taken in this dissertation is to model a credit market where both problems are simultaneously present and where the lender chooses among alternative technologies to address them.

Lenders have to worry about attracting the best possible borrowers (the most productive) and at the same time they have to worry about the incentives to repay that each borrower has. A diligent borrower, who maximizes the probability of repayment, is preferred to a borrower who is not diligent and whose behavior negatively influences the lender's profits. Besides the quality of the pool of borrowers, lenders are also interested in the size of their portfolio in order to cover their fixed costs.

Depending on the degree of available information about the distribution of potential borrowers in the population and on the lender's technology, the terms of different loan contracts can be derived. The theoretical model makes it possible to

understand the type of loan contracts offered by two successful Bolivian microlenders and the revisions they have incorporated in their contracts due to increasing competition.

The main hypothesis of this dissertation is:

In a credit market where collateral is scarce, lenders rely on alternative mechanisms such as a pooling contract (“one for all” type of contract) or a separating contract with intensive screening (“all for one” type of contract), which create incentives to repay in the absence of traditional collateral. Low productivity borrowers will prefer pooling contracts, since in this case there is a possibility of cross-subsidization of risk premiums. If the costs are reasonable, high productivity borrowers will prefer separating contracts, so they can avoid paying the premiums which result from a pooling contract and obtain terms better tailored to their own circumstances. Microlenders implicitly target a particular pool of borrowers (matching) when they choose between these lending technologies and the accompanying contract terms, but these relationships are modified when competition is introduced.

C. Organization

This dissertation is organized as follows. Chapter 2 is a review of the literature on models of lending behavior. Chapter 3 develops a benchmark model for the analysis of a microcredit market. In this chapter, the lender is assumed to have perfect information about the productivity type of each borrower. The level of effort of the borrower is unobservable, however, and opportunistic behavior (negatively influencing the quality of the lender’s portfolio) is possible. The benchmark model analyzes the effects of different loan contracts under the presence of moral hazard problems only.

Chapter 4 extends the model in order to examine the effects of adverse selection. In this model, the lender has to deal with imperfect information about both the borrower's productivity type and actions. This chapter explores the design of an optimal contract under different assumptions about the type of information available to the lender.

Chapter 5 uses the theoretical framework developed by this dissertation to study how two of the most important Bolivian microlenders (BancoSol and Caja Los Andes) actually deal with moral hazard and adverse selection problems. The explanation jointly considers constraints on information, fixed costs, and increasing competition. Chapter 6 presents a non-parametric exploration of the features of borrowers of BancoSol and Caja Los Andes, to verify their consistency with the theoretical predictions. Finally, conclusions are discussed in Chapter 7.

CHAPTER 2

EVOLUTION OF ECONOMIC THOUGHT

ON LENDING BEHAVIOR

A. Introduction

A basic assumption in the analysis of competitive markets is perfect information. Predictions about the optimality of market outcomes may break down when this assumption is not valid. In the absence of perfect information, markets may not grow to their socially optimum size and shape.

The study of markets under these circumstances was started by Akerlof (1970). In his seminal paper, this author showed that asymmetric information between the parties in a transaction can lead to the destruction of a market. The new generations of models that followed this seminal contribution have been able to better reflect reality, where information is scarce (expensive) and incomplete, and where agents behave strategically.

In financial markets, information asymmetries may lead to agency problems. As Allen (1987) and others have pointed out, conflicts of interests are a fact of financial life recognized by borrowers and lenders. The need to resolve these conflicts shapes their actions.

Imperfect and asymmetric information characterizes credit markets and especially microcredit markets. In order to maximize their profits, lenders create different devices to overcome the negative effects of incomplete information. This leads to the key questions addressed in this dissertation: How do lenders actually respond to information problems? What is the information structure in microcredit markets?

Economists early recognized that credit markets do not behave as a typical competitive market. This section reviews the way economists have tried to explain why this is the case.

B. Models of Credit Markets

It is usually observed that markets for loans do not clear through prices (interest rates) but through non-price mechanisms that are used to allocate funds to borrowers. A whole branch of the literature was born to explain this observation. This is the theory of credit rationing. Next, the most influential models are discussed in chronological order.

1. The Availability Doctrine

The availability doctrine emerged as a monetarist response to an apparently low interest-rate elasticity of investment. The idea was that the effectiveness of monetary policy would be enhanced if money influences aggregate demand both through the interest rate and credit supply (availability). Despite a low-interest rate elasticity, investment was supposed to adjust to changes in credit supply through credit rationing, thereby intensifying the power of monetary policy.

The weakness of the availability doctrine was that the existence of credit rationing was supposed to depend on various institutional constraints such as interest-rate ceilings or minimum bank liquidity ratios (Roosa, 1951; Scott, 1957). Nevertheless, this theory called attention to the causes of credit rationing and led to a reformulation of the credit rationing problem in terms of lender attitudes in the face of risk (Ishwaran, 1997).

2. Rationalizing Credit Rationing

Credit rationing was considered a widespread phenomenon but, did it reflect the rational behavior of profit-maximizing economic agents? Samuelson (1951) argued that non-price rationing was inconsistent with profit-maximizing bank [lender] behavior. Hodgman showed that this inconsistency does not exist.

Hodgman (1960) examines the behavior of a lender in a non-regulated environment and explicitly models asymmetric information and risk. The lender estimates a density function that reflects the ability to pay different loan amounts by the borrowers. His model emphasizes riskiness of loans as a criterion for credit rationing. As a measure of risk, Hodgman defines the ratio (EY/EZ) . EY is the lender's expected income from a loan and EZ is the expected value of the loss of principal. EZ is independent of the interest rate charged on the loan. Hodgman assumes that the lender's utility results from maximizing EY/EZ . Furthermore, this author assumes that an equilibrium ratio (EY/EZ^*) is determined in a perfectly competitive market. Therefore, a borrower receives a loan of a given size if and only if EY/EZ is equal or greater than EY/EZ^* . The equilibrium ratio does not depend on the interest rate so, after some cut-off point, the supply of credit for a particular borrower becomes completely inelastic. Regardless of how high an interest rate a borrower is willing to pay, when the maximum

risk (EY/EZ^*) is reached, the lender will not offer any larger loan. Under these assumptions, risk depends on loan size and it leads to a supply curve as shown in Figure 1.

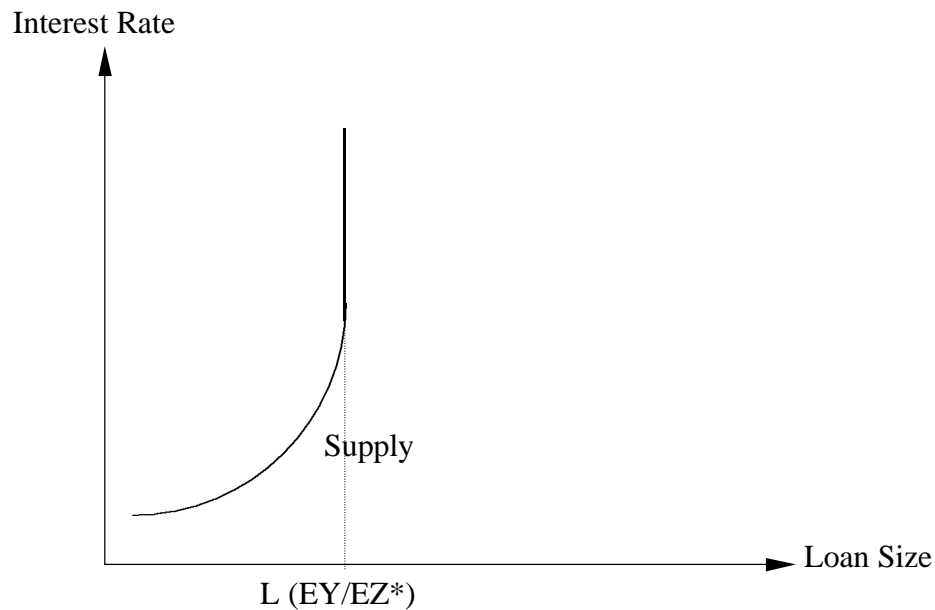


Figure 1: Supply in the Loan Market (Hodgman)

Hodgman's work ignited a fruitful debate. Some of the immediate responses brought up important points for further discussion. An interesting issue taken up by Chase (1961) was the possibility of lack of independence between loan size and ability to pay. An inventory acquisition, for example, would increase the borrower's ability to pay. This author also observed that borrowers have alternative sources of funding and that this should be explicitly included in the model. These revisions, he asserted, would not change the basic conclusions of the model, they would simply enrich it.

Chase's strongest criticism, however, was more fundamental. In Hodgman's model, the ratio (EY/EZ) determines the maximum loan size offered to a borrower. This implies that if a borrower can offer a sufficiently high EY , even at the risk of total failure (low EZ), a loan would be offered. This would imply very risky behavior when most people believe that bankers are very conservative. Furthermore, in Hodgman's model rationing only occurs when, even if the borrower promises all of the proceeds from the project, the lender still thinks that repayment will not occur. Chase argued that this divergence in expectations is quite implausible.

In a response, Hodgman (1961) agreed with Chase that the ability-to-pay function could be presented in a more general manner and that conservative lenders may be more common, although this would have to be determined empirically. Hodgman, however, strongly emphasized that different expectations of borrowers and lenders are very likely. In the modern jargon, Hodgman was referring to asymmetric information in loan contracts.

Ryder (1962) uses Hodgman's framework but includes long-term profit considerations. The lender expects borrowers to come back in the future, unless "the banker [lender] kills the goose that lays the golden eggs by exerting such a high repayment that the borrower becomes bankrupt" (Ryder, 1962: pp. 474). Any current promise of repayment is compared to the reduction in future income due to the increased probability of bankruptcy. This results in a backward-bending supply of curve of credit and may be the reason why lenders seem too conservative.

The discussion geared around reasonable assumptions that could induce credit rationing in the absence of any external constraint (*e.g.*, usury laws). In this venue, Miller

(1962) introduced bankruptcy costs in the expected utility of the lender. In his model, a risk-averse lender has two options: to lend (a fixed loan size) or to invest in a riskless asset. As the interest rate increases, the lender's expected utility grows but only up to a point. After this point, the risk associated with default will offset any increase in returns due to the higher interest rates. If the riskless asset gives the lender a greater return than lending the pre-fixed amount, borrowers will be rationed no matter what interest rate they offer to pay.

An alternative approach to Hodgman's ratio was later on presented by Freimer and Gordon (1965). In their model, these authors argued that lenders determine the optimum loan size for a given interest rate and that this optimum size reaches a maximum at some finite interest rate. So, regardless of the interest rate they offer to pay, the borrowers will not get a loan that exceeds this maximum.

The argument for this conclusion is that borrowers face a maximum return on their projects. If the interest rate increases take the promised repayment beyond this maximum, default becomes virtually certain. As the interest rate increases, the lender needs to invest less (smaller loan size) to become the owner of the net results of the firm's project. The contribution of Freimer and Gordon amounted to the construction of a backward-bending supply curve, but it did not address the question of equilibrium credit rationing. These authors defined credit rationing as a situation where excess demand persists, but they did not address the issue of why this excess demand can not be solved by a higher interest rate. The existence of a backward-bending supply curve, however, does not guarantee credit rationing. An excess demand for credit only persists if the demand curve is completely to the right of the supply curve, as shown in Figure 2.

Freimer and Gordon also showed that the backward-bending portion of the supply curve would disappear if the returns on the project were positively correlated with the size of the loan, given constant returns to scale.

Jaffee (1971) showed that the backward-bending supply curve can appear even when the return of a variable-size investment is positively related to loan size as long as the investment project is subject to decreasing returns to scale.

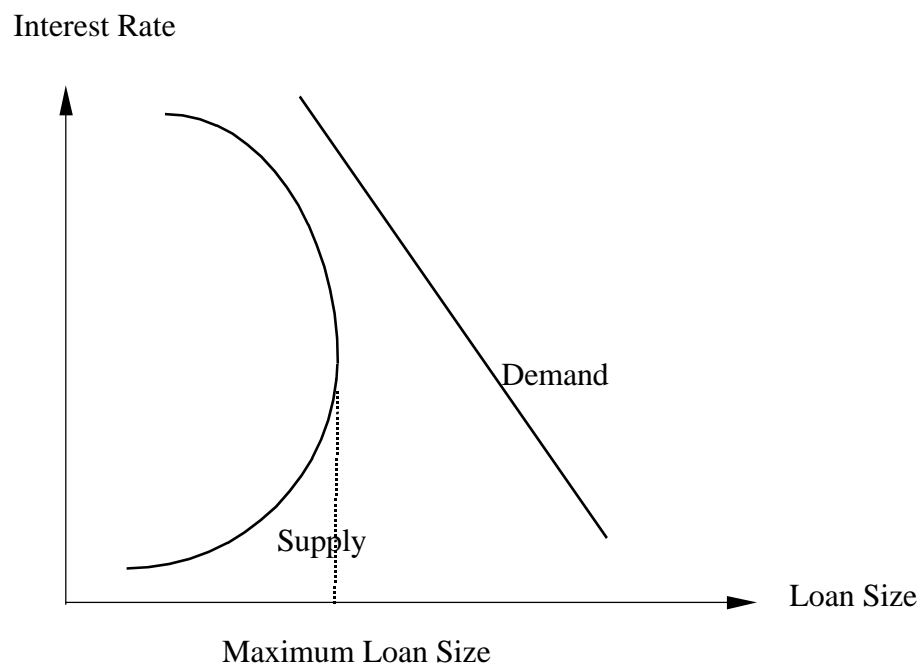


Figure 2: Supply and Demand in the Loan Market (Freimer and Gordon)

In Jaffee and Modigliani (1969), the argument is that the lender is a discriminating monopolist with more classes of borrowers than interest rate levels (prices) to be matched with. The lender will ration some borrowers rather than charge still a different interest rate. The unwillingness to sufficiently differentiate across borrowers was an external assumption imposed on the model from the observation of actual behavior. The unresolved question remained: Is it too costly (or impossible) to differentiate across classes of borrowers? The answer was not complete.

Gonzalez-Vega (1976,1980) analyzes the case when two classes of potential borrowers exist. Their income levels are a function of their productive opportunities as well as of their command over resources to take advantage of those opportunities. Each productive opportunity is a reflection of the farmer's technology, endowment of land, human capital, entrepreneurial ability, and physical capital. Command over resources is obtained through savings (endowment of own resources) or credit. The lender recognizes different classes of borrowers but it is assumed to be constrained to charge a uniform, freely-chosen, profit-maximizing interest rate. Charging a small farmer a higher interest rate than a large farmer was, at that time, seen as politically impossible. Gonzalez-Vega showed that "uniform interest rates for all borrower classes impose net social costs which imply, either a situation where the best marginal productive opportunities are not being taken advantage of, or a situation where the additional resources spent in the administration of the financial system are more than those generated by its extra activity" (Gonzalez-Vega, 1980: pp. 23).

In this framework, for credit rationing to occur "it is necessary that the profit-maximizing uniform interest rate for the bank [lender] become equal to the marginal cost

of granting the loan to a particular borrower, for a loan size smaller than the size of loan demanded by the producer at the uniform rate charged. On the other hand, rationing will not take place if the uniform interest rate charged is higher than the marginal cost of granting the loan, for the size of loan demanded” (Gonzalez-Vega, 1980: pp. 17).

The argument relied on the assumption of a uniform interest rate being charged to different classes of borrowers (pooling equilibrium), but it did not explain why the uniform rate would prevail in a non-regulated environment. Otherwise, prices (interest rates) should be adjusted for different kinds of borrowers by the lender. Although incomplete information was recognized by Gonzalez-Vega as one among several possible sources of uniform interest rates, it was not explicitly incorporated in the model.

A different kind of explanation of credit rationing is presented by Aigner and Sprenkle (1968), who developed a classical model of optimal short-run lending behavior using information as an input. These authors explore the implications of the information technology for the behavior of the loan market. The institutional constraint or institutional assumption in this case is that lenders always overestimate the probability of default of the borrowers.

3. Information Models

The sets of models reviewed in the previous section analyzed lender’s risk in terms of the lender’s uncertainty about the returns on the borrower’s project. Information asymmetries about these returns or uncertainty about the type of borrower were not yet endogenized.¹

¹ In his response to Chase (1961), however, Hodgam (1961) observes that this asymmetry is very likely.

Jaffee and Russell (1976) built a model where imperfect information plays an explicit and vital role. These authors examined the loan market by introducing two types of borrowers: honest borrowers, who only accept contracts that they expect to repay and dishonest borrowers, who default on their loans whenever the costs of default are sufficiently low. Hence, default is utility-increasing for dishonest borrowers.

Lenders know the proportion of honest and dishonest borrowers in the market, but they cannot recognize individual borrowers. Dishonest borrowers tend to prefer larger loans than honest borrowers. Because both types of borrowers are indistinguishable, the lender limits loan size to reduce the probability of default and to induce the self-selection of borrowers. Self-selection occurs because the incentive for dishonest borrowers to engage in a loan contract decreases when the benefits (loan size) decrease. An equivalent result is obtained when borrowers are classified as lucky or unlucky.

Jaffee and Russell analyze the results in a competitive market and in a monopolistic market. These authors conclude that, under competition, equilibrium may be unstable, and that the monopolistic nature of this market keeps this inherent instability under control.

Koskela (1976) discussed a more general model, where one of the key assumptions was the existence of information asymmetries. This assumption refers to the lender's imperfect ability to screen applicants, because, given the available information set, they are indistinguishable. An equivalent outcome is obtained when it is possible to distinguish across applicants but it is too costly to adapt the interest and non-interest terms of the contract to each class of borrowers. Koskela endogenized imperfect information and highlighted that the loan contract is a complex agreement between

parties, where the quantity and price vectors include not only the amount of money lent and the interest rate charged but also other terms and conditions such as collateral, equity ratios, terms to maturity, or frequency of payment.

By the late 1970s, the understanding of credit rationing had increased enormously; it was time to define some concepts better. Two outstanding examples are Baltenspeger (1978) and Keeton (1979). Baltenspeger (1978) called attention to the definition of price and quantity credit rationing. Price rationing occurs, as in any other market, when the borrower cannot pay the price of the good (loan). Quantity rationing occurs when the borrower is rationed through non-price devices. It is important, therefore, to correctly define which terms and conditions belong to the price vector and which ones belong to the quantity vector.

Keeton (1979) proposed a clear distinction between two types of non-price credit rationing. Loan size rationing (Type I) occurs when all borrowers receive loans but the size of the loan is below the amount demanded at the going rate of interest. Loan quantity rationing (Type II) occurs when two indistinguishable borrowers are treated differently. Some of them receive loans and others do not. In his model, a Walrasian equilibrium can arise only by accident. To be able to show non-price credit rationing, Keeton developed the following model.

The market for loans is competitive. The iso-profit curve is constructed by solving the lender's expected profit function for the interest rate at a given profit level. In perfect competition, this level is zero. Keeton also constructs the borrower's iso-utility (or iso-profit) curve by solving the expected utility function for the interest rate at a given utility level. Assuming identical firms, equilibrium takes place at loan size L^F in Figure 3, where

the lender's isoprofit curve is tangent to the borrower's iso-utility curve. There is credit rationing because at this level of the interest rate, the borrowers demand L^D but receive only L^F . This rationing is type I rationing or loan size rationing.

Keeton extends the model to introduce the concept of moral hazard. Moral hazard can arise when the borrower's choice of project characteristics depends on the terms of the loan contract. The net effect of an increase in the interest rate may thus reduce the lender's expected profit from a loan. Thus, if it is not possible to commit a borrower to a fully-specified set of project characteristics, a lender may be unwilling to accommodate, at a higher interest rate than is being currently charged, those firms that have not been able to obtain credit elsewhere. These new firms may be identical to those already in the lender's portfolio, but they are denied credit because of the lender's recognition that at higher interest rate firms will choose projects so risky as to reduce expected lender's profits. Loan quantity rationing can happen in this situation.

Interest Rate

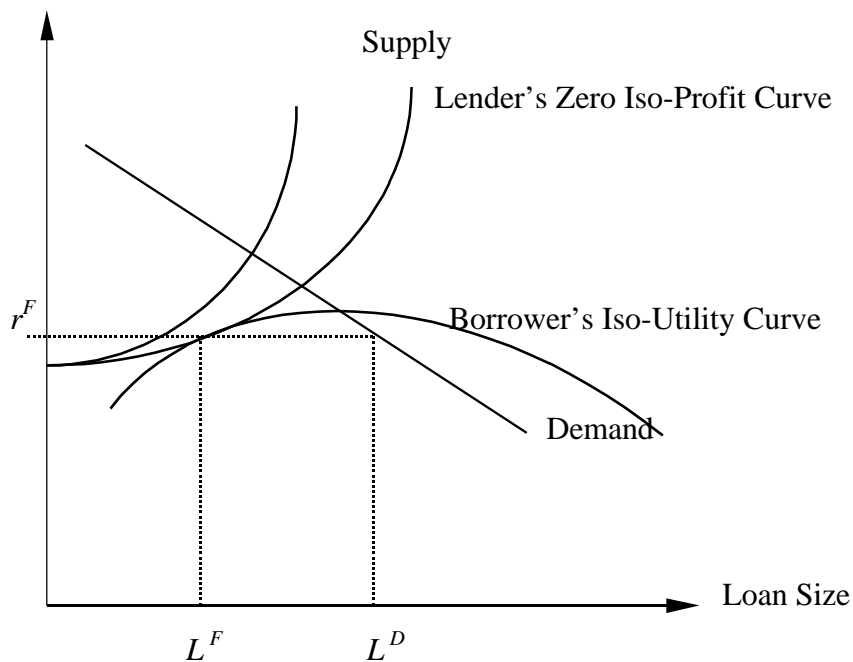


Figure 3: Supply and Demand in the Loan Market (Keeton)

Stiglitz and Weiss (1981) also developed a credit rationing model. The gist of the model is that the interest rate is not used by the lender as a sorting device because changes in the interest rate may affect the riskiness of the pool of borrowers. The risk of a project is reflected by the variance of returns. Lenders can observe the mean returns from the projects but not their variance. In their model all projects have the same mean but different variances (mean-preserving spreads). Under this sort of imperfect information, Stiglitz and Weiss show that expected returns to the lender increase with the interest rate only up to a point.

This behavior of expected returns would lead, as in Freimer and Gordon (1965), to a backward-bending supply curve. The rationale, however, is different. In Stiglitz and Weiss, this phenomenon is caused by adverse selection and moral hazard problems. As the interest rate is increased, the mix of the pool of applicants changes adversely (it includes more risky borrowers than before). Due to moral hazard (incentive effect), as the interest rate increases, borrowers are induced to switch from safer projects to more risky ones. This switch affects the expected returns of the lender because of the limited-liability characteristics of the loan contract.

