Moral Hazard and Capital Requirements in a Lending Model of Credit Denial

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Abstract

In this paper we analyze a repeated game in which an intermediary offers unsecured loans to entrepreneurs using future credit denial to induce repayment. To finance the loans, the intermediary uses a combination of equity capital and external funds. We focus on a moral hazard problem that emerges between the intermediary and the less informed external investors over a costly loan monitoring choice. The presence of informed borrowers in the lender's portfolio turns out to act as a substitute for capital requirements. The result is that the lending strategy utilized by the intermediary minimizes the moral hazard problem but implies the intermediary's balance sheet is fragile to exogenous risk.

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1. Introduction

Over the years, a variety of different strategies have been proposed on how to deepen financial markets in the developing economies. Policy makers have encouraged foreign bank entry, pushed for reforms of collateral and bankruptcy laws, and advocated subsidizing capital loans. A key motivation behind these diverse efforts has been the persistent difficulty firms have in accessing external finance. By one measure, the ratio of credit allocated to the private sector to GDP is generally only a third of what it is in developed economies. For small business especially, access to credit is reported to be one of the most important obstacles, having negative implications for growth, innovation and development.[2]

When financial intermediaries are successful in extending credit