If the project is successful, the lender will receive at most the loan amount plus the interest accrued, while if the project fails, the lender will receive zero (or any residual value). The incentive of borrowers to gamble by undertaking riskier projects is greater when the interest rate is higher. Thus, “high interest rates may make projects with low mean returns -the projects undertaken by risk-averse individuals - unfeasible, but leave relatively unaffected the riskier projects. The mean return to the bank, however, is lower on the riskier projects than on the safe projects” (Stiglitz and Weiss, 1980: pp. 230). The resulting backward-bending supply curve creates the possibility of loan size and loan quantity rationing.

Under the assumption of Stiglitz and Weiss equity-financing would lead to an optimum level of investment, where as debt-financing may lead to underinvestment. Slightly different assumptions can lead, however, to completely different results. An outstanding example is presented by de Meza and Webb (1987, 1992).

In their first paper, de Meza and Webb (1987) studied the case when projects have the same variance but different mean returns, in contrast to Stiglitz and Weiss’ model

where projects have different variance but the same mean returns. In the model, overinvestment is possible under debt-financing.

In a second paper, de Meza and Webb (1992) show that information asymmetries should not be considered as the sole source of imperfections in financial markets. They show that in competitive markets and under symmetric information, credit rationing (loan size rationing) is also possible. Their model is driven by the limited-liability character of the loan contract and the possibility of bankruptcy.

If bankruptcy (failure of the project) occurs, all proceeds from the project go to the lender, but they fall short of the promised repayment. Therefore, the borrowers demand credit up to the point where the marginal product of funds in the good state is equal to the marginal costs of funds, since they receive nothing in the case of bankruptcy. Lenders, in contrast, maximize their return by taking into account both states. They will charge an interest rate such that losses in the failure state are covered with gains in the good state. Since lenders receive a return in the failure state (average product) in excess of the marginal product, they will charge a sub-optimal interest rate. At this interest rate, demand exceeds supply and credit rationing occurs.

Another important contribution of the second paper is the notion that credit rationing may be entirely consistent with an efficient market allocation. It is important “to recognize that the mere observation of credit rationing is not sufficient to conclude that market failure must be present and hence government action is worth considering” (de Meza and Webb, 1992: pp. 1290). Although it may be difficult to justify symmetric information in financial markets, the paper sheds light about credit rationing in a complete information framework.

Clemenz (1986) introduces a different set of assumptions under which credit rationing is also plausible. The objective is to show under what other reasonable circumstances a backward-bending supply curve can exist. This author finds two additional situations:

(1) *Borrowers differ in skills.* If borrowers are risk neutral, they will take a loan only if the expected return is greater than the prevailing wage for their skills class. As the interest rate increases, the returns from using the loan decrease. As a result, high-ability borrowers start to leave the market voluntarily, thereby hurting the quality of the lender's portfolio. Only low-ability borrowers or those with a low reservation wage will stay in the portfolio.

(2) *Unobservable effort of borrowers.* The probability of project success changes with effort. Being risk neutral, an increase in the interest rate reduces the expected marginal return of effort for the borrower. In order to maintain equality between marginal cost and the expected marginal return of effort, the borrower must decrease effort. This reduction in effort conspires against the interests of the lender.

Devinney (1984, 1986) contributed to the literature when pointing out that lenders usually have a number of options to overcome information asymmetries. In his model, lenders have access to different risk-reducing information technologies. One of these strategies is a screening technology where risk is minimized before loans are granted. The other alternative is a collection technology where the lender uses incentives (*e.g.*, large penalties upon default) to control risk. Screening and collection are substitute technologies and depend on the type of information available in the market. One or the other (or a combination of both) will be chosen by the lender. In Devinney's model

credit rationing (type II or loan quantity rationing) only occurs as a byproduct of imperfect screening (misclassification of good and bad borrowers). This author claims that while perfect screening is possible, it may be technically feasible but economically inefficient, as it is costly.

C. Extensions to the Basic Theory

A usual criticism of the models presented in the previous section is that financial markets are more complex than is assumed. Therefore, the literature has been extended in different directions to deal with these complexities.

1. Collateral

The basic theory focuses on the effects of interest rates on the lender's profits and on why credit rationing may be an equilibrium phenomenon. If the interest rate cannot be used as a proper sorting device, why not design contracts where other devices - such as collateral - are used? If we took collateral as just another dimension of the price vector of the loan, price rationing would take place as in any other market. Those who cannot pay the price, will be kept out of the market and the market will clear. But, would the use of collateral sufficient to overcome informational disadvantages?

The ability to pledge collateral is a sign of reliability. Borrowers who expect not to repay the loan will be the least likely to risk their assets by pledging them (Barro, 1976). So, moral hazard (incentive) problems can be eliminated when a loan is fully collateralized (Guttentag and Herring, 1984). In a fully-collateralized loan, the asset pledged (as valued by the lender) is at least equal to promised payment (principal plus

interest). Borrowers who pledge collateral are no longer able to shift the risks to the lender. Then, why do lenders not simply supply fully-collateralized loans?

First, this would restrict them to a limited segment of the market. Even though risk is totally eliminated, the lenders' expected profit function may not be maximized. There must be some set of contracts where some degree of certainty is sacrificed in order to increase expected profits.

Second, to establish a contractual relationship is costly, and the lender expects an appropriate return from it. If the lender is risk averse, he will prefer to fully insure against all potential losses. To require full collateral is a means to insure the lender completely for an initial loan, but what the lender would have liked is to insure the whole lender-borrower relationship. Of course, no borrower can be expected to offer more collateral than what is needed for one loan. Therefore, even in a perfect world where full collateralization is possible, credit rationing can still arise.

Collateral influences the choice of project by a particular borrower, but it also affects the quality of the pool of borrowers. If borrowers have access to different kinds of projects, the risk the lender faces changes as the pool of borrowers changes.

Lenders can design loan contracts where the interest rate and collateral requirements are combined (Bester, 1985). Assume that there are two types of borrowers -high and low risks- and two types of contracts.² A low-risk borrower would choose a loan contract with a low interest rate and high collateral; the high-risk borrower will choose a loan contract with a high interest rate and low collateral. This allows to lender to

² Equivalently, where the set of projects that the high risk-borrowers have access have access to are riskier than those the low-risk borrower have access to.

discriminate between classes of borrowers, and no rationing should occur. The assumption is that low-risk borrowers can meet the collateral requirement, but if this is a binding constraint because not all borrowers can meet the requirement, some rationing may still remain in the market (Chan and Thaker, 1987).

In these models, lenders compete for borrowers until benefits go to zero. As Allen (1987) points out, this separating equilibrium fails to recognize that interest charges and collateral are not perfect substitutes. If interest rates are lowered and collateral requirements are raised, the lender's returns may decline. Given competition and zero profits, any unforeseen pooling (high risk in the low risk category) will imply losses for the lender.

It is also possible that borrowers with more assets to offer may be riskier borrowers. Stiglitz and Weiss (1981) and Wette (1983) explained that raising collateral requirements may have negative adverse selection effects. If collateral requirements are increased, only wealthy people would be able to get a loan. But wealthy "borrowers may be those who in the past have succeeded at risky endeavors" (Stiglitz and Weiss, 1981: pp. 251). As some of them may have succeeded just by chance, the group might be less risk adverse. Even in a world with diverse collateral requirements, credit rationing may still be an optimal lender's response.

Stiglitz and Weiss (1986) developed a model where moral hazard and adverse selection problems and the role of collateral were jointly analyzed. These authors explained that equilibrium can take the form of pooling or separating contracts. In a pooling equilibrium, credit rationing may persist (even in the presence of collateral) because increasing the interest rate may have negative incentive effects and increasing

collateral requirements may have negative adverse selection effects. In the separating equilibrium case credit, rationing may still occur for each one of the different contracts.

Collateral requirements improve the lender's degrees of freedom. Better contracts can now be designed to differentiate among borrowers (Stiglitz and Weiss, 1987). However, "as long as the dimensionality of the space of borrower characteristics is larger than the dimensionality of the space of contracts, it seems unlikely that perfect information can be obtained" (Jaffee and Stiglitz, 1990: pp. 867).

2. The Multiperiod Framework

A common criticism to models of loan markets is the treatment of the lender-borrower relationship as a one-time event. A multiperiod framework is more appropriate for the analysis, as the relationship occurs over time and in different instances. This dynamic relationship includes several contacts between lender and borrower. Both parties, lender and borrower, behave so as to maximize the returns of the whole relationship and not just the returns of a single transaction. Under these circumstances, "an optimal arrangement is for agents to enter into multiperiod contracts [implicit or explicitly] which, in effect constrain future actions," so returns are maximized in the long-run (Townsend, 1982: pp. 1181). The next set of models use this framework for the analysis.

a. Implicit Contracts

Fried and Howitt (1980) explained that the benefits from a long-lasting relationship are drawn in an implicit contract concerning the amounts (loan sizes) they will be willing to trade, at what prices, and under which conditions in the future. In this way, they can share the risks of an uncertain future.

The model emphasizes the importance of customer relationships and explains the possibility of credit rationing in this different setup. Risk sharing occurs when the lender reduces the variability of the interest rate charged in the expectation of being compensated with a higher average interest rate. The possibility of non-price rationing is opened by the limited flexibility of the interest rate, even if information is not asymmetric.

In the Fried and Howitt framework, credit rationing in the short-run may be optimal as the result of a long-run optimal contract. It is possible that satisfying the borrower's demand at the going interest rate will result in an increase of current benefits but in a reduction of the present value of future benefits. Thus, credit rationing will occur. Credit rationing is treated in this model as one additional term of an incentive compatible contract between the two parties.

b. Reputation

Reputation allows lenders to reduce information asymmetries through the observation of payment patterns. Not only the reputation of the borrowers but also the reputation of the lender matter.

In the one-period case, if default occurs, the game comes to an end and no further interaction is possible. In the multiperiod framework, default signals information that can be used in the next round of the game. Lenders have to be careful in how they react to default. In some cases, renegotiation of the loan terms can be mutually beneficial. Then, why does renegotiation not happen all the time? Lenders know that, if borrowers believe that renegotiations are possible, then they will undertake riskier actions and gamble more, undermining the lender's profits (Eaton and Gersovitz, 1981).

Stiglitz and Weiss (1983) explained that the threat of cutting off credit after default has important incentive effects for all borrowers. This threat makes all borrowers undertake less risky projects. Lenders are effectively using lack of satisfaction of future loan demand as a threat to constraint today's behavior. This threat, however, must be credible. Reputation is important on both sides of the transaction. Borrowers have to protect their costly-acquired and only partially transferable reputation asset. This intangible asset enables borrowers to have a reliable source of funds for satisfying future liquidity constraints. Lenders also need to maintain a reputation of making credible threats. Gonzalez-Vega (1993) has argued that the perception of lender permanency is the most important determinant of lender credibility and repayment behavior.

Diamond (1989) studied the formation of reputation and the evolution over time of the incentive effects of reputation to solve the conflict of interests between borrowers and lenders. The novelty of the model is that it does not require the lender to have a commitment technology.

The model begins with an observationally equivalent cohort of three types of risk-neutral borrowers with no credit history. One type of borrowers has access to two projects. A safe project (high expected return) and a risky project (low expected return but higher maximum return). The other two types of borrowers have access to only one kind of project. Some have access to the safe project only and others have access to the risky project. The incentive problem might arise if the contract leads the first type of borrowers to choose the risky project.

Due to imperfect information, in the beginning all borrowers are treated equally. The interest rate charged is the same. The future interest rate will depend, however, on

the information that becomes available later on (credit history). The most positive signal from a borrower is repayment. Since some of the borrowers who select the risky project do not immediately default, it takes time to recognize which borrowers have chosen the safe project.

In the first period, some borrowers default. Now the lender observes two groups: defaulters and non-defaulters. In the next period, the interest rate charged to non-defaulters is less than in the first period. This decline continues over time for the class of non-defaulters. How high the interest rate is in the beginning and how the contract improves over time depends on the proportion of borrower types in the pool. As time goes by, the present value of being a non-defaulter increases. Borrowers of type one compare the present value of gambling (when the risky project is chosen) to the gains of being in the select group of non-defaulters with certainty (when the safe project is chosen). The reputation of being a non-defaulter is a valuable asset which it is worth protecting.

Reputation effects may also explain why new firms face disproportionately high interest rates and small loans compared to larger firms in a similar sector (Martinelli,1997). Lending to new firms is risky because lenders have had no time to accumulate observations about their behavior. As relationship with the firm ages and observations accumulate, lenders are able to distinguish risk profiles better.

3. The Hypothesis of *Ex-Post* Asymmetric Information

Ex ante asymmetric information has become a central assumption in the analysis of loan markets. The assumption of the borrowers having more information than the lenders about the projects to be financed gives rise to the threat of moral hazard or

adverse selection. These models have also assumed a standard debt contract without deriving it from an optimization exercise.

A strand of the literature considers a different working hypothesis: *ex post* asymmetric information. In these models, lenders and borrowers have the same information about the projects to be financed. However, once the returns on the projects are realized, only the borrowers can observe them costlessly. Lenders have to spend resources to obtain this information (monitoring). Information is asymmetric with regards to the realized returns of the projects. In these models all borrowers are potentially dishonest. They will default or misreport their projects' returns if their expected utility is increased by doing so. This is called *ex post* moral hazard behavior.

A key issue is, then, how are monitoring decisions made? Townsend (1979), for example, shows that random monitoring is sufficient to overcome *ex post* moral hazard and to induce honesty. Williamson (1986, 1987) assumes that monitoring decisions are made *ex post* rather than *ex ante*. Cosci (1992), following Williamson, considers that lenders monitor borrowers only enough to induce honesty (perfect monitoring is costly not necessary). In Gale and Hellwig (1985) monitoring costs are state dependent.

Although monitoring is introduced differently in each model, these models have the virtue of deriving the standard debt contract as an optimal arrangement (Diamond, 1984; Gale and Hellwig, 1985; Williamson 1986 and 1987; Boyd and Smith, 1994; Conning, 1996). It is also possible to show that under *ex post* asymmetric information, credit rationing in the sense of a typical non-monotonic expected profit function may also be obtained.

D. Summary

This chapter has summarized the literature on lending behavior. The main objective of these models is to offer some insight into the way credit markets function. Lenders face information asymmetries about the probability of repayment. Borrowers usually have more information than lenders because they are the agents who actually invest the money. Lenders must also take into account that the terms of the loan contract influence borrower behavior.

Credit models began by emphasizing the role of risk of the project in influencing lending behavior only. Later on, the emphasis changed to the consequences of risk and asymmetric information on credit markets. Asymmetric information has been studied when it occurs before disbursement (borrowers have more information about the project to be financed) and after disbursement (borrowers and lenders have the same information about the project to be financed but once the returns are realized only borrowers know them). Both families of models have attempted to explain why credit markets seem to clear through non-price mechanisms and credit rationing takes place.

Information models usually analyze one type of asymmetric information at a time (moral hazard, adverse selection or *ex post* moral hazard) and study the consequences of the introduction of collateral, monitoring, and other changes in the terms of loan contracts. Also, few models analyze the consequences of different lending technologies used to reach a similar pool of borrowers. This dissertation analyzes a credit market when both moral hazard and adverse selection problems are present.

It also addresses the problem of the lender, who has to deal with scale issues in order to cover fixed costs at the organizational level (handling costs). The dissertation makes predictions about degrees of credit rationing under different information, collateral, and competition regimes.

CHAPTER 3

A BENCHMARK MODEL FOR THE ANALYSIS OF MICROCREDIT MARKETS

A. Introduction

This chapter builds a benchmark model for the analysis of microlending.³ Microlending refers to the supply of loans when features of the transaction (*e.g.*, very small size, lack of collateral, short term to maturity, and the need for frequent payments as a monitoring tool), features of the borrower (*e.g.*, joint firm-household unit, informal, poor, distant producers without financial statements and formal credit rating), or the features of the project to be funded (risky, heterogeneous activities) make lending unprofitable when a traditional bank lending technology is used (Gonzalez-Vega, 1997a). Due to the accompanying difficulties, the microcredit market is frequently missing.

The technologies required to expand the frontier of microlending not only differ significantly from banking technologies; they also differ significantly among themselves. This dissertation examines the nature of these technologies and the reasons for their multiplicity.

³ Microfinance usually denotes the provision of various types of financial services, including loans, deposit facilities, and payments instruments. This dissertation focuses on the credit dimension of microfinance.

Any lender faces risks each time he disburses a loan. These risks result from the borrower's project and are accentuated by (*ex ante* and *ex post*) information asymmetries about the nature of the project and the intentions of the borrower. Besides solving the uncertainty problem and attracting good borrowers, lenders are also interested in lending to enough good borrowers to cover their fixed costs.

This and the next the next chapter build a general and flexible model of lending behavior. This model offers an appropriate framework to analyze the microcredit market of Bolivia. This chapter deals with the loan market when only moral hazard exists. The next chapter considers a case where both adverse selection and moral hazard are possible. The model builds on earlier work of Conning (1996, 1998) and Madajewicz (1998).

B. Self-financing

Consider a risk neutral microentrepreneur (ME) with the opportunity to undertake a productive project. The project requires the use of a tradable input (I) and a non-tradable input (z). The tradable input I represents all intermediate goods that can be bought and traded in the market place. The non-tradable input z represents the productivity (ability) type of the ME. At any particular moment, the ME's productivity type cannot be changed. It is given for each ME. Over time, though, productivity can be improved through education or experience. The non-tradable input also represents the *animal spirits* of the ME.

The production function is represented by $F(z, I)$ or, for simplicity, $zf(I)$, where $f_I(I) > 0$ and $f_{II}(I) < 0$. The outcome of the project is stochastic. Two events

are possible. In the first event, the outcome is success and equal to $zf(I)$. In the second event, the outcome is failure and equal to zero.

The probabilities associated with each outcome are influenced by the ME's behavior. When the ME is diligent, the probability of success is P^d and the probability of failure is $(1 - P^d)$. When the ME is not diligent, the associated probabilities are P^{nd} and $(1 - P^{nd})$, respectively, where $P^d > P^{nd} > 0$.

Lack of diligence means that the ME is able to divert funds and/or effort away from the project and enjoy a non-tradable benefit of a value equivalent to BI that is a source of utility. This private benefit is proportional to total investment, where $0 < B < I$. This proportion B is a function of the diligence exerted by the ME. When the ME is diligent, B is assumed to be equal to zero, and $B(P^d)I = 0$. When the ME is not diligent, B is a proportion of total investment (I) in the project, or $B(P^{nd})I = BI$, with $0 > B > I$. The important condition is that $B(P^{nd}) > B(P^d) \geq 0$. Assuming $B(P^d) = 0$ does not change the predictions of the model.

The non-tradable benefit is characterized here as the outcome of any activity carried out by the ME that cannot be transferred to others (say, a potential lender). For example, a ME who takes a nap instead of working will lower the probability of success of the project but derives the same utility as from having BI available. Only the project renders a monetary and transferable outcome that can be used to pay the loan, but non-diligent behavior may increase returns to the ME. Consumption of loan funds in an emergency or event (*e.g.*, wedding) is a good example of a non-tradable benefit. When

the ME is diligent, the borrower's entire return from his activities is transferable; when the ME is not diligent, a portion of the returns is not transferable.

The ME needs funds (I) to take advantage of the opportunity and carry out the project. Assume first that the ME can self-finance the project and must only pay for the opportunity cost of the funds. The opportunity cost of I is equal to $(1+r)I = \mathbf{g}I$. For a competitive lender, \mathbf{g} is assumed to be constant. In the optimization, the ME takes into account all sources of returns (project returns and non-tradable benefits). Then, the optimization problem for the ME is:

$$\text{Max } P^i z_f(I) + B(P^i) - \mathbf{g}I$$

$$I, P^i \begin{cases} P^d \\ P^{nd} \end{cases}$$

$$\text{s.t. } 0 \geq I \geq I_0, \tag{3.1}$$

$$P^i z_f(I) + B(P^i) - \mathbf{g}I \geq Ur = 0, \tag{3.2}$$

The two choice variables are the level of investment (I) and the level of diligence (P^i). There are two constraints. The first constraint (3.1) indicates that, under self-financing, the level of I chosen cannot be negative or greater than the ME's initial endowment (I_0). The second constraint (3.2) is the participation constraint. The ME will not take advantage of this productive opportunity unless the expected returns are greater than those from the best alternative (for example, a job in a factory). For simplicity, the returns from the alternative (Ur) opportunity are set equal to zero.

The first-order conditions (FOC) for a maximum, assuming that the first constraint is not binding, are as follows:⁴

$$\text{If diligence is chosen: } P^d z_{f_I} (I^*) = g \quad (3.3)$$

$$\text{If non-diligence is chosen: } P^{nd} z_{f_I} (I^{**}) = g + B \quad (3.4)$$

The ME will then compare the maximum expected returns under diligence and under non-diligence:

$$E(R / D) = P^d z_f (I^*) + B(P^d)I^* - g^* = P^d z_f (I^*) + 0 - g^* \quad (3.5)$$

$$E(R / ND) = P^{nd} z_f (I^{**}) + B(P^{nd})I^{**} - g^{**} = P^{nd} z_f (I^{**}) + BI^{**} - g^{**} \quad (3.6)$$

Diligence is here assumed to be always more profitable than non-diligence. Thus, under self-financing, the ME will choose to be diligent and choose I^* [$E(R / D) > E(R / ND)$].

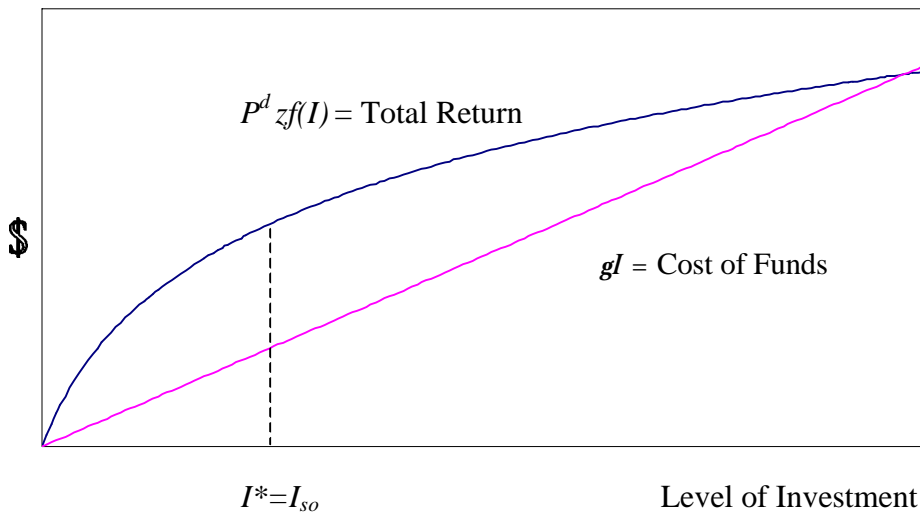


Figure 4: The Socially Optimum Level of Investment

⁴ Second-order conditions (SOC) are assumed to be satisfied.

C. The Model with Borrowing: Moral Hazard Can Happen

The model in the previous section can be extended to the situation where the ME cannot reach the socially optimum level of investment (I_{so}) by self-financing. In other words, constraint (3.1) is binding. In these circumstances, the ME has two options. One, the ME can use all his own available resources (I_0) up to the point where the constraint is binding. Two, the ME can look for outside funding. The terms of the potential loan contract will determine total investment and the total returns for both borrower and lender.

When a loan of size I is taken (assuming $I_0=0$ for simplicity), the borrower has the option of not being diligent, thereby diverting a fraction of effort (proportional to total investment) to obtain a non-tradable benefit of size BI . Non-diligence raises the probability that the project will fail and that the borrower will not generate enough tradable returns to repay the loan. If the borrower is not diligent, the probability of failure increases. The increase must be large enough, however, to make tradable returns from the project insufficient to cover the lender's costs.

If tradable returns are enough to cover the opportunity cost of the funds (assuming no other costs are incurred by the lender) only when diligence is exerted, then condition (3.7) is true:

$$P^d z_f(I) - gI \geq 0 > P^{nd} z_f(I) - gI \quad (3.7)$$

Condition (3.7) states that if the borrower is diligent, tradable returns will be sufficient, in expected value, to pay for the opportunity cost of the funds.⁵ If non-diligence is chosen, expected returns will not be enough to pay for the lender's opportunity cost of funds. Otherwise, the problem will be trivial: either all MEs receive loans or none does.

Under these assumptions, if the lender wants to recover costs, then the lender must attract diligent borrowers that make repayment more likely. If diligence could be observed and contracted upon, then diligence could be stipulated in a state-contingent loan contract (Townsend, 1979). Diligence is, however, difficult to observe, especially in microcredit markets.

There is a conflict of interests (a potential moral hazard problem) when the borrower prefers not to behave diligently, when at the same time the lender expects diligent behavior. Under diligence, the probability of repayment is maximized and lending costs can be covered. The conflict of interests arises if, after paying the lender, the borrower's expected residual is greater with non-diligence (which includes non-tradable benefits) than when he is diligent. Therefore, when borrowers cannot credibly contract on diligence, lenders have to find a set of incentives that assure diligence.

Figure 5 illustrates the case when the borrower has enough incentives to be diligent. Note that under diligence, if the promised repayment (R_s) increases, expected repayment will eventually be equal to all tradable returns and will leave the borrower with zero surplus. Under non-diligence, in contrast, the borrower will always keep the

⁵ For a large enough I and as a consequence of decreasing returns, tradable returns will not be enough to cover costs even in the case of diligence.

non-tradable returns, no matter how high the promised repayment becomes. Thus, to be diligent, the borrower's surplus under diligence must compensate for the loss of surplus under non-diligence. This loss is $BI + (P^{nd} - P^d)zf(I)$.

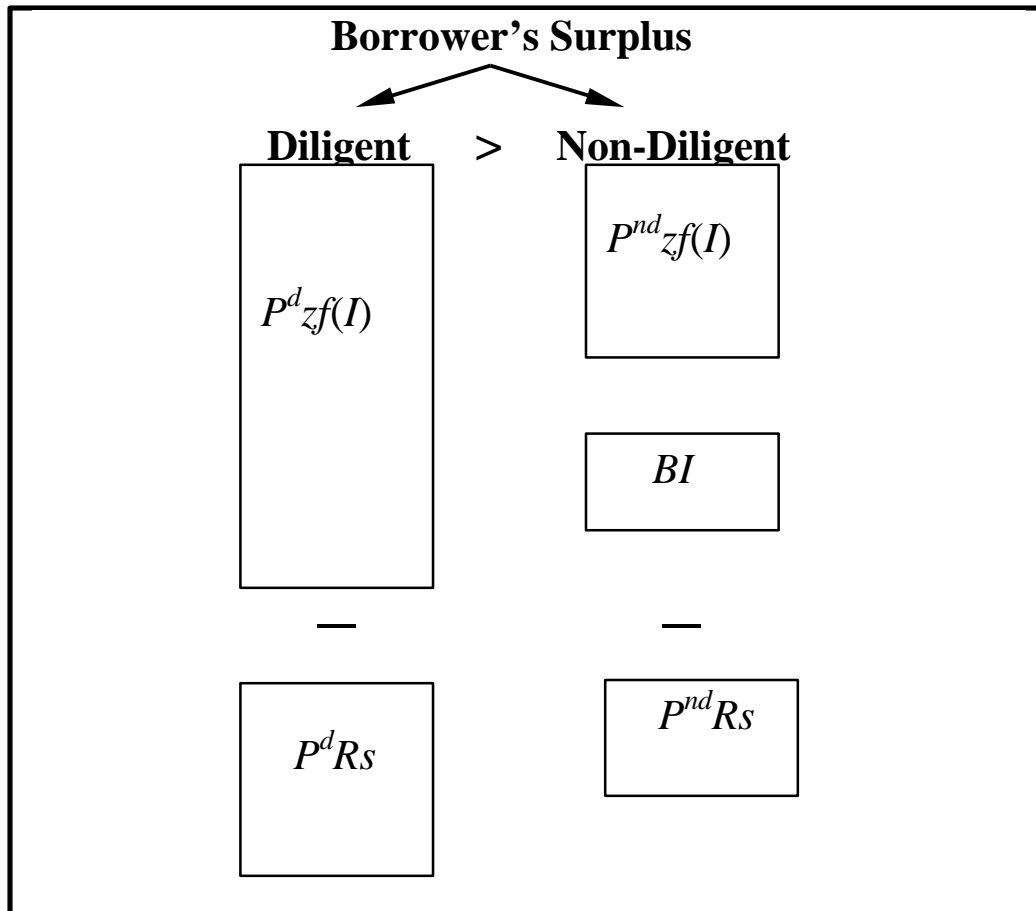


Figure 5: Borrowers' Surplus Under Different Choices of Diligence

The sequence of actions happens like this. The borrower and a competitive lender agree on the terms of a loan contract. The loan funds are invested in a project. The borrower takes some action (diligence or not), then nature takes its course. Finally, depending on the outcome, the borrower will have enough tradable returns to repay the loan or not. The incentives to repay are embedded in the terms of the loan contract. The optimization problem presented next summarizes the problem in the case of a loan with one lump payment at maturity and a borrower with collateral of size (CL).

$$\text{Max } P^i z_f(I) + B(P^i)I - P^i R_s - (1 - P^i) R_f - g I_0$$

$$I, P^i \begin{cases} P^d \\ P^{nd} \end{cases}$$

$$\text{s.t. } I_0 = 0, L \geq 0, I = I_0 + L, \quad (3.8)$$

$$P^i z_f(I) + B(P^i)I - P^i R_s - (1 - P^i)R_f - gI_0 \geq Ur = 0 \quad (3.9)$$

$$P^i R_s - (1 - P^i)R_f \geq gI, \quad (3.10)$$

$$R_s \leq z_f(I) + CL, \quad R_f = CL, \quad (3.11)$$

$$\begin{aligned} P^i z_f(I) + B(P^i)I - P^i R_s - (1 - P^i)R_f &\geq \\ P^j z_f(I) + B(P^j)I - P^j R_s - (1 - P^j)R_f & \quad i \neq j \end{aligned} \quad (3.12)$$

Equations (3.8) are the non-negativity constraints for the loan and total investment. Total investment is the sum of the initial endowment (the borrower's equity in the project) and loan size. Equation (3.9) is the borrower's participation constraint. Equation (3.10) is the lender's participation constraint. It states that the expected revenue for the lender should be equal to or greater than the lender's costs. In this case, the opportunity cost of the funds is the only cost for the lender. If competition prevails in this market, this inequality becomes an equality, to make profits equal to zero. R_s represents total repayment in case of success of the project, and R_f is repayment in case of failure of

the project. Equation (3.11) represents the limited liability constraint. Repayment, in the case of success [$R_s \leq z_f(I) + CL$] cannot exceed all the proceeds from the project plus any collateral pledged. Repayment is equal to the value of collateral ($R_f = CL$) in case of failure.

Equation (3.12) represents the incentive compatibility constraint (ICC). This constraint states that the borrower's expected return should be greater when he is diligent (not diligent) than when he is not diligent (diligent). The lender needs diligent borrowers, so the ICC under diligence will be imposed.

Let us analyze the rationale of statement (3.12) more carefully. The borrower compares his returns under each choice of effort. That is, the borrower is interested in his expected net income (surplus) after repayment. This surplus depends on diligence, as follows:

$$P^d z_f(I) - [P^d R_s + (1 - P^d) R_f] \text{ versus}$$

$$P^{nd} z_f(I) + BI - [P^{nd} R_s + (1 - P^{nd}) R_f]$$

To see under what conditions the borrower will choose to be diligent, first, let us assume that $P^d R_s + (1 - P^d) R_f = gL$. If this is true, expected repayment will just cover the opportunity cost of the lender. Next, replace this expression in the borrower's expected returns function when diligence is chosen. The resulting returns are $P^d z_f(I) - gL = P^d z_f(I) - gI$, which by assumption (3.7) are greater or equal to zero. Thus, if the borrower is diligent, expected returns will cover the promised repayment. Second, let us see what happens if we set $P^{nd} R_s + (1 - P^{nd}) R_f = gL$. Will expect

repayment cover the lender's cost? If this expression is replaced in the borrower's expected returns function when non-diligence is chosen, one gets $P^{nd} z_f(I) + BI - gL = P^{nd} z_f(I) + BI - gI$. But BI is not tradable and cannot be used to repay the loan; then, the transferable portion minus repayment is equal to $P^{nd} z_f(I) - gI$, which is negative by assumption (3.7). In other words, when non-diligence is chosen, the borrower will not have enough tradable returns to repay the loan. Therefore, the lender cannot find any set of contract terms sufficient to induce repayment under non-diligence.

If the promised repayment becomes too large, the borrower may prefer non-diligence, because under non-diligence he can always enjoy the non-tradable benefits, independently of the outcome of the project. In contrast, if the borrower is diligent, he may end up with no returns at all, since all returns may have to be used to repay the loan before any surplus is generated. Behavior will therefore depend on the borrower's surplus under each choice of action.

When the borrower is not diligent, he enjoys non-tradable benefits (the opportunity cost of diligence) at the expense of reduced tradable returns. Hence, the larger the non-tradable benefits are, the larger the difference in expected tradable returns under diligence for the borrower to have sufficient incentives to be diligent. By the same token, the larger the losses in tradable returns from not being diligent [$P^d z_f(I) - P^{nd} z_f(I)$], the less compensation the borrower needs to be diligent. The loss in tradable returns increases as the difference in probabilities of success of the debt-financed project ($\Delta P = P^d - P^{nd}$) increases when being diligent and non-diligent.

If the lender cannot be sure that the borrower has enough incentives to be diligent, no loan will be granted. This negatively affects the levels of investments. The moral hazard problem can be solved by designing a loan contract that gives the borrower enough incentives to be diligent. This can be done through changing the terms (interest rate, loan size, collateral, debt-equity ratios or monitoring) of the loan contract.

To solve the optimization problem, a simplified version of the model above is used. This version captures the most important features of the general model. The absence of an endowment of own resources is assumed ($I_0 = 0$), along with no collateral ($CL=0$). The competitive lender has perfect information about the nature of the borrower's productive project, with the exception of effort, which is unobservable. The borrower is constrained to be diligent ($P=P^d$) and has to choose a level of investment to maximize net returns. With no initial endowment, the level of investment I is equal to the size of the loan ($L=I$).

$$\text{Max}_I \quad P^d z_f(I) - P^d R_s - (1 - P^d)R_f$$

$$\text{s.t.} \quad I_0 = 0, L \geq 0, I = I_0 + L, \quad (3.13)$$

$$P^d z_f(I) - P^d R_s - (1 - P^d)R_f \geq 0, \quad (3.14)$$

$$P^d R_s + (1 - P^d)R_f = gI, \quad (3.15)$$

$$R_s \leq z_f(I), \quad R_f = 0, \quad (3.16)$$

$$P^d R_s + (1 - P^d)R_f \leq P^d z_f(I) - \frac{P^d B}{\Delta P} I + R_f, \quad (3.17)$$

$$\text{where } \Delta P = P^d - P^{nd}.$$

The incentive compatibility constraint was rearranged such that the maximum expected repayment ($P^d R_s$) compatible with diligence is on the right-hand side of inequality (3.17). If the incentive compatibility constraint is binding, the maximum

expected repayment compatible with diligence would be $P^d z_f(I) - \frac{P^d B}{\Delta P} I$. A greater promised repayment (via larger loan size or higher interest rate) is not compatible with diligence (see Appendix A for the solution).

If the incentive compatible constraint is not binding, then the optimal level of investment compatible with diligence (I_{cd}) is still equal to the social optimum, ($L = I_{cd} = I_{so}$). Under this choice, the lender still breaks even and the borrower maximizes returns at $I_{cd} = I_{so}$. However, if the constraint is binding, the resulting level of investment (I_{cd}) compatible with diligence will be lower than the social optimum (I_{so}). If this is the case, the maximum loan size offered by a competitive lender is $L = I_{cd} < I_{so}$. This case is illustrated next.

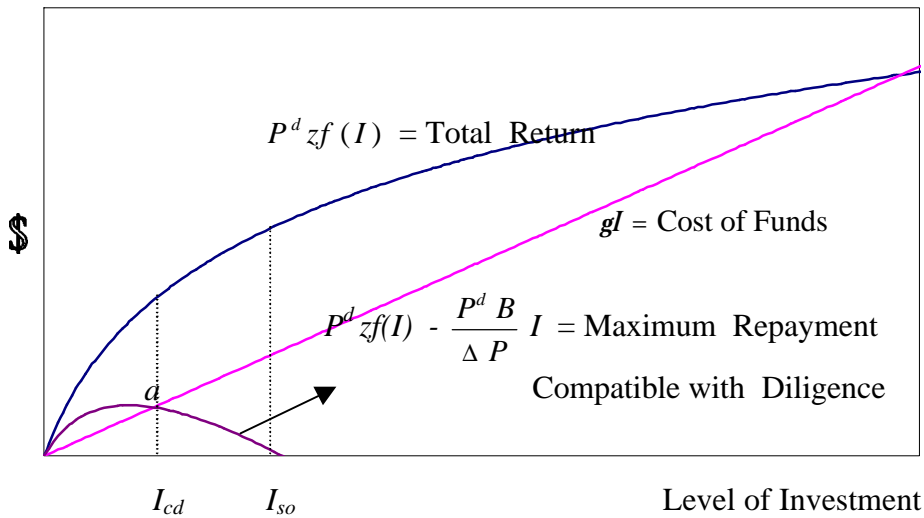


Figure 6: Maximum Loan Size with Outside Financing

Figure 6 depicts the graphic solution to the optimization problem. The maximum loan size compatible with diligence is I_{cd} , at an interest rate just enough to cover the opportunity cost of funds (point a in Figure 6). A larger loan size (at the same interest rate) or a higher interest rate (at the same loan size) will exceed the maximum repayment compatible with diligence. As the moral hazard problem intensifies (a larger B or a smaller difference in probabilities ΔP), the maximum loan size available for the ME shrinks.

The moral hazard problem has resulted in a level of investment smaller than the social optimum. How much smaller? This depends on how significant the moral hazard problem is. If the opportunity cost of being diligent (measured by the parameter B) increases, then maximum repayment compatible with diligence for each loan size shrinks. The same happens when the difference in probabilities decreases, namely, when the returns from being diligent compared to being non-diligent are not that larger. Loan size also changes with the assumptions about market structure. If this is a monopolistic market, loan size shrinks even more, compared to the social optimum (see Figure 7).

1. The Monopolistic and the Competitive Lender

Figure 7 shows the total returns of the borrower's project under diligence, the cost of funds for the lender (gI), and the minimum returns ($\frac{P^d BI}{\Delta P}$) the borrower must be allowed to keep to have enough incentive to be diligent. For this last reason, not all of the returns are available for repayment. The amount available for repayment or maximum

repayment compatible with diligence is equal to $P^d z_f(I) - \frac{P^d z_f(I)}{\Delta P} I$ (see Panel B in Figure 7).

The maximum loan size compatible with diligence under competition (profits equal to zero) is I_{cd} . If the lender is a monopolist, this loan size shrinks to I_{md} , and the lender gets monopoly rents equal to mr as shown in Panel B of Figure 7. The socially optimum level of investment is equal to $I_{so} > I_{cd} > I_{md}$. These two cases show that the effects of moral hazard differ with the structure of the market.

Yet, actual loan contracts are more complex than what has been presented here. Loan contracts use different mechanisms (for example, collateral or debt-equity requirements) to deal with information asymmetries. When these mechanisms are effective, the negative consequences of moral hazard on the level of investment can be reduced. Several of these mechanisms are studied next.

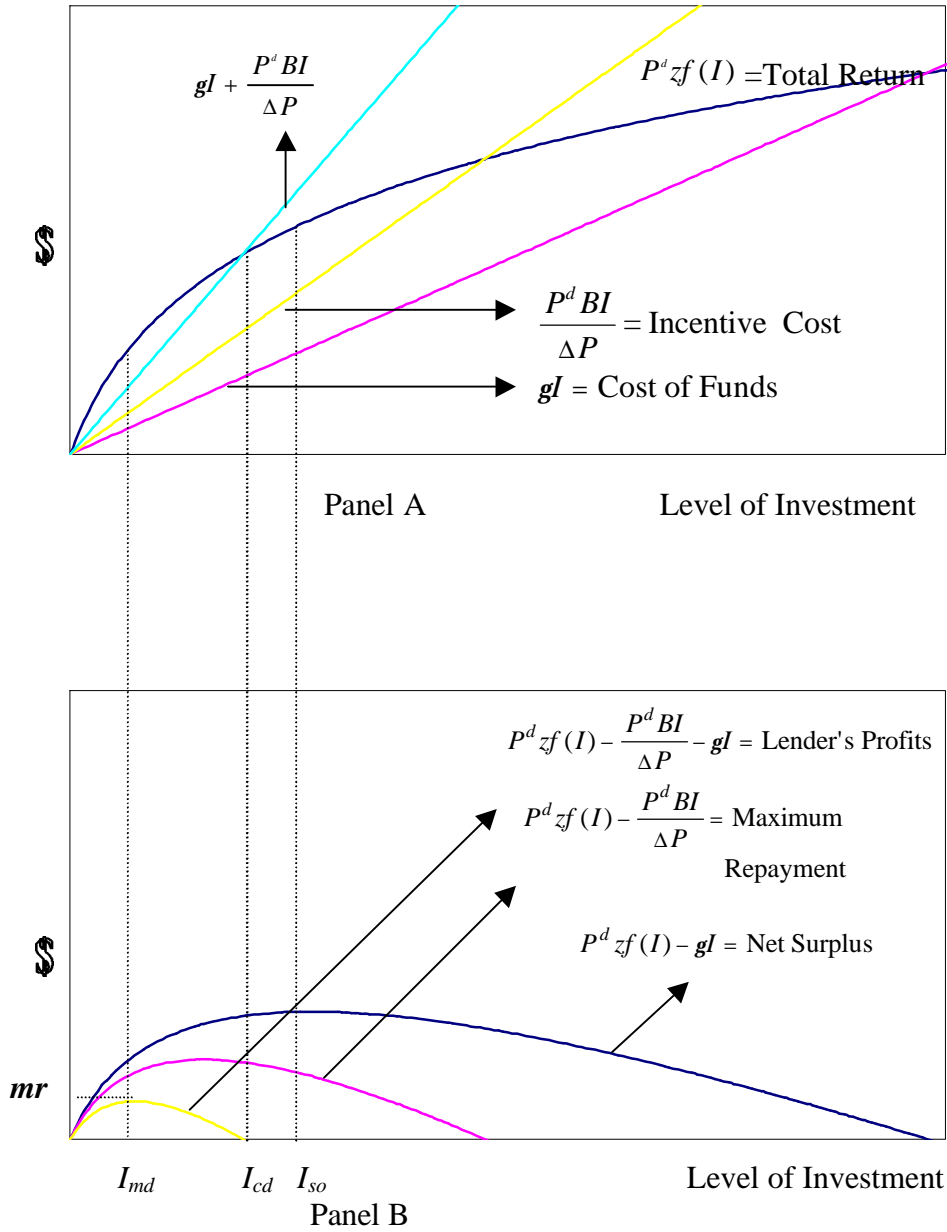


Figure 7: Net Returns, Costs and Residuals in a Competitive and a Monopolistic Market

D. Extensions of the Basic Model

1. Collateral

The introduction of collateral (CL) modifies the basic model in two ways. First, collateral increases the lender's expected repayment for a given loan size because, in case of failure of the project, there is an alternative source of repayment (equations 3.21 and 3.22). Second, collateral increases the losses for the borrower when default occurs, so the gains from opportunistic behavior are less (equation 3.23). The modified optimization problem is presented next.

$$\begin{aligned} \text{Max} \quad & P^d z_f(I) - P^d R_s - (1 - P^d)R_f \\ & I \end{aligned}$$

$$\text{s.t. } I_0 = 0, L \geq 0, I = I_0 + L, \quad (3.19)$$

$$P^d z_f(I) - P^d R_s - (1 - P^d)R_f \geq 0, \quad (3.20)$$

$$P^d R_s + (1 - P^d)R_f = gI, \quad (3.21)$$

$$R_s \leq z_f(I), \quad R_f = CL, \quad (3.22)$$

$$P^d R_s + (1 - P^d)R_f \leq P^d z_f(I) - \frac{P^d B}{\Delta P} I + R_f \quad (3.23)$$

This presentation assumes perfect transferability of the asset pledged as collateral. In other words, collateral is worth the same for both borrower and lender and nothing is lost when collateral is transferred. Graphically, the only modification to the model is the upward shift of the diligence-compatible maximum repayment function, as shown in Figure 8. The maximum repayment compatible with diligence for each loan size increases by the amount of collateral (CL). The maximum loan size compatible with diligence and a competitive lender now is $I_{pc} > I_{cd}$. Collateral is useful to ameliorate the moral hazard problem, but it limits access to only those MEs who have collateral to pledge.

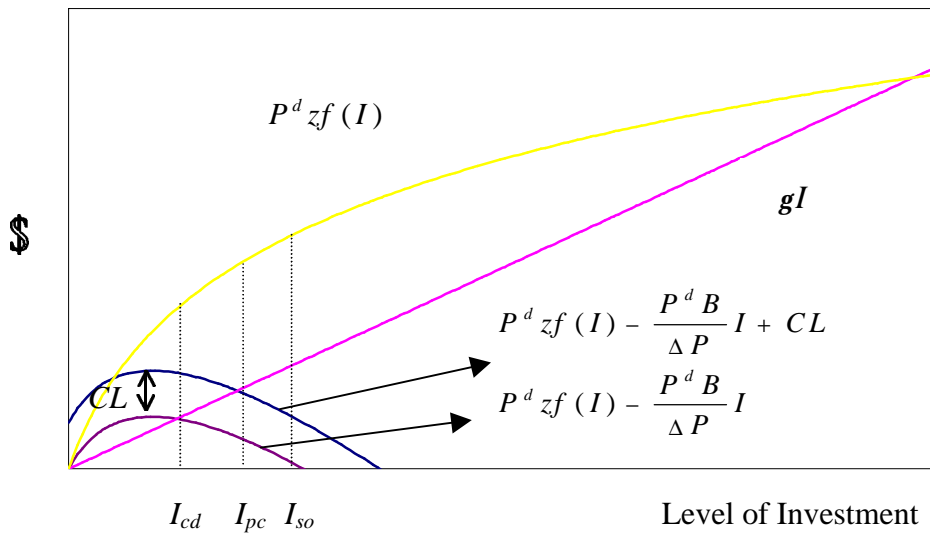


Figure 8: Effects of Perfect Collateral

2. Imperfect Collateral

Imperfect collateral are assets subject to asymmetric valuation. The lender values the assets pledged as collateral at a portion ($1 < a < 0$) of the borrower's valuation. Collateral still has a full incentive value (equation 3.28 has not been modified), but a diminished repayment value (see equation 3.26). When default occurs and collateral is transferred, for each unit of collateral the borrower loses, the lender only receives a portion a . There is a loss of $(1 - a)$ of collateral value in the transfer.

How transferable the asset pledged as collateral is depends on various factors, such as:

- (a) Enforcement mechanism. As the cost of seizing collateral increases, the value for the lender of the assets pledged decreases.

- (b) Nature of the assets. There are assets that are highly valued by the borrower but have none or little value in the market (low resale value). This is possible even in the absence of any enforcement costs, when the assets are specific or can only be replaced at a higher cost.
- (c) Information. The borrower may possess better information than the lender about the quality (*e.g.*, maintenance) of the asset (lemons' problem).

The optimization problem changes only with regards to the lender's participation constraint (equation 3.26):

$$\text{Max } P^d z_f(I) - P^d R_s - (1 - P^d)R_f$$

$$I$$

$$\text{s.t. } I_0 = 0, L \geq 0, I = I_0 + L, \quad (3.24)$$

$$P^d z_f(I) - P^d R_s - (1 - P^d)R_f \geq 0, \quad (3.25)$$

$$P^d R_s + (1 - P^d)aR_f = gI, \quad (3.26)$$

$$R_s \leq z_f(I), R_f = CL, \quad (3.27)$$

$$P^d R_s + (1 - P^d)R_f \leq P^d z_f(I) - \frac{P^d B}{\Delta P} I + R_f \quad (3.28)$$

Graphically (Figure 9), the maximum repayment function has not changed compared to the situation with perfect collateral. The only condition that has changed is the lender's participation constraint (equation 3.26), which now is equal to $P^d R_s + (1 - P^d)aCL = gI$ or $P^d R_s + (1 - P^d)CL = gI - (1 - P^d)(1 - a)CL$. Each combination of repayment and collateral ($R_s, R_f=CL$) results in a smaller return [of size $(1 - P^d)(1 - a)CL$] for the lender than with perfect collateral. This smaller return translates into a leftward shift of the cost function in Figure 9.

In summary, the introduction of imperfect collateral has two effects. The first one is an upward shift of the maximum repayment function by the size of the collateral. The

second effect is the leftward shift of the cost of funds function. The lack of perfect transferability ($a < 1$) in part diminishes the positive effect of the introduction of collateral.

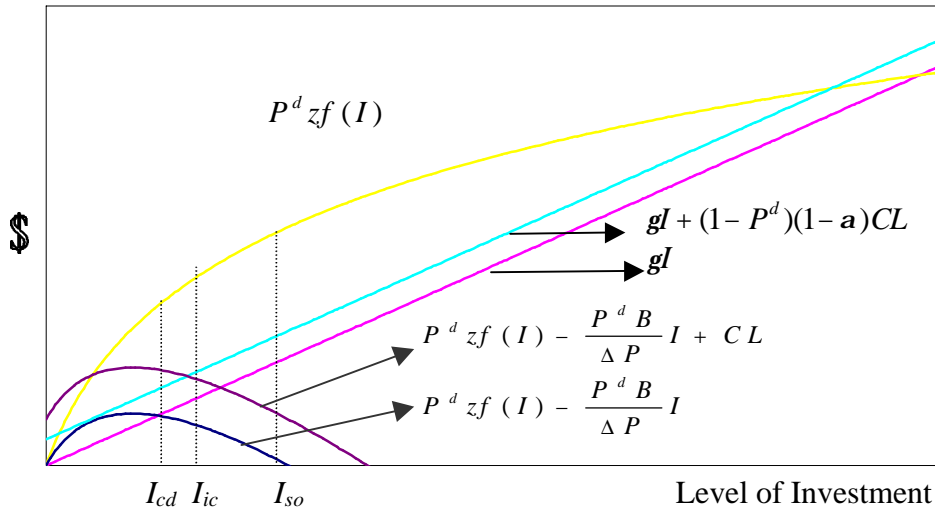


Figure 9: Effects of Imperfect Collateral

3. Debt-Equity Requirements

Another common practice among lenders are minimum debt-equity requirements. The reasoning is that an increased stake in the project will reduce the borrower's gains from opportunistic behavior. The question in the model is if equity participation takes the investment level closer to the social optimum.

In the absence of equity and when project failure occurs, the borrower's returns are zero. When the borrower invests his own money and failure occurs, his returns turn

negative. Thus, the losses from project failure increase.⁶ The optimization problem changes little:

$$\begin{aligned} \text{Max} \quad & P^d z_f(I) - P^d R_s - (1 - P^d) R_f - gI_0 \\ & I \end{aligned}$$

$$\text{s.t. } I_0 > 0, L \geq 0, I = I_0 + L, \quad (3.29)$$

$$P^d z_f(I) - P^d R_s - (1 - P^d) R_f - gI_0 \geq 0, \quad (3.30)$$

$$P^d R_s + (1 - P^d) R_f = g(I - gI_0), \quad (3.31)$$

$$R_s \leq z_f(I), R_f = 0, \quad (3.32)$$

$$P^d R_s + (1 - P^d) R_f \leq P^d z_f(I) - \frac{P^d B}{\Delta P} I + R_f \quad (3.33)$$

The equity contribution modifies the capital structure of the project: it changes the source of funds. A portion of total investment (I_0) is financed by the borrower's equity and a portion is financed by a lender ($I - I_0$). The maximum repayment function for an investment of size I does not change.

For an investment of size I , all the lender needs to cover are the costs of the loan. Tradable returns must be sufficient for this. The relevant lender's cost is now $g(I - I_0)$ instead of gI , as shown in Figure 10. Is diligence still required by the lender? It depends on leverage. We know that $P^{nd} z_f(I) - gI < 0$, so if the project is fully funded by the lender ($L=I$), then diligence is required. As leverage ($\frac{L}{I}$) decreases, there is a loan size L^* , for each level of investment, such that $P^{nd} z_f(I) - gL^* = 0$. If $L < L^*$, even under non-diligence, tradable returns will be enough to repay the loan.

⁶Since the model analyzes repayment capacity only (not willingness to repay), the borrower is assumed to use all available tradable returns to repay the loan. Default occurs only when the project fails.

For each level of investment (and consequently for each loan size), the lender compares total returns under each choice of effort, given that the lender will receive all tradable returns up to the point necessary to cover the lender's opportunity cost of funds. If $I_0 \rightarrow 0$ then $L \rightarrow I$, then most of the investment is being financed by the lender, so the moral hazard problem is present and loan size is still limited by the possibility of opportunistic behavior. As I_0 increases, the portion of tradable returns necessary to pay the loan, for each level of investment, decreases, so total investment increases. If $I_0 \rightarrow I_{so}$ then $L \rightarrow 0$, and it will be in the borrower's interest to be diligent since most of the costs are his own opportunity cost of funds

Total investment reaches $I_e > I_{cd}$ and the maximum loan size compatible with diligence is $L = I_e - I_0$. Payments to the lender are not the only expense for the borrower, who must also cover the opportunity cost of his own funds (gI_0). Payments to the lender, however, are the only portion of costs that must be covered with tradable returns.

The equity contribution positively influences total investment. But, is the borrower better off? In Figure 10, without equity, total investment reaches I_{cd} and the total return of the project is distributed as follows:

$$\begin{aligned}
 \text{Borrower's return} &= \text{Total return of} - \text{Payment to} \\
 \text{with no equity} & \quad \text{the project} \quad \quad \quad \text{the lender} \\
 &= P^d z f(I_{cd}) - g(I_{cd}) \\
 &= \overline{eg} - \overline{fg} = \overline{ef}
 \end{aligned}$$

In other words, the net return of a borrower with no equity is equal to the distance \overline{ef} in

Figure 10. The borrower will contribute some equity if his net return increases:

$$\begin{aligned}
\text{Borrower's return with equity} &= \text{Total return of the project} - \text{Payment to the lender} - \text{Opportunity cost of equity} \\
&= P^d z_f(I_e) - g(I_e - I_0) - gI_0 \\
&= \overline{ad} - \overline{cd} - \overline{bc} = \overline{ab}
\end{aligned}$$

Graphically, when there is an equity contribution, the borrower's return (distance \overline{ab}) is greater than when there is no equity contribution (distance \overline{ef}). The reason is that the equity contribution makes possible a larger investment, with marginal returns still higher than the opportunity cost of funds.

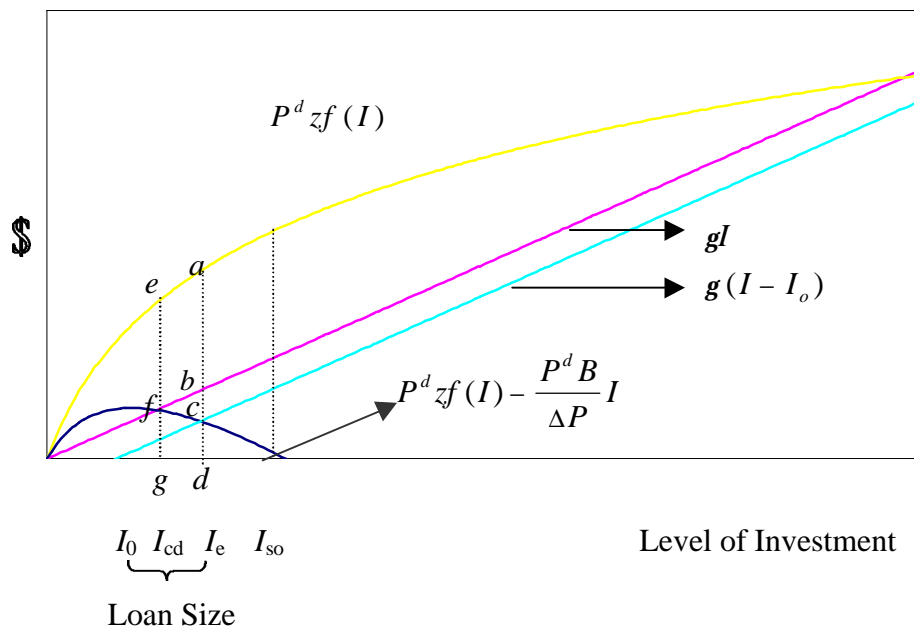


Figure 10: Effects of Debt-Equity Requirements

4. Fixed Lending Costs

Lenders not only have to pay for the opportunity cost of funds, there are usually fixed lending costs (fc) associated with the loan, independently of loan size. The introduction of these costs in the model is simple. Expected repayment now has to cover the opportunity cost of funds (gl) plus the fixed lending costs (fc).

The effect of fixed costs translates graphically into an upward shift of the lender's cost line (Figure 11). Therefore, the maximum loan size compatible with diligence and zero profits for the lender shrinks from I_{cd} to I_{fc} .

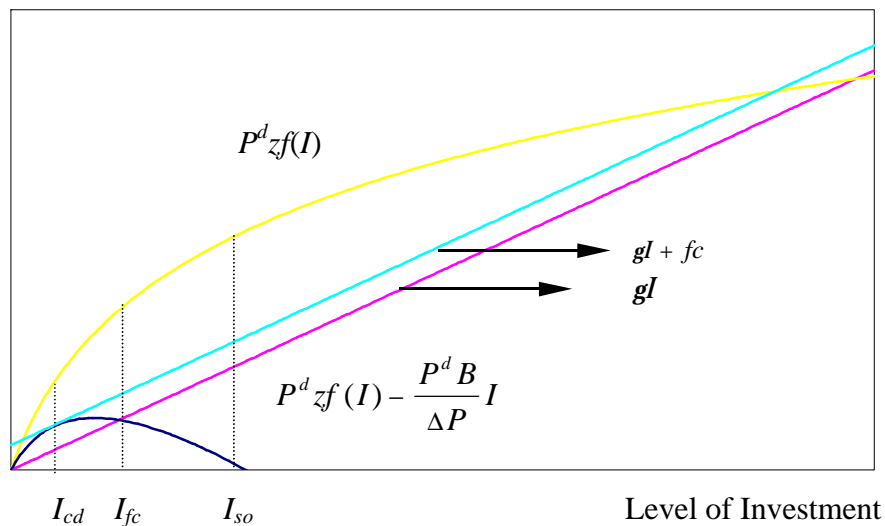


Figure 11: Effects of Fixed Lending Costs

5. Monitoring

Monitoring is designed to constraint the borrower's behavior and reduce the gains from opportunistic behavior. Through monitoring, lenders want to ensure that the borrowers are diligent. Monitoring does not simply consist in supervising the borrower; it will have an effect only if the borrower's gains or losses are influenced by monitoring.

In the model, the influence of monitoring (cm) is two-fold. First, it increases the costs of the lender for any given loan size. Second, it reduces the borrower's non-tradable benefits up to a point [$B'(cm) < 0$ and $B''(cm) \geq 0$]. Thus, monitoring increases the maximum repayment for each loan size (Conning, 1996 and 1998):

$$\begin{aligned} \text{Max } & P^d z_f(I) - P^d R_s - (1 - P^d)R_f \\ & I \\ \text{s.t. } & I_0 = 0, L \geq 0, I = I_0 + L, \end{aligned} \quad (3.34)$$

$$P^d z_f(I) - P^d R_s - (1 - P^d)R_f \geq 0, \quad (3.35)$$

$$P^d R_s + (1 - P^d)R_f = gI + cm, \quad (3.36)$$

$$R_s \leq z_f(I), \quad R_f = CL, \quad (3.37)$$

$$P^d R_s + (1 - P^d)R_f \leq P^d z_f(I) - \frac{P^d B(cm)}{\Delta P} I + R_f \quad (3.38)$$

As shown in Figure 12, monitoring reduces the gains from not being diligent, so the slope of the maximum repayment function becomes steeper and the maximum repayment consistent with diligence for each loan size increases. The increased cost is reflected in an upward shift of the lender's cost function.

If the positive effect of monitoring on the lender's returns - through the maximum repayment function - is greater than the negative effect of the increased cost, then the level of investment increases. This case is shown in Figure 12, where the level of

investment goes from I_{cd} to I_{cm} when monitoring takes place. The positive effects of monitoring reach a limit when $B(cm)'=0$. At this point, any increase in monitoring only affects costs.

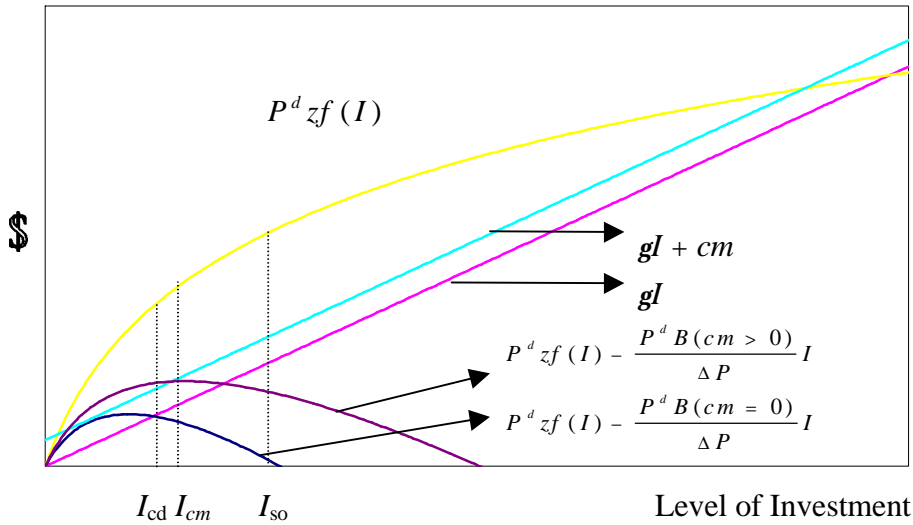


Figure 12: Effects of Monitoring

E. Summary

This chapter has analyzed the effects of moral hazard on the level of investment. When the ME finances his project with a loan, the possibility for opportunistic behavior arises (moral hazard). To avoid this problem, lenders use different mechanisms. Table 1 summarizes the result from the adoption of these mechanisms.

	Changes in the Level of Investment (I)
Collateral (CL)	+
Imperfect Collateral ($a CL$)	+
Equity Contribution (I_o)	+
Fixed Lending Costs (fc)	-
Monitoring (cm)	+ / -

Table 1: The Effects of Collateral, Equity and Costs on the Level of Investment

Collateral requirements decrease the losses for the lender and increase the losses for the borrower when the project fails. The introduction of collateral increases the level of investment.

Not all assets are valued the same by borrowers and lenders. When there is asymmetric valuation, especially when the lender values the asset pledged as collateral at a portion of what it is valued by the borrower, the positive effects of collateral are less than under perfect collateral. The effects of imperfect collateral, however, are still positive.

The requirement of an equity contribution increases the losses for the borrower when the main source of repayment (the project) fails, therefore diminishing the gains from opportunistic behavior.

Fixed lending costs influence the residual left to the borrower, as the lender needs to charge more to recover his costs. The gains from opportunistic behavior increase.

Given the usual class of production function (decreasing marginal returns) and the nature of non-tradable benefits (proportional to the level of investment), loan size has to be reduced for borrowers to still have incentives to behave diligently. Accordingly, total investment declines.

The effects of monitoring are ambiguous. Monitoring negatively influences the gains from opportunistic behavior (reducing non-tradable benefits), but it also increases lender costs and thereby in interest rates. Total investment is reduced when the negative effects of the increased costs dominate the positive effects of the reduction of non-tradable benefits. Monitoring will only occur when its net benefits are positive.

CHAPTER 4

A JOINT TREATMENT OF MORAL HAZARD AND ADVERSE SELECTION

A. Introduction

Chapter 3 analyzed the effects of the terms of the loan contract on borrower behavior and on the resulting level of investment, under the maintained assumption that the only piece of information that the lender does not possess concerns the degree of diligence exerted by the borrower. It was assumed that all other relevant variables are known to the lender.

This chapter analyzes changes in the terms of the loan contract when one more unknown is introduced. This unknown is the productivity type of the ME (parameter z in the model). The uninformed party, the lender, must now deal with the effects of information asymmetries about both actions (diligence) and type (productivity).

The features of the population of MEs are summarized by a cumulative density function $G(z)$ over productivity type z . Assuming that the lowest z in the population is z_L and the highest is z_H , then the unconditional mean z for the population is:

$$E(z) = \int_{z_L}^{z_H} zg(z)dz \quad (4.1)$$

The ability of the lender to design a profitable contract depends on how much information he has about this distribution. Different stocks of information lead to different loan contracts, which in turn match different ME types. Several cases are examined next.

B. A Loan Contract Based on Average Productivity

The simplest case of adverse selection occurs when the lender has information *only* about the average productivity of the MEs in the population, where productivity is the only difference among them. A contract based on the average ME results from the following optimization exercise:

$$\begin{aligned} \text{Max } & P^d \bar{z}f(I) - P^d Rs - (1 - P^d)R_f \\ & I \\ \text{s.t. } & I_0 = 0, L \geq 0, I = I_0 + L, \end{aligned} \quad (4.2)$$

$$P^d \bar{z}f(I) - P^d Rs - (1 - P^d)R_f \geq Ur, \quad (4.3)$$

$$P^d Rs + (1 - P^d)R_f = gI, \quad (4.4)$$

$$Rs \leq \bar{z}f(I), R_f = 0, \quad (4.5)$$

$$P^d Rs + (1 - P^d)R_f \leq P^d \bar{z}f(I) - \frac{P^d B}{\Delta P} I + R_f, \quad (4.6)$$

where \bar{z} is the MEs' average productivity.

The solution to this problem is a loan contract of size \bar{I} and a promised repayment equal to \bar{Rs} . Given these loan terms, a competitive lender expects to be able to recover costs, which implies $P^d \bar{Rs} = g\bar{I}$. Not all borrowers will be diligent, however, and not all MEs will be willing to participate by taking this contract.

Assuming that the ICC (equation 4.6) is a binding constraint for the average ME, then, for high-productivity MEs ($z \geq \bar{z}$), this constraint will not be binding:

$$P^d \bar{R}_s < P^d z f(\bar{I}) - \frac{P^d B}{\Delta P} \bar{I} \quad , \quad \text{or}$$

$$P^d z f(\bar{I}) - P^d \bar{R}_s > P^{nd} z f(\bar{I}) - P^{nd} \bar{R}_s - B \bar{I}$$

because $\frac{\partial [P^d z f(\bar{I}) - P^d \bar{R}_s]}{\partial z} = P^d f(\bar{I}) > \frac{\partial [P^{nd} z f(\bar{I}) - P^{nd} \bar{R}_s + B \bar{I}]}{\partial z} = P^{nd} f(\bar{I})$.

In other words, as productivity increases, the returns from being diligent increase more than the returns from not being diligent do. Thus, high-productivity MEs will become diligent borrowers and low-productivity MEs will become non-diligent borrowers.

Not all low-productivity MEs will take this loan contract, however. MEs with very low productivity will be better off by taking advantage of their best alternative occupation. Recall the borrower's participation constraint:

$$P^{nd} (z f(\bar{I}) - \bar{R}_s) + B \bar{I} \geq U r \quad , \quad \text{or}$$

$$z \geq \frac{P^d \bar{R}_s}{P^{nd} f(\bar{I})} + \frac{U r - B \bar{I}}{P^{nd} f(\bar{I})} = z_0$$

All MEs of productivity type $z < \bar{z}_l$ will be better off by engaging in the best alternative opportunity than by taking a loan contract of terms (\bar{I}, \bar{R}_s) . Notice that the threshold \bar{z}_l is independent of any assumptions about the distribution $G(z)$ in the population. It is only a function of the loan terms (\bar{R}_s, \bar{I}) .

Table 2 summarizes the results for three classes of MEs:

ME Class	Productivity Type	Incentive Compatibility Constraints
Diligent Borrowers	$z_H \geq z > \bar{z}$	$P^d z f(\bar{I}) - P^d \bar{R}s \geq P^{nd} z f(\bar{I}) - P^{nd} \bar{R}s + B\bar{I} > Ur$
Non-Diligent Borrowers	$\bar{z} \geq z > \bar{z}_l$	$P^{nd} z f(\bar{I}) - P^{nd} \bar{R}s + B\bar{I} \geq P^d z f(\bar{I}) - P^d \bar{R}s > Ur$
Non-Applicants	$\bar{z}_l \geq z \geq z_L$	$Ur \geq P^{nd} z f(\bar{I}) - P^{nd} \bar{R}s + B\bar{I} > P^d z f(\bar{I}) - P^d \bar{R}s$

Note: The population is distributed from z_L to z_H , where \bar{z} is the average productivity and is at the same time the upper threshold that separates diligent from non-diligent borrowers, \bar{z}_l represents the lower threshold that separates MEs that prefer to stay out of this market.

Table 2: Conditions for Self-Selection of Applicants for an Average Contract

The lender's expected repayment is a weighted average of the repayment from all borrowers (diligent or not):

$$j(\bar{R}s, \bar{I}) = b(\bar{R}s, \bar{I})P^d \bar{R}s + [1 - b(\bar{R}s, \bar{I})]P^{nd} \bar{R}s \quad (4.7)$$

where b is the proportion of diligent borrowers and the complement $(1 - b)$ is the proportion of non-diligent borrowers in the lender's portfolio. The contract was designed so $P^d \bar{R}s = g\bar{I}$. For the lender to break even, given the loan terms $(\bar{R}s, \bar{I})$, all borrowers must be diligent ($b = 1$). However, a proportion of borrowers will not be diligent ($b < 1$), so expected repayment does not cover the lender's costs ($j(\bar{R}s, \bar{I}) < g\bar{I}$).

Therefore, a contract based on the average ME is not profitable. This is a typical result in adverse selection models. The reason why this is the case here is, nevertheless, different. In the insurance problem, for example, an average contract is not profitable because the average applicant is a worse risk type than the population average upon

which the contract is based. In the present case, the average borrower is even more productive than the average ME, because the least productive MEs will find the best alternative occupation to be more attractive and will not demand credit. Nonetheless, only the most productive borrowers ($z_H \geq z > \bar{z}$) will be diligent, and the rest of the borrowers ($\bar{z} \geq z > \bar{z}_l$) will not. With this limited information, no lender will be willing to offer a loan contract, unless the lender can design a contract such that his costs can be covered, by designing either profitable pooling or profitable separating contracts.

C. Collateral and Adverse Selection

As the available information improves, the opportunities to design better contracts also improve. This section analyzes changes in the model when collateral is introduced. The assumptions are that the lender has information only about the average productivity of the MEs and about the holdings of collateral assets of the ME of average productivity (\overline{CL}).

1. Average Collateral

The loan terms offered by the lender result from the following optimization problem:

$$\begin{aligned} \text{Max } & P^d \bar{z}_f(I) - P^d R_s - (1 - P^d)R_f \\ & I \\ \text{s.t. } & I_0 = 0, L \geq 0, I = I_0 + L, \end{aligned} \tag{4.8}$$

$$P^d \bar{z}_f(I) - P^d R_s - (1 - P^d)R_f \geq Ur, \tag{4.9}$$

$$P^d R_s + (1 - P^d)R_f = g, \tag{4.10}$$

$$R_s \leq \bar{z}_f(I) + CL, R_f = \overline{CL}, \tag{4.11}$$

$$P^d R_s + (1 - P^d) R_f \leq P^d \bar{z} f(I) - \frac{P^d B}{\Delta P} I + R_f, \quad (4.12)$$

The resulting loan terms offered by a competitive lender to a ME of average productivity (\bar{z}) and collateral assets equal to \overline{CL} are a loan of size $\overline{I_{CL}}$ with repayment in the success state equal to $\overline{Rs_{CL}}$ and repayment in the failure state equal to \overline{CL} . If this is the loan contract offered to all MEs, will the lender be able to break even? This depends on how productivity and holdings of collateral assets are related. There are three possible scenarios.

a. Positive Relationship between Productivity and Collateral

In this first case, where $r(z, CL) > 0$, the loan terms $(\overline{Rs_{CL}}, \overline{CL}, \overline{I_{CL}})$ divide MEs into two classes. The first class is composed of those MEs of productivity \bar{z} or greater, who have collateral assets of size \overline{CL} or greater. These MEs have enough collateral assets to be able to take the loan. The second class consists of all those MEs who have less collateral assets than what is required by this particular loan contract ($CL < \overline{CL}$).

As in the previous case, all well-endowed, high-productivity MEs ($z \geq \bar{z}$ and $CL \geq \overline{CL}$) have enough incentives to be diligent, because the ICC is not binding. Since poorly-endowed, lower-than-average productivity MEs ($z < \bar{z}$ and $CL < \overline{CL}$) cannot take the loan, all borrowers are now diligent.

Table 3 summarizes the results for the case when collateral is a good signal of productivity type. This allows the lender to design a contract that leads to perfect screening.

MEs Class	Productivity Type and Collateral Assets	Incentive Compatibility Constraints
Diligent Borrowers	$z_H \geq z \geq \bar{z}$ and $CL \geq \bar{CL}$	$P^d \bar{z} f(\bar{I}_{CL}) - P^d \bar{R}_{S_{CL}} - (1 - P^d) \bar{CL} \geq$ $P^{nd} \bar{z} f(\bar{I}_{CL}) - P^{nd} \bar{R}_{S_{CL}} - (1 - P^{nd}) \bar{CL} + B \bar{I}_{CL} > U r$
Non-Applicants	$\bar{z} > z \geq z_L$ and $CL < \bar{CL}$	n.a.

n.a.= Not applicable

Table 3: Conditions for Self-Selection of Applicants for an Average Contract that includes Collateral (Case a)

In this case, the expected repayment from each borrower is $P^d \bar{R}_{S_{CL}} + (1 - P^d) \bar{CL}$, which is equal to $g \bar{I}_{CL}$ because all borrowers are diligent. Low productivity MEs are not able to pledge the required collateral, so they will not adversely influence the returns of the lender. Collateral is an efficient screening tool.

b. No Relationship between Productivity and Collateral

If there is no relationship between productivity and collateral assets [$r(z, CL) = 0$], the loan terms $(\bar{R}_{S_{CL}}, \bar{CL}, \bar{I}_{CL})$ will divide the MEs into three classes.

The first class will include those MEs who have enough collateral assets (more than the average) and who find the loan contract attractive enough to be diligent. The second class is composed of those MEs with enough collateral who still find investing under the loan terms more attractive than the best alternative, but who do not face enough incentives to be diligent. The third class consists of non-applicant MEs, either because

they find the best next alternative more attractive than the debt-financed project or because they do not have enough collateral assets to pledge, as shown in Table 4.

MEs Class	Productivity Type and Collateral Assets	Incentive Compatibility Constraints
Diligent Borrowers	$z_H \geq z \geq \bar{z}$ and $CL \geq \bar{CL}$	$P^d z f(\bar{I}_{CL}) - P^d \bar{R}_{S_{CL}} - (1 - P^d) \bar{CL} \geq$ $P^{nd} z f(\bar{I}_{CL}) - P^{nd} \bar{R}_{S_{CL}} - (1 - P^{nd}) \bar{CL} + B \bar{I}_{CL} > Ur$
Non-Diligent Borrowers	$\bar{z} > z \geq z_0$ and $CL \geq \bar{CL}$	$P^{nd} z f(\bar{I}_{CL}) - P^{nd} \bar{R}_{S_{CL}} - (1 - P^{nd}) \bar{CL} + B \bar{I}_{CL} \geq$ $P^d z f(\bar{I}_{CL}) - P^d \bar{R}_{S_{CL}} - (1 - P^d) \bar{CL} > Ur$
Non-Applicants	$z_0 > z \geq z_L$ and $CL \geq \bar{CL}$	$Ur \geq P^{nd} z f(\bar{I}_{CL}) - P^{nd} \bar{R}_{S_{CL}} - (1 - P^{nd}) \bar{CL} + B \bar{I}_{CL} >$ $P^d z f(\bar{I}_{CL}) - P^d \bar{R}_{S_{CL}} - (1 - P^d) \bar{CL}$
	$z_H \geq z \geq z_L$ and $CL < \bar{CL}$	n.a.

n.a.= Not applicable

Note: The population is distributed from z_L to z_H , where \bar{z} is the average productivity and is at the same time the upper threshold that separates diligent from non-diligent collateral-endowed borrowers, and z_0 represents the lower threshold that separates collateral-endowed MEs who prefer to stay out of this market.

Table 4: Conditions for Self-Selection of Applicants for an Average Contract that includes Collateral (Case b)

The resulting expected repayment for the lender will be an average for all borrowers who were able to pledge collateral assets equal to \bar{CL} and who find the loan terms attractive enough to engage in the debt-financed project:

$$j(\bar{R}_{S_{CL}}, \bar{CL}, \bar{I}_{CL}) = b \left[P^d \bar{R}_{S_{CL}} + (1 - P^d) \bar{CL} \right] + (1 - b) \left[P^{nd} \bar{R}_{S_{CL}} + (1 - P^{nd}) \bar{CL} \right]$$

where, again, b is the proportion of diligent borrowers and $(1 - b)$ is the proportion of non-diligent borrowers in the portfolio. This loan contract was designed so

$P^d \overline{Rs_{CL}} + (1 - P^d) \overline{CL} = g \overline{I_{CL}}$, that is, the lender breaks even. If a portion of the borrowers are not diligent ($b < 1$), then the contract yields negative profits [$j(\overline{Rs_{CL}}, \overline{CL}, \overline{I_{CL}}) < g \overline{I_{CL}}$]. In this particular case, the availability of collateral is not a good signal of ME type and, therefore, it is not enough to separate MEs by productivity type. The success of the lending technology will depend on the proportion of applicants with enough collateral who also choose to be diligent.

c. Negative Relationship between Productivity and Collateral

The last case is when there is a negative relationship between productivity and holdings of collateral assets [$r(z, CL) < 0$]. What will happen if, under these conditions, a contract based on the average ME is offered?

Highly productive MEs ($z > \bar{z}$) do not have, by assumption, enough collateral ($CL < \overline{CL}$) to comply with the terms of the loan contract. Only low-productivity borrowers possess enough collateral to apply for a loan ($z \leq \bar{z}$ and $CL \geq \overline{CL}$).

Since the loan contract is based on the average ME, the ICC becomes an equality; in this case, average MEs will be diligent borrowers. For low-productivity MEs, the ICC becomes an inequality of the form:

$$P^d \overline{Rs_{CL}} + (1 - P^d) \overline{CL} < P^d \bar{z} f(\overline{I_{CL}}) - \frac{P^d B}{\Delta P} \overline{I_{CL}} + \overline{CL}, \text{ or}$$

$$P^d \bar{z} f(\overline{I_{CL}}) - P^d \overline{Rs_{CL}} - (1 - P^d) \overline{CL} < P^{nd} \bar{z} f(\overline{I_{CL}}) - P^{nd} \overline{Rs_{CL}} - (1 - P^{nd}) \overline{CL} + B \overline{I_{CL}}$$

low-productivity MEs will become non-diligent borrowers because:

$$-\frac{\partial \left[P^d z f(\overline{I_{CL}}) - P^d \overline{R_{S_{CL}}} - (1 - P^d) \overline{CL} \right]}{\partial z} = -P^d f(\overline{I_{CL}}) <$$

$$-\frac{\partial \left[P^{nd} z f(\overline{I_{CL}}) - P^{nd} \overline{R_{S_{CL}}} - (1 - P^{nd}) \overline{CL} + B \overline{I_{CL}} \right]}{\partial z} = -P^{nd} f(\overline{I_{CL}})$$

since $P^d > P^{nd}$.

Ceteris paribus, as productivity decreases, the return from being non-diligent increases more than the return from being diligent, so low-productivity MEs will prefer to be non-diligent. Again, not all low-productivity MEs will be willing to take this loan contract. Recall the participation constraint:

$$P^{nd} z f(\overline{I_{CL}}) - P^{nd} \overline{R_{S_{CL}}} - (1 - P^{nd}) \overline{CL} + B \overline{I_{CL}} \geq Ur, \text{ or}$$

$$z \geq \frac{P^d \overline{R_{S_{CL}}} + (1 - P^d) \overline{CL}}{P^{nd} f(\overline{I_{CL}})} + \frac{Ur - B \overline{I_{CL}}}{P^{nd} f(\overline{I_{CL}})} = z_0$$

Some wealthy, but too low productivity MEs ($z < z_0$ and $CL > \overline{CL}$) are better off by taking advantage of their best next alternative occupation. Results for the three classes of MEs are presented in Table 5.

The lender's expected return will be

$$b \left[P^d \overline{R_{S_{CL}}} + (1 - P^d) \overline{CL} \right] + [1 - b] \left[P^{nd} \overline{R_{S_{CL}}} + (1 - P^{nd}) \overline{CL} \right] < g \overline{I_{CL}}$$

where b is the proportion of diligent borrowers (in this case, only the average MEs) and $(1 - b)$ is the proportion of non-diligent borrowers in the portfolio. Under present assumptions, this pooling contract creates incentives enough to be diligent only for the average ME. The rest of the borrowers will not be diligent, making the loan contract unprofitable.

ME Class	Productivity Type and Collateral Assets	Incentive Compatibility Constraints
Diligent Borrowers	$z = \bar{z}$ and $CL = \bar{CL}$	$P^d \bar{z}f(\bar{I}_{CL}) - P^d \bar{R}S_{CL} - (1 - P^d)\bar{CL} =$ $P^{nd} \bar{z}f(\bar{I}_{CL}) - P^{nd} \bar{R}S_{CL} - (1 - P^{nd})\bar{CL} + B\bar{I}_{CL} > Ur$
Non-Diligent Borrowers	$\bar{z} > z \geq z_0$ and $CL > \bar{CL}$	$P^{nd} \bar{z}f(\bar{I}_{CL}) - P^{nd} \bar{R}S_{CL} - (1 - P^{nd})\bar{CL} + B\bar{I}_{CL} \geq$ $P^d \bar{z}f(\bar{I}_{CL}) - P^d \bar{R}S_{CL} - (1 - P^d)\bar{CL} > Ur$
Non-Applicants	$z_0 > z \geq z_L$ and $CL > \bar{CL}$	$Ur \geq P^{nd} \bar{z}f(\bar{I}_{CL}) - P^{nd} \bar{R}S_{CL} - (1 - P^{nd})\bar{CL} + B\bar{I}_{CL} >$ $P^d \bar{z}f(\bar{I}_{CL}) - P^d \bar{R}S_{CL} - (1 - P^d)\bar{CL}$
	$z_H \geq z > \bar{z}$ and $CL < \bar{CL}$	n.a.

n.a.= Not applicable

Note. The population is distributed from z_L to z_H , where \bar{z} is the average productivity and z_0 represents the lower threshold that separates collateral-endowed MEs who prefer to stay out of this market.

Table 5: Conditions for Self-Selection of Applicants for an Average Contract that includes Collateral (Case c)

Collateral is both an incentive to repay and a signal for low productivity. That is, borrowers with more collateral than others will be less likely to engage in opportunistic behavior, given the incentive effect of collateral, but at the same time their low productivity (signaled by collateral) accomplishes the opposite. In this case, collateral-based lending will result in a misallocation of resources. High-productivity MEs will underinvest and low-productivity MEs will overinvest.

D. Known Distribution of Productivity Types

Let us assume now that the lender has prior beliefs about the distribution of productivity types (z) in the population of MEs but cannot determine the productivity type of each particular ME.⁷ That is, the lender knows the cumulative density function $G(z)$ but not z . The terms of the loan contract will lead the MEs to self-select into different classes.

Given (Rs, I) , some MEs will find attractive to take the loan and be diligent.

Recall the incentive compatibility constraint (without collateral):

$$P^d Rs \leq P^d z f(I) - \frac{P^d B}{\Delta P} I \quad \text{or} \quad z \geq \frac{B}{\Delta P f(I)} I + \frac{Rs}{f(I)} = z_T$$

Any borrower with $z \geq z_T(Rs, I)$ prefers to be diligent. Low-productivity MEs with $z < z_T(Rs, I)$ will prefer not to be diligent and rather enjoy non-tradable benefits. Not all low-productivity MEs will apply for a loan, however. Those MEs with very low z will prefer to remain engaged in their next best opportunity and earn Ur . That is, the lender will receive only applications from MEs who earn more with the loan contract than without it:

$$P^{nd} (z f(I) - Rs) + BI \geq Ur$$

or

$$z \geq \frac{Rs}{f(I)} + \frac{Ur - BI}{P^{nd} f(I)} = \underline{z}$$

The two thresholds (z_T, \underline{z}) are independent of the underlying distribution $G(z)$, but are affected by changes in the terms of the loan contract.

⁷ If productivity type could be recognized by the lender, the problem is reduced to the general problem presented in Chapter 5.

If the lender raises the interest rate without changing any other term of the loan contract, a large number of borrowers will prefer to enjoy non-tradable benefits (be non-diligent)

because $\frac{dz_T}{dRs} = \frac{1}{f(I)} > 0$, and the total number of borrowers will decline because

$\frac{dz}{dRs} = \frac{1}{f(I)} > 0$. An increase in the opportunity cost of being diligent has, however,

opposite effects on the threshold values of z 's. A higher opportunity cost decreases the number of diligent borrowers because $\frac{dz_T}{dB} = \frac{I}{\Delta Pf(I)} > 0$, but it increases the total

number of borrowers since $\frac{dz}{dB} = -\frac{I}{P^{nd} f(I)} < 0$. In summary, the terms of the loan

contract (Rs, I) divide MEs in three classes, as shown in Table 6:

MEs Class	Productivity Type	Incentive Compatibility Constraints
Diligent Borrowers	$z_H \geq z > z_T$	$P^d z f(I) - P^d Rs \geq P^{nd} z f(I) - P^{nd} Rs + BI > Ur$
Non-Diligent Borrowers	$z_T \geq z > \underline{z}$	$P^{nd} z f(I) - P^{nd} Rs + BI \geq P^d z f(I) - P^d Rs > Ur$
Non-Applicants	$\underline{z} \geq z \geq z_L$	$Ur \geq P^{nd} z f(I) - P^{nd} Rs + BI > P^d z f(I) - P^d Rs$

Table 6: Conditions for Self-Selection of Applicants for a Pooling Contract with a Known Distribution

The lender's expected repayment $j(Rs, I)$ will be, again, a weighted average of expected repayment from diligent and non-diligent borrowers:

$$j(Rs, I) = b(Rs, I)P^d Rs + [1 - b(Rs, I)]P^{nd} Rs$$

A competitive lender will break even only if:

$$j(R_s, I) = b P^d R_s + (1 - b) P^{nd} R_s = gI.$$

For a given loan of size I , the lender faces two offsetting effects when he raises interest rates. On the one hand, a raising R_s means that the lender obtains a higher promised repayment from all successful borrowers, diligent or otherwise. On the other hand, a higher interest rate changes the composition the borrowing pool, as some previously diligent borrowers (z just above z_T) now decide to become non-diligent and some previously non-diligent borrowers decide to drop out of the pool (z just above \underline{z}). The precise manner in which the lender's expected return will change thus depends on the distribution of z in the population.

1. The Loan Contract

In this case, the lender knows the distribution of productivity types in the population. This allows the lender to design a pooling contract to break even. This requires:

$$j(R_s^*, I^*) = b(R_s^*, I^*) P^d R_s^* + [1 - b(R_s^*, I^*)] P^{nd} R_s^* = gI^*$$

As shown in Table 6, any pooling contract (R_s^*, I^*) divides the population into a class of borrowers and a class of non-applicants. Depending on their productivity, the borrowers will choose to be diligent or not.

The expected repayment from the diligent borrowers is equal to $P^d R_s^*$ which is greater than the cost of funds gI^* . The reason for this is that diligent borrowers cross-subsidize non-diligent borrowers, who on average pay $P^{nd} R_s^*$, which is smaller than gI^* . The degree of subsidy will depend on the proportion of diligent versus non-diligent

borrowers in the lender's portfolio. If the diligent borrowers were able to reveal their type (without incurring in any cost), they would get a larger loan at a lower interest rate. By the same token, low-productivity types would get a smaller loan at a higher interest rate.

In other words, high-productivity borrowers will underinvest for two reasons. First, they cannot be distinguished from less productive MEs (adverse selection effects). Second, diligence cannot be observed (moral hazard effects). In turn, lower ability borrowers ($z_T \geq z > \underline{z}$) invest more than if their type could be observed (cross-subsidization effect) and some very low productivity types ($\underline{z} \geq z \geq z_L$) do not invest at all, although some investment from them may be socially desirable.

E. When the Distribution of Collateral Assets among the Population is Known

As the stock of information increases, lenders find more opportunities to design even better loan contracts. Suppose that the lender has information about both the distribution of available collateral assets and the distribution of types among the population of MEs, but that he does not know the productivity type of each particular ME. Earlier, a pooling contract was obtained in the absence of collateral. If the possibility of pledging collateral exists, is it possible to use it to separate borrower types?

A lender with this information and the lending technology to design a wider set of contracts can now offer loan contracts that require a minimum size of collateral for a maximum size of loan, expecting to break even with each borrower. This separating equilibrium works as long as there is a positive relationship between ability type and collateral assets, so low-productivity types cannot mimic high-productivity types. If this is not true and if low-productivity types can mimic high-productivity types, then these

contracts will not be enough to separate borrower types. These two cases are explored next.

a. Positive Relationship between Productivity and Collateral

In this case, the resulting terms of the contract result from the following optimization for the j borrower:

$$\text{Max } P^d z_j f(I) - P^d R_s - (1 - P^d) R_f$$

$$I$$

$$\text{s.t. } I_0 = 0, L \geq 0, I = I_0 + L_j, \quad (4.13)$$

$$P^d z_j f(I) - P^d R_s - (1 - P^d) R_f \geq 0, \quad (4.14)$$

$$P^d R_s + (1 - P^d) R_f = gI, \quad (4.15)$$

$$R_s \leq z_j f(I) + CL, R_f = \overline{CL}, \quad (4.16)$$

$$P^d R_s + (1 - P^d) R_f \leq P^d z_j f(I) - \frac{P^d B}{\Delta P} I + R_f, \quad (4.17)$$

The solution to this problem is (R_{s_j}, CL_j, I_j) . The lender expects only borrowers of class j to take this contract, so $j(R_{s_j}, CL_j, I_j) = gI_j$. If there is a positive relationship between ability type and collateral assets, by definition less productive borrowers ($z_i < z_j$) cannot mimic j types ($CL_i < CL_j$). The question is, will more productive borrowers ($z_i > z_j$) and ($CL_i > CL_j$) find it profitable to take the contract designed for j types? Let us analyze this in two steps. First, we need to know if when borrowers i take the contract designed for j types they will prefer to be diligent or not. Once their optimal behavior under contract j is determined, we need to compare their returns to the situation where contract i is taken.

This contract j requires a repayment of $P^d R s_j + (1 - P^d) CL_j$ equal to $P^d z_j f(I_j) - \frac{P^d B}{\Delta P} I_j + CL_j$, which is smaller than $P^d z_i f(I_j) - \frac{P^d B}{\Delta P} I_j + CL_j$, the maximum repayment for borrowers i compatible with diligence. This happens because $z_i > z_j$. In other words, if borrowers i took contract j ($R s_j, CL_j, I_j$), they would choose to be diligent.

Next, we must compare the return for borrowers i when they are diligent under contract i and j . If contract i is preferred, then the following inequality must hold:

$$P^d z_i f(I_i) - P^d R s_i - (1 - P^d) CL_i \geq P^d z_i f(I_j) - P^d R s_j - (1 - P^d) CL_j$$

$$P^d z_i f(I_i) - g I_i \geq P^d z_i f(I_j) - g I_j$$

where $z_i \geq z_j$.

This inequality holds as long as $I \leq I_{so}^i$, where I_{so}^i is the socially optimum size of investment for MEs of type i . This happens because I_{so}^i maximizes $P^d z_i f(I) - g I$. Borrowers of type i are better off by taking their own contract than by taking contract j . In conclusion, collateral requirements successfully separates borrowers, so profitable separating contracts are possible.

b. Negative Relationship between Productivity and Collateral

If there is a negative relationship between productivity and collateral assets, more productive MEs ($z_i > z_j$) cannot take the contract designed for j types because they will not be able to pledge the required collateral. Low-productivity types ($z_i < z_j$), however, have enough collateral to take the contract designed for j types. As in the previous case, we will first compare the returns for the low-productivity types ($z_i < z_j$ and $CL_i > CL_j$) who

take contract j and will then determine if they will be diligent or not. Once their optimal behavior is determined, the return has to be compared to the situation under their own contract.

The j contract requires a repayment of $P^d R_{S_j} + (1 - P^d)CL_j$ equal to $P^d z_j f(I_j) - \frac{P^d B}{\Delta P} I_j + CL_j = gI_j$, which is greater than $P^d z_i f(I_j) - \frac{P^d B}{\Delta P} I_j + CL_j$, the maximum repayment for borrowers i compatible with diligence. This happens because $z_i < z_j$. In other words, if borrowers i took contract j (R_{S_j} , CL_j , I_j), they would choose to be non-diligent. These lower productivity borrowers then compare the return from being not diligent under contract j versus their returns under their own contract i :

$$P^{nd} z_i f(I_j) + BI_j - P^{nd} R_{S_j} - (1 - P^{nd})CL_j \text{ versus } P^d z_i f(I_i) - P^d R_{S_i} - (1 - P^d)CL_i$$

Depending on the value of the parameters, it may be attractive to take the loan contract of borrowers with higher productivity. If this is the case, the separating contracts will be unprofitable.

F. Summary

This chapter analyzed several ways how loan contracts are designed when the lender has asymmetric information about the productivity type of the borrowers (adverse selection problem) and about their actions (moral hazard problem). The lender's response to these problems depends on the type of information and collateral available.

The first case is when the lender has information only about the average productivity of the MEs and there is no collateral, either because the MEs do not have assets to pledge or because the lender does not have the technology to take the type of

collateral the MEs have. A pooling contract based on this limited information is unprofitable. This results not from the average borrowers being less productive than the average ME; in fact, the average borrower is more productive than the average ME, because the least productive MEs prefer to engage in their best alternative occupation. Instead, the loan contract is unprofitable because it offers enough surplus for diligent behavior only to borrowers of average or more than average productivity. The rest of the borrowers are better off by not behaving diligently and thereby taking advantage of non-tradable benefits.

The second case inquires about changes in loan contract terms when the lender has information about the average productivity and holdings of collateral assets of the MEs. If the lender is constrained to a single contract and designs this contract based on this limited information, three scenarios are possible.

The first scenario is when there is a positive relationship between productivity and collateral assets. In this case, collateral serves as a powerful filter. Only high-productivity MEs will be able to fulfill the terms of the contract and they are the only type of borrowers who have incentives to be diligent. In consequence, collateral successfully separates higher from lower productivity MEs and discourages the latter from taking the loan contract. The loan contract is profitable.

The second and third scenarios consider the consequences of a negative relationship or no relationship at all between productivity and collateral, respectively. In both cases, collateral is useful as a means to separate higher productivity from low productivity borrowers, but the loan contract is unprofitable.

The third case analyzes the implications of increased lender information. In this case, the lender has information about the whole distribution of productivity types and not only about a moment of the distribution (average). The lender cannot locate, however, a specific individual in the distribution. A pooling contract under these limitations can be profitable. The lender can design a loan contract that takes into account the facts that some MEs will not take the contract and that among those who do take the contract some will be diligent and others will not. Separating loan contracts are not possible because low-productivity borrowers can take the loan contracts designed for high-productivity borrowers, thereby negatively influencing the profitability of these loan contracts.

In the fourth case, the lender has information about the distribution of productivity types and collateral assets among the population of MEs. The question here is if the lender can design separating loan contracts where a maximum loan size is offered for a minimum size of collateral. Two broad scenarios are studied. When there is a positive relationship between productivity and collateral, low-productivity borrowers cannot take the loan contract designed for high-productivity borrowers. High-productivity MEs are better off by taking their own contract rather than by taking the loan contracts designed for low-productivity borrowers. When there is a negative relationship between productivity and collateral, low-productivity borrowers may take the loan contract designed for high-productivity borrowers. Therefore, profitable separating contracts may not exist even with this increased amount of information and collateral possibilities.

CHAPTER 5

THE CONTRACTS OF TWO MICROLENDERS IN BOLIVIA:

BANCOSOL AND CAJA LOS ANDES

A. Introduction

One of the most interesting, competitive, and rapidly changing markets for microfinance today is the market in the city of La Paz, Bolivia. The population of borrowers being reached by Bolivian microlenders is quickly expanding, as a growing number of state-owned, non-governmental, and private microfinance providers enter to supply the market (Baydas *et al.*, 1997; Dorado-Banacloche, 1998; Marulanda, 1998; Navajas and Schreiner, 1998; Wall Street Journal, 1997). The introduction of new lending technologies and the achievement of economies of scale have been key determinants of this growth.

A number of microlenders compete and coexist in this market, each one using different organizational structures and lending technologies to reach the poor in a cost-effective manner. Two lenders stand out: Banco Solidario (BancoSol), arguably one of the world's most famous profitable commercial microlenders, and Caja Los Andes (Los Andes), also a profitable competitor. Both began operations as not-for-profit NGOs but later became profitable commercial lenders. Measured both by the number of borrowers

reached and the amount of portfolio outstanding, these two microlenders together supply over 50 percent of all lending to small and medium urban businesses in Bolivia, a market that hardly existed more than a decade ago (Navajas and Schreiner, 1998).

B. The Development of Microfinance in Bolivia

The development of the market for microfinance in Bolivia may be usefully divided into three stages.

The first stage is characterized by the dominance of BancoSol.⁸ Created in 1992 from the client base developed since 1987 by PRODEM, its NGO predecessor, BancoSol established an early presence through the extensive use of its group lending technology. To qualify for a loan, a borrower needs no physical collateral but must belong to a joint-liability credit group (Casanovas and Mac Lean, 1994).

The second stage is marked by the emergence of Caja Los Andes in 1992 as a new lender and serious competitor⁹. In contrast to BancoSol, Caja Los Andes uses individual liability lending. Los Andes also differs in that it spends substantially more resources in screening borrowers and that it also asks borrowers to pledge their valuables as collateral, even though it is evident that seizing these valuables (*e.g.*, sofa, television set, radio) typically would yield relatively little to the lender (Gonzalez-Vega *et al.*, 1997a).

⁸A more detailed discussion about the creation and evolution of BancoSol can be found in Aganoff (1994), Glosser (1992), Gonzalez-Vega *et al.* (1997b), Katsuma (1997), Mosley (1996), and Krützfeldt (1997).

⁹ See Solares de Valenzuela (1997) for more details about Caja Los Andes.

Both BancoSol and Caja Los Andes have greatly expanded the scale of their operations since 1992. Although Los Andes has grown in part by reaching some larger clients that BancoSol might never have reached with its group lending technology, it is also evident that their clienteles substantially overlap. Many of Los Andes' new clients shifted from BancoSol, but the evidence suggests that BancoSol has captured very few borrowers in return.

Los Andes clients appear to possess more liquid collateral wealth, and they are on average more educated. This is also true of the borrowers who shifted from BancoSol to Caja Los Andes. Both lenders offer contingent-renewal loans that grow larger over time when borrowers repay on time, but BancoSol tends to offer a smaller and more standardized loan contract to first-time borrowers, which also grows more slowly over time compared to the loans provided by Los Andes.

BancoSol and Caja Los Andes were, by the end of 1995, the two largest microlenders in Bolivia. BancoSol had 63,038 borrowers and Caja Los Andes 15,954 borrowers. Together they shared around 40 percent of the microlending market. These are impressive numbers since all commercial banks (without including BancoSol) were reaching only 126,912 borrowers. The growth in scale is remarkable when the situation is compared to a few years back. In 1990, for instance, commercial banks and microlenders had only around 120,000 borrowers (CIPAME, 1997; Gonzalez-Vega *et al.*, 1997a and SBIF, 1997).

The third and most recent stage has been characterized by increasing competition from new commercial lenders and a process of consolidation of the initial actors. New lenders in Bolivia include finance companies that offer new forms of consumer credit to

a segment of the population that considerably overlaps with the existing customer base served by BancoSol and Caja Los Andes. These processes, though particular to Bolivia, may well reflect similar processes unfolding in other countries and contexts (Sharma and Zeller, 1996).

C. The Relevance of the Theoretical Framework

In order to better understand the dynamics of contract choice and competition in this market, a theoretical model was developed to explain behavior when the lender is faced with both moral hazard and adverse selection problems (Chapters 3 and 4). The analysis in the present chapter is enriched with the introduction of problems of scale and with an application of the model to two Bolivian microlenders.

The effects of contract design and market competition on the potential pool of MEs faced by lenders that use different lending technologies are studied within this theoretical framework. Lenders compete with one another in the market for loans by offering different loan contracts to a population of MEs (Petersen and Rajan, 1995; Van Tassel, 1998). The population of MEs is assumed to be heterogeneous, as different MEs have different levels of productivity and collateral wealth. The level of productivity of a ME cannot be observed by a lender unless a screening cost is incurred. A lender who does not screen will attract a different pool of borrowers depending on the terms of the loan contract that it offers as well as on the nature of the contracts from other lenders in the market.

1. The Importance of Economies of Scale

This chapter also sheds light on another important but frequently overlooked tradeoff between size (number of borrowers) and quality (repayment record) in a loan portfolio. Increasing size is important because lenders typically have substantial fixed costs at the organization's level (handling costs). An increase in the number of borrowers helps to reduce average fixed costs of lending (Gonzalez-Vega, 1976). One way to expand very quickly and to keep the costs of handling each loan application low is to offer a simplified and standardized loan contract. If the lender economizes on the resources used to select the best borrowers from its pool of applicants and to tailor contracts to each borrower, however, it may find that the quality of its applicant pool declines, as measured, for example, by its arrears rate.

Micro lenders always face a tradeoff between relaxing their requirements, in the hope of being able to reach a larger scale at a lower average cost, and the fall off in quality that often accompanies rapid expansion and standardization. The nature of this tradeoff changes, however, with different lending technologies with the level of interest rates, and as competition from other lenders alters the pool of applicants.

D. Two Lenders, Two Different Loan Contracts

To set up the model, let us abstract from peer-monitoring and peer-selection effects. BancoSol offers individual loans backed by the joint liability of all members of a credit group. Los Andes offers individual loans with no joint liability clause, but it screens borrowers more intensively and accepts imperfect collateral, thereby reducing uncertainty about productivity type.

BancoSol offers a standardized loan contract based on its best guess about the distribution of the quality of projects because it does not screen its borrowers as well as Los Andes does. As a consequence of more effective screening, over time Los Andes will attract the most productive borrowers in the pool and those endowed with more valuable assets. These two lenders compete for clients via the terms in their loan contracts and differences in contract terms match different segments of the target population.

1. The “All for One” Contract offered by Caja Los Andes

Los Andes offers a personalized loan contract. This is possible because its lending technology allows the lender to recognize the borrower’s productivity type (z in the model) through sufficient screening. Thus, the adverse selection problem is minimized, at a cost, for Los Andes. The moral hazard problem is, however, still present, since diligence is unobservable. Screening also allows Los Andes to recognize which collateral assets have high consumption value for the borrower and could potentially be used as imperfect collateral, since perfect collateral is scarce in this market niche.

To reflect Caja Los Andes’ actual practices and circumstances, we need to modify the model in the following form. First, to break even, every borrower is charged an amount to cover the lender’s fixed costs ($fc + hc$), made up of a fixed screening cost fc and handling cost hc . Screening costs are independent of loan size and, in addition, handling costs are given independently of portfolio size. Also, each borrower’s promise to repay must cover any individual monitoring costs cm that may be incurred to ameliorate moral hazard problems (cases D.4 and D.5 in Chapter 3). Second, Los Andes employs imperfect collateral (case D.2 in Chapter 3). As part of its lending technology,

Los Andes draws up an inventory of household valuables such as TV sets, radios or furniture, which the borrower is in effect asked to pledge as collateral. The ME pledges an asset worth CL to the borrower. If Los Andes were to seize the asset, however, it would only collect aCL . The discrepancy reflects differences in valuation or the costs of seizing and reselling property.

With respect to the simplest case (a case with no collateral or additional fixed costs), the specification of the problem changes in the following way. The function for maximum repayment compatible with diligence is first revised to reflect the presence of collateral and of monitoring costs. Thus,

$$(P^d R_s + (1 - P^d)CL) \leq P^d z f(I) - \frac{P^d B(cm)}{\Delta P} I + CL,$$

since collateral still has a full incentive value on the borrower. Second, the lender's participation constraint changes because collateral is imperfect and fixed costs of two types as well as monitoring costs are added:

$$P^d R_s + (1 - P^d)aCL = gI + fc + hc + cm \tag{6.1}$$

For each individual borrower, handling costs (hc) are "fixed", since they do not vary with the size of loan, but they vary with the size of the lender's pool of borrowers. Average handling costs are equal to the lender's total handling costs divided by the number of borrowers ($hc = \frac{THC}{nb}$).

As in Chapter 3, the solution to the problem can be calculated by combining limited liability, incentive compatibility, and the break-even conditions of the lender.

The solution is such that maximum repayment compatible with diligence is equal to the lender's costs:

$$gI + cm + fc + hc + (1 - P^d)(1 - a)CL = P^d z f(I) - P^d \frac{B(cm)}{\Delta P} I + CL, \text{ or}$$

$$gI + cm + fc + hc = P^d z f(I) - P^d \frac{B(cm)}{\Delta P} I + CL - (1 - P^d)(1 - a)CL$$

In other words, part the value of the borrower's repayment is lost in the transfer.

The value of repayment is reduced for the lender by $(1 - P^d)(1 - a)CL$. This term reflects the fact that when the borrower gives up CL , only a portion is received by the lender. A portion $(1 - a)$ is lost in the transfer when default occurs.

As noted before, the screening investment fc allows Los Andes to reduce uncertainty about each individual z and thereby offer a better contract. Remember, however, that without sufficient collateral or with excessive costs, the loan size offered by Los Andes may still be smaller than the loan needed for a socially optimum level of investment.

2. The "One for All" Contract offered by BancoSol

BancoSol needs to cover handling costs just as Caja Los Andes does. BancoSol, does not, however, incur fixed screening costs because, in contrast to Los Andes, it offers a standardized loan contract to all takers (a pooling equilibrium). Screening allows Los Andes to identify imperfect collateral (assets with high consumption value) in a market niche where perfect collateral is scarce. BancoSol does not have the lending technology to assess imperfect collateral, so this option does not exist for this organization. Monitoring costs are also lower, because BancoSol uses joint liability as an

alternative mechanism to secure repayment.¹⁰ For simplicity, the effects of joint liability can be captured through the introduction of monitoring in the borrower's return function but with zero cost to BancoSol.

In other words, BancoSol forms a prior guess about the productivity type of the MEs. The lender's prior beliefs are summarized by a cumulative density function over the productivity of the borrowers (z). Assuming that the lowest z in the population is z_L and the highest is z_H , then the unconditional mean z in this population is:

$$E(z) = \int_{z_L}^{z_H} zg(z)dz \quad (6.2)$$

This, however, is not the average quality of the borrower who actually arrive at BancoSol's loan desk. When BancoSol offers a standard loan contract, some borrowers will find it profitable to accept the contract and others will not. Furthermore, amongst those who accept the contract, some will be diligent and others will not, because high-productivity borrowers (high z) earn a higher expected return from being diligent, while low-productivity borrowers (low z) earn more by diverting funds into non-tradable benefits. The manner in which borrowers self-select into these categories will obviously have an impact on BancoSol's expected profits. BancoSol must take this into account at the time of designing its contracts, so its operation remains financially sustainable. Results for the three classes of MEs are shown in Table 7.

¹⁰ Joint-liability contracts, including some similar to the contract used by BancoSol, have been explored, among others, by Armendariz de Aghion, 1994; Berenbach and Guzmán, 1994; Besley and Coate, 1996; Benjamin, 1994; Conning, 1997; Ghatak, 1997; Paxton, 1996; Sadoulet, 1997; Stiglitz, 1990; Untalan, 1996; Varian, 1990; and Wenner, 1995).

MEs Class	Productivity Type	Incentive Compatibility Constraints
Diligent Borrowers	$z_H \geq z > z_T$	$P^d z f(I) - P^d R_s \geq P^{nd} z f(I) - P^{nd} R_s + BI > Ur$
Non-Diligent Borrowers	$z_T \geq z > \underline{z}$	$P^{nd} z f(I) - P^{nd} R_s + BI \geq P^d z f(I) - P^d R_s > Ur$
Non-Applicants	$\underline{z} \geq z \geq z_L$	$Ur \geq P^{nd} z f(I) - P^{nd} R_s + BI > P^d z f(I) - P^d R_s$

Note: The population is distributed from z_L to z_H , where z_T is the upper threshold that separates diligent from non-diligent borrowers and \underline{z} represents the lower threshold that separates MEs who prefer to stay out of this market.¹¹

Table 7: Conditions for Self-Selection of Applicants for BancoSol's Contract

In other words, for given R_s and I , only those borrowers with productivity $z \geq z_T(R_s, I)$ will choose to be diligent. Any borrower with $z < z_T(R_s, I)$ earns more by not being diligent. If BancoSol raises the interest rate without changing any other terms of the contract, more borrowers become less diligent because $\frac{dz_T}{dR_s} = \frac{1}{f(I)} > 0$. Very low productivity borrowers with $z < z_T(R_s, I)$ are lower quality borrowers because they are less diligent and therefore have a higher default rate in BancoSol's portfolio. But not all MEs with low z will apply for a loan. Very low productivity MEs ($z < \underline{z}$) will prefer to remain engaged in their next best opportunity and earn Ur .

¹¹ The determination of the threshold z 's can be found in section D of Chapter 4.

Ceteris paribus, more MEs decide to stay out of the market (threshold \underline{z} rises) as the interest rate (expected repayment level R_s) rises, because $\frac{d\underline{z}}{dR_s} = \frac{1}{f(I)} > 0$. Also, fewer MEs will be interested in starting the lending relationship as outside opportunities (e.g., the expected compensation from working in a formal factory job rather than being a ME) improve ($\frac{d\underline{z}}{dU_r} = \frac{1}{P^d f(I)} > 0$). In fact, BancoSol started when these job opportunities fell dramatically in Bolivia (Sachs and Morales, 1988).

BancoSol's total expected repayment $j(R_s, I)$ will be a weighted average of its expected average repayment from diligent and non-diligent borrowers:

$$\begin{aligned}
 j(R_s, I) &= \frac{\int_{\underline{z}(R_s, I)}^{z_H(R_s, I)} g(z) dz}{z_H(R_s, I) - \underline{z}(R_s, I)} P^d R_s + \frac{\int_{\underline{z}(R_s, I)}^{z_T(R_s, I)} g(z) dz}{z_H(R_s, I) - \underline{z}(R_s, I)} P^{nd} R_s \\
 &= \frac{[G(z_H(R_s, I)) - G(z_T(R_s, I))]}{[G(z_H(R_s, I)) - G(\underline{z}(R_s, I))]} P^d R_s + \frac{[G(z_T(R_s, I)) - G(\underline{z}(R_s, I))]}{[G(z_H(R_s, I)) - G(\underline{z}(R_s, I))]} P^{nd} R_s \\
 &= b P^d R_s + (1 - b) P^{nd} R_s
 \end{aligned}$$

BancoSol will be financially sustainable only if:

$$j(R_s, I) = b P^d R_s + (1 - b) P^{nd} R_s \geq gI + hc \quad (6.3)$$

For a given loan size I , BancoSol faces two offsetting effects when it raises the interest rate on its loans. On the one hand, raising R_s means that the lender earns a higher expected return from all successful borrowers, diligent or otherwise. On the other hand,

the higher interest rate also changes the composition of the borrowing pool, as some previously diligent borrowers (who had z just above z_T) decide to become non-diligent and some previously non-diligent borrowers decide to drop out of the pool (those who had z just above \underline{z}). The precise manner in which BancoSol's expected return will change depends on the distribution of z in the population.

The expected average repayment has to be sufficient to cover the opportunity cost of capital and all fixed costs (screening and monitoring costs are assumed to be zero for BancoSol). Note that the average handling costs change with the absolute number of borrowers in the pool, while the fixed screening cost is constant for each borrower no matter how many borrowers the lender reaches. The quality of BancoSol's portfolio will deteriorate as it raises the interest rate on a given size of loan. One indicator of quality is the default rate of its portfolio, which can be calculated as:

$$\text{Proportion of loans in default} = \mathbf{b}(1 - P^d) + (1 - \mathbf{b})(1 - P^{nd}) \quad (6.4)$$

E. A Numerical Simulation

1. One lender: BancoSol

Suppose that the distribution of z in the population is standard normal, so $G(z) = N[0,1]$. To be concrete, suppose that with a loan size of $I = 100$, diligent MEs of productivity level z have a probability $P^d = 0.9$ of successfully generating a return equal to $zf(I) = z \cdot 300$. Since z varies between 0 and 1, the distribution of returns in the population varies between 0 and 300. A non-diligent ME generates the same return but less frequently, as $P^{nd} = 0.6$. Assume also that the total population of MEs is 100 and

that there are \$1,000 of total handling costs (*THC*). Table 8 summarizes the parameters of the simulation.

Lump sum investment	<i>I</i>	100
Fraction of investment diverted	<i>B</i>	0.15
Equity	<i>I_o</i>	0
Opportunity cost of funds	<i>g</i>	1.10
ME's Alternative Opportunity	<i>Ur</i>	15
Production function	<i>z_f(I)</i>	<i>z</i> (300)
Probability of project success:		
Diligent	<i>P^d</i>	0.9
Non-Diligent	<i>Pnd</i>	0.6
Total Number of MEs	<i>MEs</i>	100
Total Handling Costs	<i>THC</i>	1000

Table 8: Parameters of the Simulation

Assume furthermore that the only lender in the market is BancoSol and that this lender knows all the parameters of the problem, including those of the distribution of z in the population. The specific location of each individual in that population is unknown, however, Table 9 summarizes the results of the simulation on the composition of borrowers and the lender's expected return as a function of the interest rate charged (the interest rate is $\frac{R_s}{I} - 1$).

This simple simulation captures several interesting features of the loan market in the presence of moral hazard and adverse selection. As Table 9 indicates, raising the interest rate (raising R_s) raises both \underline{z} and z_T . At an interest rate of around 70 percent, 43 percent of the population of MEs apply for a loan. Thus, BancoSol earns an expected

repayment of $P^d R_s = 0.9(170) = 153$ on each of its diligent borrowers, and $P^{nd} R_s = 0.6(170) = 102$ on each of its non-diligent borrowers.

Interest Rate (%)	\underline{z}	z_t	Number of Borrowers	Average Repayment		Average			Default Rate (%)
				Non-Diligent	Diligent	Repayment	Costs	Profits	
0	0.33	0.50	67	60	90	82	125	-43	18
10	0.37	0.53	64	66	99	90	126	-36	18
20	0.40	0.57	60	72	108	98	127	-29	19
30	0.43	0.60	57	78	117	105	128	-22	19
40	0.47	0.63	53	84	126	112	129	-16	20
50	0.50	0.67	50	90	135	119	130	-11	20
60	0.53	0.70	47	96	144	126	131	-5	21
70	0.57	0.73	43	102	153	133	133	-1	22
80	0.60	0.77	40	108	162	139	135	3	23
90	0.63	0.80	36	114	171	144	138	7	24
100	0.67	0.83	33	120	180	149	141	9	25
110	0.70	0.87	29	126	189	153	144	9	27
120	0.73	0.90	26	132	198	156	149	7	29
130	0.77	0.93	23	138	207	157	154	3	32
140	0.80	0.97	19	144	216	156	162	-6	35
150	0.83	1.00	16	150	0	150	173	-23	40

Table 9: BancoSol’s Portfolio Composition as a Function of the Interest Rate

BancoSol’s costs have two components. These are the opportunity cost of funds (\$110 on each \$100 lent) and handling costs (\$1000/number of borrowers). Average handling costs increase as the interest rate increases because the pool of borrowers shrinks (influencing hc).

When the interest rate reaches 70 percent, the lender breaks even. At this point, the lender will be charging 13 percent above its costs of lending to diligent borrowers and this will cross-subsidize the 23 percent expected loss on non-diligent borrowers. Since

the non-diligent borrowers are $\frac{[G(z_T) - G(\underline{z})]}{[1 - G(\underline{z})]} = 43$ percent of the pool of clients and the diligent borrowers are the remaining 57 percent, the lender's average expected return on its portfolio is:

$$\begin{aligned} & \frac{[G(z_T) - G(\underline{z})]}{[1 - G(\underline{z})]} P^{nd} R_S + \frac{[1 - G(z_T)]}{[1 - G(\underline{z})]} P^d R_S \\ &= (0.40)(0.6)(170) + (0.60)(0.9)(170) \\ &= 40.8 + 91.8 \approx 133 \end{aligned}$$

Table 9 also shows that at the break even interest rate (70 percent), the subsidy from the diligent to the non-diligent borrowers is just enough to cover costs. Before this level of the interest rate is reached, diligent borrowers already pay more than non-diligent borrowers compared to the cost of lending to them but in a proportion not yet sufficient to cover all the costs of the lender.

The numerical simulation shows how one would calculate an interest rate that is consistent with allowing the lender to break even on a loan of a given size. The break-even condition is met when BancoSol charges an interest rate of 70 percent. Profits are maximized at an interest rate of around 100 percent.

a. Ability to Repay

The break-even loan contract ($R_S=170, I=100$) divides the population of MEs into three classes, non-applicants, non-diligent borrowers, and the diligent borrowers, depending on their ability to repay and best alternative occupation. The breakdown of MEs is shown in Figure 13. The diagonal tells how much a ME of a given productivity type will generate if the project is successful. For example, a borrower of productivity type \underline{z} will generate 170 and a borrower of productivity z_t will generate 220 in tradable

returns. These tradable returns are available for repayment if the project is successful. The project, however, is not always going to be successful. The probability of being successful depends on diligence. If the ME is diligent, we assume that the project is successful 90 percent of the time and, if he is not diligent, the project is successful 60 percent of the time. The expected returns from the project that are available for repayment are the probability of success of the project times the diagonal or $P^i z f(I)$. When the ME is diligent, so $P^i = P^d = 0.90$, the expected available return for repayment is closer to the diagonal. When the ME is non-diligent, $P^i = P^{nd} = 0.60$, the expected returns for repayment are farther down from the diagonal.

Above the threshold z_t , borrowers are diligent. The relevant expected ability to repay is $0.90 z f(I)$. Below z_t , the expected ability to repay is lower and equal to $0.6 z f(I)$. Under the threshold \underline{z} , the MEs prefer not to borrow because their productivity is very low, so the best alternative occupation is preferred.

For a loan of size 100 and an interest rate of 70 percent, all borrowers (ME of at least productivity type \underline{z}) promise to repay 170. Some of them will generate returns that are sufficient to repay the loan. All diligent borrowers will generate, on average, 198 or more in tradable returns. So, all of them will be able to repay the loan. The borrowers of productivity type below z_t will no generate, on average, sufficient returns to repay the loan.

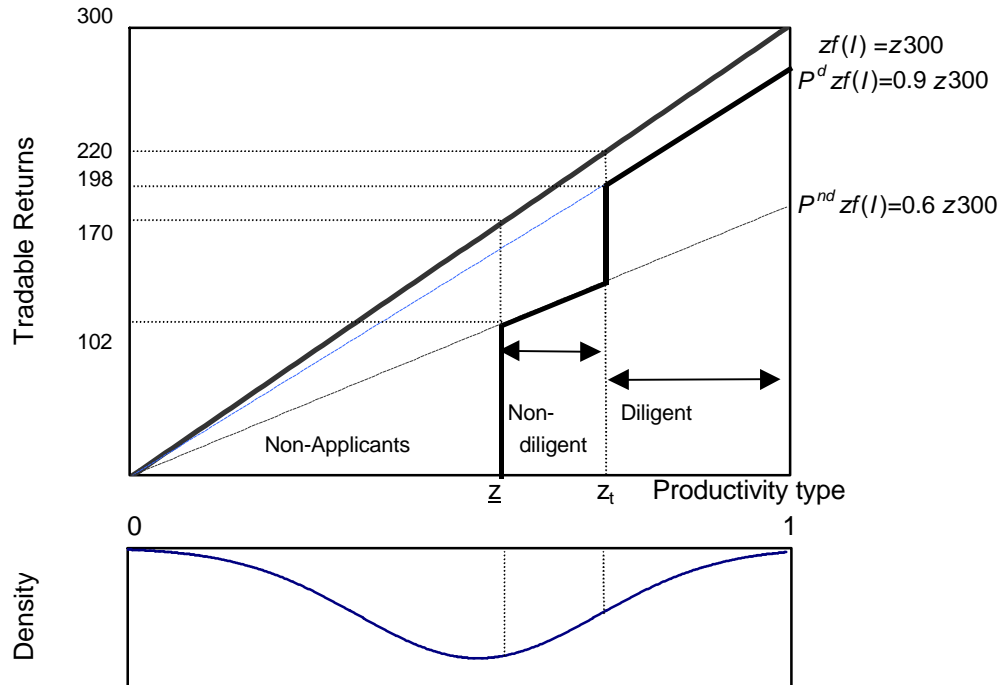


Figure 13: Ability to Repay for the Break-Even Loan Contract ($R_s=170, I=100$)

Given the fixed-sum character of the loan contract, borrowers have to pay 170 no matter how large the returns generated. The more productive the borrowers are, the greater the surplus they have to keep after repayment and the greater their incentives to be diligent.

In summary, there are some borrowers who will not be able to repay the loan, but they are observationally equivalent to those who will repay and the lender cannot separate them. The lender needs to make sure that what he expects to collect from diligent borrowers will more than compensate the lower collection from non-diligent borrowers so the lender can break even. This is why the diligent borrowers end up cross-

subsidizing the non-diligent borrowers. The proportion of each class of MEs is shown in the lower graph. The lower graph depicts the distribution of MEs by productivity types.

b. Profits and Interest Rates

As the interest rate increases, average profits increase up to a maximum only, to decrease afterwards (see Figure 14). This occurs because average profits are impacted in three ways. First, profits increase because repayment from all successful borrowers (diligent and non-diligent) increases. Second, the proportion of non-diligent borrowers increases, reducing average expected repayment. Third, the absolute number of borrowers drops, making it more difficult to dilute fixed handling costs.

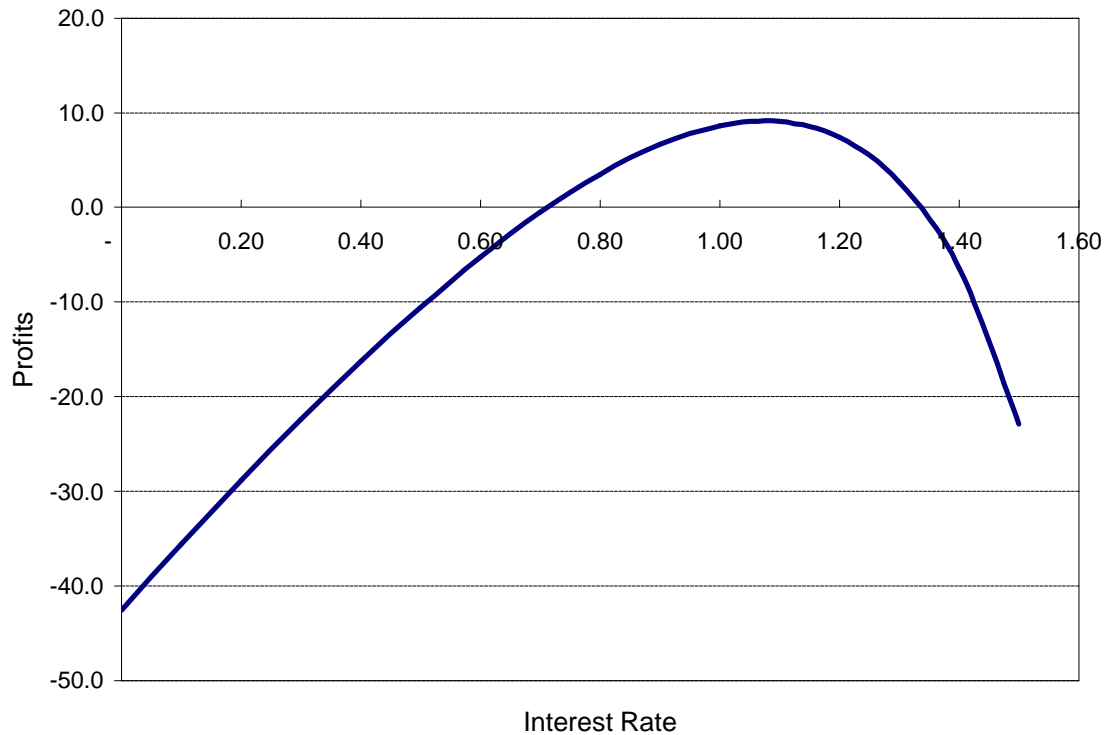


Figure 14: The Non-Monotonic Relationship between Profits and Interest Rate

In the simulation, at an interest rate of 150 percent, only 16 percent of the total pool of MEs will take the loan contract and all borrowers (100 percent) will be non-diligent. Compare this with the composition of the portfolio at the break-even interest rate of 70 percent. In this case, 43 percent of all MEs take out loans and from the total number of borrowers, 60 percent will be diligent.

c. Profits and Default Rates

The model also reveals that a lower default rate does not necessarily mean higher profits (see Figure 15). In some circumstances, a lower default rate might be obtained by charging lower interest rates. At lower interest rates, borrowers are left with enough residula to be diligent, so arrears are minimized. But, a low interest rate may also imply low (or even negative) profits.¹² Profits can be improved by accepting higher rates of default but charging a higher interest rate. However, the positive effect of higher interest rates on profits is counterbalanced at some point by the negative effect of changes in portfolio quality (relatively less diligent borrowers).

¹² The model ignores the negative impact on repayment of the perception that the lending operation may not be sustainable when it suffers from steady losses due to low interest rates (Gonzalez-Vega, 1993)

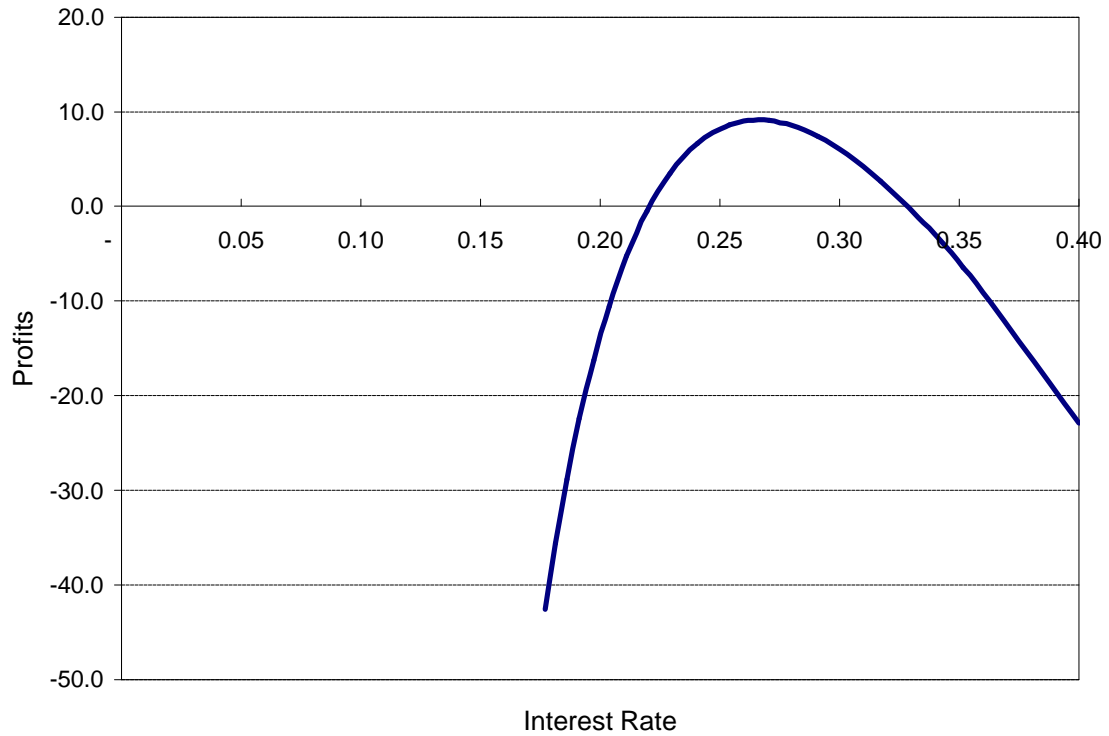


Figure 15: The Non-Monotonic Relationship between Profits and Default Rate

d. Profits and Scale

Another interesting observation is the non-monotonic relationship between profits and the number of borrowers (see Figure 16). If BancoSol charges very high interest rates, very few borrowers will be attracted. With high fixed handling costs, fewer borrowers may result in low or even negative profits. It is in the interest of BancoSol to attract a sufficient number of borrowers to cover its handling costs. If in order to attract more borrowers, however, interest rates must be lowered. If interest rates are lowered too much profits will also decline.

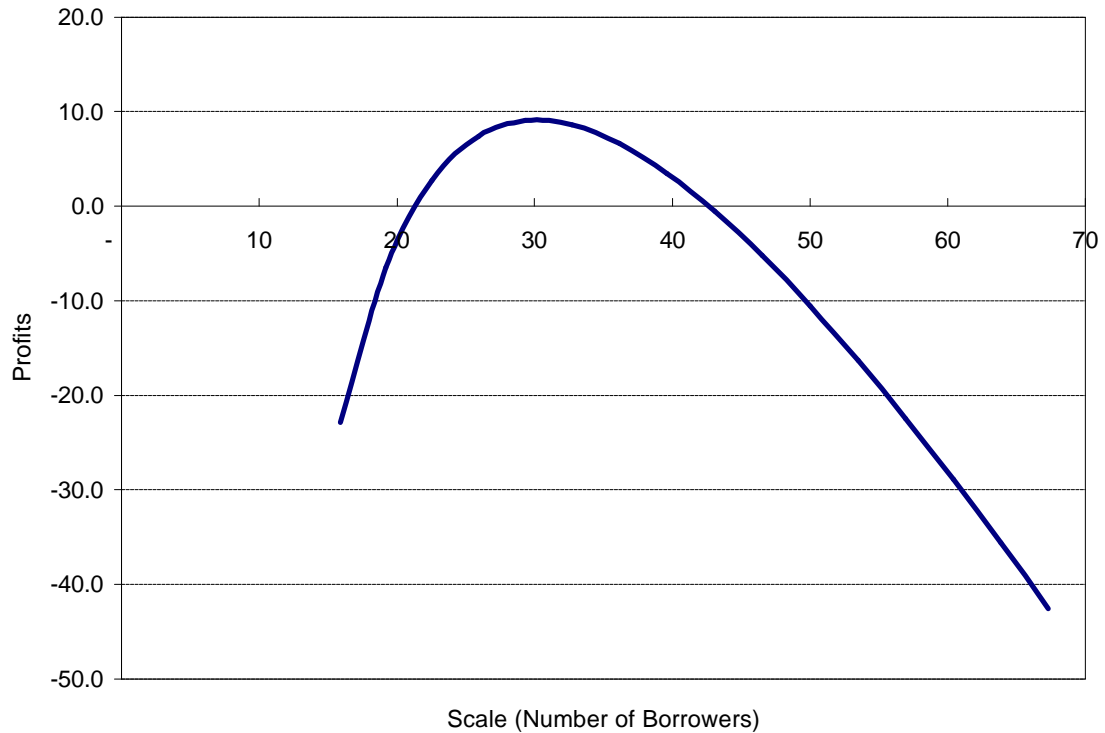


Figure 16: Profits and Scale (Number of Borrowers)

If the lender is interested in borrower welfare, then it will not charge the maximum possible (profit-maximizing) interest rate. At the minimum interest rate consistent with breaking even (around 70 percent in this simulation), the largest fraction of the market is served at the lowest sustainable interest rate.¹³ To decide on the optimal size of loan, the lender would calculate the lowest interest rate consistent with each loan size, and then decide on the loan size that maximizes borrower welfare.

Since at different loan sizes and interest rates, different proportions of the population will borrow from each of the ME classes, some way of weighting the

borrowers in the lender's objective function must be specified for a social welfare analysis of loan contracts.

2. Competition with Caja Los Andes

The cost of asymmetric information and little collateral wealth of BancoSol's clients is that BancoSol offers a single loan contract. This means that higher productivity borrowers (those with $z \geq z_T$) obtain smaller loan sizes and pay higher interest rates than if they could reveal their productivity to the lender and obtain a contract tailored to their circumstances.

If Caja Los Andes competes head-to-head with BancoSol in the same market niche, substantial harm can be done to BancoSol's portfolio. If Caja Los Andes would offer a personalized loan contract without requiring any collateral or incurring in any additional cost (for both the borrower and the lender), then all BancoSol high productivity borrowers ($z \geq z_T$) would be interested in borrowing from Caja Los Andes. With positive screening costs and collateral requirements, a likely scenario is that only borrowers with $z > z_A > z_H$ will switch from BancoSol to Los Andes.

As the most productive borrowers leave BancoSol, the size and quality of its portfolio decline. If BancoSol did not readjust its contract terms, this lender would see an immediate rise in its default rate and a decline in its profitability. This will be the case because the most productive borrowers (those who have the most incentive to be diligent) leave BancoSol.

¹³ Capitalization of profits is needed, however, to increase future outreach. This requires a higher interest rate.

How should BancoSol optimally adjust? Competition by Caja Los Andes means that the distribution of potential borrowers has changed. Rather than z being distributed between z_L and z_H , BancoSol now faces potential borrowers with z distributed between z_L and $z_H < z_A$. That is, the pool has lost the most productive borrowers (upper tail of the former distribution). All of the formulas for BancoSol described above can be easily adjusted to reflect this (by simply substituting z_A by z_H in the formulas).

New applicants, who now have the option of borrowing from either BancoSol or Caja Los Andes, will be sorted as follows. The wealthiest MEs, who at the same time have the greater chance of being the most productive MEs, will borrow from Caja Los Andes, because they will get a personalized loan contract and because they can offer some form of imperfect collateral. As a result, the interest rate they pay will be lower. Poorer MEs will choose BancoSol because they do not have the collateral required by Caja Los Andes.

Poorer MEs and most likely less productive borrowers will then prefer the pooling loan contract of BancoSol, because in borrowing from this lender there is chance that they will be cross-subsidized by high productivity borrowers who could not borrow from Caja Los Andes.

In summary, due to the differences in lending technologies (standard versus non-standard loan contracts), borrowers of Caja Los Andes should be wealthier and more productive than those of BancoSol. If switching occurs, it should happen mainly from BancoSol to Caja Los Andes. The borrowers who switch should be the most productive among BancoSol's clients.

CHAPTER 6

A NON-PARAMETRIC EXPLORATION OF THE CHARACTERISTICS OF THE BORROWERS OF BANCOSOL AND CAJA LOS ANDES

A. Introduction

The numerical simulation developed in Chapter 5 concluded with four hypotheses:

- (a) The borrowers of Caja Los Andes are expected to be wealthier than their counterparts in BancoSol.
- (b) The average borrower of Caja Los Andes is more productive than the average borrower of BancoSol.
- (c) If the possibility exists, the higher productivity borrower of BancoSol will switch to Caja Los Andes.
- (d) The terms of the loan contract at BancoSol will show less variability (standard loan contracts) than at Caja Los Andes, where the loan terms are adjusted to each class of borrower (non-standard loan contracts).

In this chapter, I will explore these four hypotheses with the aid of proxy indicators for poverty, productivity type, and variability of loan terms.

B. The Data

This section is based on the research project conducted in Bolivia in late 1995 by the Rural Finance Program at The Ohio State University. The goal of the project was to examine and compare key dimensions in the evolution of five microfinance organizations in Bolivia, including BancoSol and Caja Los Andes. A key input for this study was a random household survey in the city of La Paz which included 239 borrowers from BancoSol and 128 from Los Andes (for more details see Gonzalez-Vega *et al.*, 1996).

By 1995, BancoSol had been operating in the market for eight years: from 1987 to 1992 as a financial NGO (PRODEM) and after 1992 as a fully-chartered commercial bank. Caja Los Andes was established in 1992 as a financial NGO (Pro-Crédito) and became a regulated non-bank financial organization after 1995. Both organizations comply with all the requirements of financial regulation in Bolivia, show extremely low arrears rates, and are profitable.

C. Hypothesis One: Level of Poverty

According to the model, the typical borrower of Caja Los Andes is wealthier than the typical borrower of BancoSol. This is very plausible, since Caja Los Andes always requires some sort of collateral and offers a personalized loan. I will analyze the characteristics of the borrowers using two types of indicators. First, I will use a group of socio-economic indicators. Second, I will use an index of poverty.

The socio-economic indicators are presented in Table 10. This table reveals that borrowers from Caja Los Andes are on average more educated, are more heavily engaged in manufacturing, and have relatively larger microenterprises (as measured both by the

number of employees and monthly sales). The clients of Los Andes look less poor than BancoSol clients.

	BancoSol	Caja Los Andes
Women (%)	78	62
Borrowers with third grade education or more (%)	67	81
Borrowers have multiple occupations (%)	49	68
Manufacturing is the main occupation of the borrower (%)	15	23
Average number of workers in the borrower's microenterprise	1.2	2.1
Median monthly sales of the borrower's microenterprise ^a	646	1,735
Borrowers have no written records (%)	66	52
Business is separated from the household (%)	44	47

a. Figures in bolivianos converted into US dollars at the exchange rate as of December 1995.

Source: OSU survey

Table 10: Selected Socio-Economic Indicators of the Borrowers of BancoSol and Caja Los Andes

A more detailed examination of the poverty level of the borrowers was carried out by using an Index of Basic Needs Fulfillment (*IBNF*) used in a national assessment of poverty in Bolivia (Ministerio de Desarrollo Humano, 1995). The same methodology was used to compute an *IBNF* for the borrowers of BancoSol and Caja Los Andes. The index was calculated using three components: housing (*IH*), access to public services (*IPS*), and education (*IE*). The first two factors evaluate asset accumulation and the physical living conditions of the household and the last one evaluates the average

education of all members of the household.¹⁴ This *IBNF* is a relative measure because it compares the values of achievement for a family with a norm established for the Bolivian population (see Appendix B for more details).

The *IBNF* divides borrowers into four categories: the satisfied and the threshold households (the non-poor), and the moderately poor and the poorest households (the poor). The results for BancoSol and Caja Los Andes are shown in Table 11:

Categories	BancoSol	Caja Los Andes
Satisfied	16	19
Threshold	33	48
Non-Poor	48	67
Moderately poor	47	29
Poorest	5	4
Poor	52	33

Source: Author's calculations

Table 11: Distribution of Borrowers by Poverty Category (percentages)

The proportion of the poor (52 percent) in the portfolio of BancoSol is higher than for Caja Los Andes (33 percent). Are these differences statistically significant? Two non-parametric tests were used to answer this question.¹⁵ The Kolmogor-Smirnov test

¹⁴ The national assessment had a fourth component, access to health care services. Access to health services was not included in the OSU survey.

¹⁵ A Kolmogor-Smirnov test rejected the hypothesis that any of the distributions were normal, therefore non-parametric (or distribution free) tests were used.

rejected the hypothesis that the distributions of the index for the two lenders were equal with more than 95 percent confidence.

The difference in medians was also tested using a Wilcoxon rank-sums test. The median index for Caja Los Andes (0.97) is greater than for BancoSol (0.90), with more than 95 percent confidence. We can safely conclude that the typical borrower of Los Andes is less poor than the typical borrower of BancoSol.

D. Hypothesis Two: Productivity Level

The second hypothesis refers to the borrower's level of productivity. We expect the typical borrower of Caja Los Andes to be more productive than the typical borrower of BancoSol. Besides, a good proxy for productivity is the level of education of the borrower.

The *IE* differs from the other components of the *IBNF* because the norm is adjusted to the age of each member of the household. For example, a three-year-old child with zero years of schooling has the same index as a 36-year-old adult with eight years of schooling. The index of education of the borrower (*IEB*), which is part of the *IE* index, can be used as a proxy for productivity.

A non-parametric comparison of the components of the *IBNF* is presented in Table 12.

	P-values ^a	
	Two-sided Kolmogrov – Smirnov test ^b	One-side Wilcoxon Rank Sum test ^c
Index of housing (IH)	0.6096	0.0353
Index of public services (IPS)	0.0028	0.0002
Index of education (IE)	0.7470	0.2975
Index of education borrower (IEB)	0.0205	0.0048

a. The p-value is the maximum level of significance for which the null hypothesis can be accepted.

b. The null hypothesis is that the distribution of the respective index is equal for the borrowers of both lenders. The alternative hypothesis is that both distributions are different.

c. The null hypothesis is the equality of the medians of the distributions of the two respective indexes. The alternative is that the median of the respective index for the borrowers of Caja Los Andes is greater than that for BancoSol.

Table 12: Non-Parametric Statistical Tests Comparing the Components of the *IBNF* for the Borrowers of BancoSol and Caja Los Andes.

The results of the tests for the *IEB* (our proxy for productivity) confirm the hypothesis. The borrowers of Caja Los Andes are more productive than their counterparts in BancoSol.

E. Hypothesis Three: The Productivity Level of The Borrowers Who Switch

The model also suggests that, if given the opportunity, the more productive borrowers of BancoSol will switch to Caja Los Andes. To explore this we need to know how many borrowers of Caja Los Andes had had loans with BancoSol in the past.

By 1995, both lenders had already co-existed for three years, so the borrowers of BancoSol had had the opportunity to switch to Caja Los Andes. From the sample, 17 percent of the borrowers of Caja Los Andes had switched from Bancosol. In contrast, less than one percent of BancoSol's borrowers came from Caja Los Andes (see Table 13).

	BancoSol	Caja Los Andes
BancoSol	-	17.2
Caja Los Andes	0.8	-
Formal financial organizations^a	5.9	0.8
NGOs	7	15.5
Others^b	83.7	61.0

- a. Includes Banks, Savings and Loan Associations, and Cooperatives
- b. Includes Moneylenders, Relatives, Friends and *Pasanakus* (ROSCA)

Source: OSU survey

Table 13: Loan Activities of the Borrowers: “At about the time of the first loan with the microlender, borrower had loans from (percentages)”

What are the characteristics of the borrowers who switched? Are they the most productive? The answer is yes. Using the same non-parametric test used in part D of this chapter, we conclude with at least 93 percent confidence level that the borrowers who switched from BancoSol to Los Andes (the switching group) had a higher median than the median of the index of education for the borrowers of BancoSol (see Table 14).

	P-values ^a	
	Two-sided Kolmogrov – Smirnov Test ^b	One-Side Wilcoxon Rank Sum Test ^c
Index of Basic Needs Fulfillment (IBNF)	0.0102	0.0354
Index of Housing (IH)	0.6453	0.1622
Index of Public Services (IPS)	0.7183	0.0696
Index of Education (IE)	0.0790	0.1953
Index of Education Borrower (IEB)	0.0271	0.0611

- a. The p-value is the maximum level of significance for which the null hypothesis can be accepted.
- b. The null hypothesis is that the distribution of the respective index is equal for the borrowers of BancoSol and the switching group. The alternative hypothesis is that both distributions are different.
- c. The null hypothesis is the equality of the medians of the distributions of the two respective indexes. The alternative is that the median of the respective index of the switching group is greater than the index for BancoSol

Table 14: Non-Parametric Statistical Tests Comparing the Components of the *IBNF* for the Borrowers of BancoSol and the Switching Group.

F. Hypothesis Four: The Type of Loan Contract

According to the model, the loan contract offered by Caja Los Andes should be better tailored to the borrower’s own characteristics than the Bancosol’s loan contract. The survey data allow us to explore these differences in the following way.

First, we can analyze the correlation between the first loan disbursed and the *IBNF*. A positive correlation will indicate that the lender is able to adjust loan terms to personal characteristics. The correlation coefficient for Caja Los Andes was positive

(0.20), and negative for BancoSol (-0.11). Thus, Los Andes has some ability to distinguish across applicants that BancoSol does not have.

Second, using the borrower's loan history, we can trace the evolution of loan size and the variability of loan size through several iterations in a sequence of loans. More variability is an indication of a larger number of different loan contracts and less standardized loan contracts.

Table 15 shows the mean, median, and coefficient of variation for each rotation in the loan sequence. For the first loan, for example, the median loan size in BancoSol is \$148 and in Caja Los Andes is \$373. The median loan size for Andes is consistently higher in each iteration. Variability in each iteration is consistently higher for Caja Los Andes than for BancoSol.

In summary, the data confirms the hypotheses. The borrowers of BancoSol are poorer and less productive than their counterparts in Caja Los Andes. When given the opportunity, the best borrowers of BancoSol (the less poor and more productive) seem to prefer Caja Los Andes, where the loan contracts are much better tailored to each individual.

LOANS	BancoSol	Caja Los Andes
ITERATION 1		
N	258	138
Mean	142	373
Coefficient of Variation	114	182
ITERATION 2		
N	239	123
Mean	241	512
Coefficient of Variation	80	119
ITERATION 3		
N	201	88
Mean	380	693
Coefficient of Variation	77	115
ITERATION 4		
N	162	59
Mean	534	1022
Coefficient of Variation	85	201
ITERATION 5		
N	117	45
Mean	657	1474
Coefficient of Variation	89	214
ITERATIONS 6 to 23		
N	356	74
Mean	846	1328
Coefficient of Variation	114	103
Total		
N	1,333	527
Mean	476	760
Coefficient of Variation	133	187

Note: Figures in bolivianos converted into US dollars at the exchange rate as of December 1995.

Source: OSU survey

Table 15: Loan Size over Time

CHAPTER 7

CONCLUSIONS

A. Summary of Findings

Access to credit for the poor, especially in the urban areas, has dramatically improved in Bolivia during the past decade. This improvement has been largely due to the introduction of new microlending technologies. The new microlending technologies differ significantly from the collateral-based lending technology typically used by commercial banks. They also differ significantly across several microfinance organizations.

To compare microlending technologies, a benchmark model was developed in this dissertation that analyzes moral hazard and adverse selection simultaneously. The lender has to address the effects of information asymmetries about both actions (diligence) and type (productivity). Depending on the lender's lending technology, available information, and the borrower's collateral endowments, different loan contracts are offered that match different borrower classes.

The model explores two sets of circumstances. The model first explores the level of investment achieved when the lender has perfect information about the productivity

type of each borrower and the only information asymmetry is about diligence. The introduction of collateral, imperfect collateral, equity contributions, monitoring, and fixed lending costs is then explored. Collateral and imperfect collateral contribute in different degrees to ameliorate opportunistic behavior and to decrease lender losses in case of failure of the productive venture. Equity contributions increase the borrower's losses when the project fails, thereby inducing diligent borrower behavior. Monitoring is costly but it can prevent losses if it is effective in inducing diligent behavior. Fixed lending costs increase the average cost of loans, but they are sometime inevitably present in an important way in microcredit markets.

Second, the model explores the level of investment when both consequences of asymmetric information are present. For this, the assumptions of the model are relaxed. The lender is assumed not to be able to distinguish the productivity type of each individual borrower (potential adverse selection problems) but to have different degrees of information about this variable. The degree of information determines the outcome. For example, a lender with information only about the average productivity of the pool of potential borrowers will be unable to design profitable pooling contracts.

Using the benchmark model, the lending technology of two Bolivian microlenders is studied. These lenders are BancoSol and Caja Los Andes. These two lenders enjoy the lion's share of urban microlending in Bolivia. Each of them, however, employs a different technology to be able to lend to the poor without threatening the financial sustainability of the organization.

An important difference between the services offered by these two lenders is the level of standardization of their loan contracts. Caja Los Andes offers a personalized loan

contract (“one for all” type of contract). This is possible because Caja Los Andes screens its borrowers in order to determine their repayment capacity (productivity type of the borrower). This lender also accepts imperfect collateral (assets with high consumption value but low resale value) and monitors borrowers to minimize the possibilities of moral hazard.

In contrast, BancoSol offers a standardized loan contract to all takers (“all for one” type of contract). Personalized loan contracts are not possible because BancoSol does not screen each borrower as Caja Los Andes does. Monitoring costs are also lower because BancoSol uses joint liability in credit groups to control for moral hazard. BancoSol sacrifices some information in order to lower its overall costs. Not every standard loan contract is profitable, however.

BancoSol has been operating in the market since 1987 and since 1992 it has operated as a commercial bank. Over the years, valuable information about its market niche has been collected, which has given BancoSol the capacity to design profitable standard (pooling) contracts. In other words, BancoSol has learned about the distribution of productivity types among its potential borrowers to the point of lowering its costs to attain profitability.

In both cases, portfolio quality and portfolio size matter, because microlenders have to cover substantial fixed handling costs related to lending to the poor.

Each lending technology attracts a different pool of borrowers. Low-productivity borrowers prefer the standard loan contract since, in this case, the possibility of cross-subsidization from high-productivity borrowers exists. If the additional costs are reasonable, high-productivity borrowers prefer a personalized loan contract.

The model predicts that high-productivity BancoSol borrowers (who will most likely be the wealthiest) will switch to Caja Los Andes. The data confirm this prediction. The results show that the borrowers who have switched to Caja Los Andes are significantly less poor and more productive than the average BancoSol borrower. Also, the average Caja Los Andes borrower is less poor and more productive than the average BancoSol borrower.

Faced with recent competition, BancoSol has had two options. One option has been to revise its loan contract to reflect a shrinking and less productive pool of borrowers (loans would become more expensive in the absence of cross-subsidization). Another option has been to design new loan products to prevent high-productivity borrowers from switching. BancoSol has chosen the second option. By 1998, eight percent of its portfolio was in loans made to individuals (Morduch, 1999).

The experience in Bolivia shows that profitable microlending is possible when an appropriate lending technology is used. It also shows that there is not a unique way to achieve this result. In fact, alternative lending technologies have been equally profitable in reaching similar clientele.

When microlenders eventually faced increasing competition in overlapping market niches, this success has been threatened. The ability to adapt to the increased competition will determine the permanence of the incumbents in the market. In turn, competition has changed the type of loan contracts supplied in the market and, thereby, it has influenced the borrowing possibilities of different classes among the poor. However, competition can improve access for everyone through a decrease of monopoly rents. The overall effect of competition on the poorest is, therefore, ambiguous.

B. Policy Implications

Access to credit for the poor can be improved through reductions in the costs of information. As the costs of information decrease, lenders are able to reduce the costs of lending to less productive clienteles. Also, with better information, lenders are able to design loan contracts better tailored to individual demands. Credit rating agencies serve as information centers for lenders. Currently, credit rating agencies in Bolivia only exist for relatively larger borrowers and even in those cases the available information is limited. To the extent that credit rating agencies produce a semi-public good, there is a social interest in accelerating their development.

The improvement of contract enforcement mechanisms will also positively contribute the access to credit by the poor. For example, a higher α (the degree of transferability of collateral) will reduce loan size rationing. Institutional reforms improve the framework for contract enforcement.

An effective way to improve access to credit by the poor is through the promotion of technological change (new lending technologies). Because of failure in the market for innovations (externalities, public goods), the state may support the process of technological change with the appropriate instruments. Moreover, the regulatory authorities should not create artificial advantages for one type of organization (technology) but rather provide an environment where lenders enter and exit the market because of their technological advantages. This will encourage the process of innovation need to expand the frontier of microfinance.

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APPENDIX A

SOLUTION OF THE BENCHMARK MODEL

The optimization discussed in Chapter 3 had the following form:

$$\text{Max } P^d z_f(I) - P^d R_s - (1 - P^d) R_f$$

$$I$$

$$\text{s.t. } I_0 = 0, L \geq 0, I = I_0 + L, \tag{A.1}$$

$$P^d z_f(I) - P^d R_s - (1 - P^d) R_f \geq 0, \tag{A.2}$$

$$P^d R_s + (1 - P^d) R_f = gI, \tag{A.3}$$

$$R_s \leq z_f(I), R_f = 0, \tag{A.4}$$

$$P^d R_s + (1 - P^d) R_f \leq P^d z_f(I) - \frac{P^d B}{\Delta P} I + R_f, \tag{A.5}$$

where $\Delta P = P^d - P^{nd}$.

This problem can be simplified as follows. First, since $R_f = 0$, then R_f disappears from all constraints and the objective function. Second, if the incentive compatibility constraint (equation A.5) holds, then the limited liability constraint also holds (equation A.4), so it is not necessary to use it as a constraint. Third, the lender's participation constraint (equation A.3) is an equality that can be used in the borrower's participation constraint (equation A.2), the incentive compatibility constraint (A.5), and the objective function.

The optimization problem is reduced to:

$$\text{Max } P^d \zeta f(I) - g I \quad (A.6)$$

$$\text{s.t. } I \geq 0, \quad (A.7)$$

$$P^d \zeta f(I) - g I - \frac{P^d B}{\Delta P} I \geq 0 \quad (A.8)$$

Note that constraint (A.7) can be eliminated because, if constraint (A.8) holds, then constraint (A.7) also holds. The corresponding Lagrangean function is:

$$\text{Max } P^d \zeta f(I) - g I + I_1 I + I_2 [P^d \zeta f(I) - g I - \frac{P^d B}{\Delta P} I]$$

$$I_1, I_2, I$$

The Kuhn-Tucker first-order conditions for a maximum are:

$$\frac{\partial L}{\partial I} = P^d \zeta f'(I) - g + I_1 + I_2 [P^d \zeta f'(I) - g - \frac{P^d B}{\Delta P}] = 0, \quad (A.9)$$

$$I_1 I = 0, \quad (A.10)$$

$$I_2 [P^d \zeta f(I) - g - \frac{P^d B}{\Delta P} I] = 0, \quad (A.11)$$

$$I_1 \geq 0, \quad (A.12)$$

$$I_2 \geq 0, \quad (A.13)$$

$$P^d \zeta f'(I) - g - \frac{P^d B}{\Delta P} \geq 0, \quad (A.14)$$

$$I \geq 0, \quad (A.15)$$

Assuming that the first constraint is not binding ($I_1 = 0$), we have two cases. The first case is when the second constraint is not binding ($I_2 = 0$) and the second case is when the second constraint is binding ($I_2 > 0$).

When the second constraint is not binding ($I_2 = 0$), the optimal level of investment is solved from a modified version of equation (A.9), $P^d z f'(I^{so}) = g$, where I^{so} is the socially optimum level of investment.

When the second constraint is binding ($I_2 > 0$), the restricted maximum is a solution to $P^d z f'(I^{cd}) = g + I_2 [P^d z f'(I^{cd}) - g - \frac{P^d B}{\Delta P}]$, where I^{cd} is the level of investment compatible with all the constraints, since $z f(I)$ is a well-behaved production function ($z f'(I)$ and $z f''(I)$), $I^{cd} \leq I^{so}$.

APPENDIX B

CONSTRUCTION OF THE POVERTY INDEX

The poverty index used to compare borrowers across microlending organizations was based on an Index of Basic Needs Fulfillment of (*IBNF*). This approach requires (Boltvinik, 1994):

- (a) defining basic needs and their satisfiers in theory;
- (b) choosing observable indicators that proxy degrees of fulfillment of basic needs;
- (c) defining a point for each indicator below which the need is thought to be unfulfilled;
- (d) aggregating across the basic-needs indicators to construct an index; and
- (e) labeling households with an index below some chosen level as poor.

A. The Index for Bolivia

Based on the 1992 Census, a poverty assessment was conducted for the whole Bolivian population. The assessment picked the poverty line as well as the levels for indicators below which a need was thought to be unfulfilled (Ministerio de Desarrollo Humano, 1995). In most cases, the line was drawn at the median of the distribution of an indicator, but in some cases more complex but reasonable adjustments were made. Like all measures of absolute poverty, the poverty line and the points at which basic needs

were declared to be fulfilled were at least somewhat arbitrary. The index was computed not for individuals but for households.

The *IBNF* used in the nationwide assessment had four basic conceptual parts:

- (a) housing;
- (b) access to public services;
- (c) education; and
- (d) access to health services.

Housing and access to public services reflect the setting of day-to-day life and the quality and availability of infrastructure and household asset accumulation through housing. Education and access to health services matter for the formation of human capital.

The four components were proxied as follows:

1. Housing:
 - (a) Type of materials used for floors, walls and roof;
 - (b) Number of people per room.
2. Access to public services:
 - (a) Source of water;
 - (b) Type of sewage system;
 - (c) Access to electricity;
 - (d) Type of fuel used to cook food.
3. Education:
 - (a) Years of school completed;
 - (b) Attendance in school now;
 - (c) Literacy.
4. Access to health services:
 - (a) Use of formal health care;
 - (b) Use of informal health care.

The Index of Basic Needs Fulfillment (*IBNF*) was the simple average of the ratios for each of the four parts:

$$IBNF = \frac{1}{4} \sum_{j=1}^4 \frac{x_j}{x_{jnorm}} \quad (B.2)$$

where x_j = Observed value of the component j; and

x_{jnorm} = Value of the norm for the component j.

The range of the ratio of x_j to x_{jnorm} depended on the range of answers observed in the nationwide assessment. In the case of the indicator for education, an index was found for each person in the household. The household index was then the average of the indices of its members:

$$IE = \frac{1}{N} \cdot \sum_{j=1}^N \frac{y_i + s_i}{y_{inrom} + s_{inrom}} \cdot L_i \quad (B.3)$$

where IE = Index of education of the household;

N = Number of members of the household;

y_i = Years of schooling for person i ;

s_i = School attendance dummy for the age of person i ;

y_{inrom} = Norm of years of schooling for the age of person i ;

s_{inrom} = Norm of years of schooling for the age of person i ; and

L_i = Literacy dummy for person i .

The nationwide assessment set the poverty line at an *IBNF* of 0.9. Households below this line were considered to be poor and the were declared rest non-poor. The non-poor were further sub-classified as *threshold* or *fulfilled*. The poor were subclassified as *moderately poor* or *poorest*:

Non-poor		Poor	
2.0 to 0.9		0.9 to 0.0	
Fulfilled	Threshold	Moderate	Poorest
2.0 to 1.1	1.1 to 0.9	0.9 to 0.6	0.6 to 0.0

Table 16: Poverty Line and Definitions of Sub-Classes of Poor and Non-Poor Households According to the Level of the *IBNF*.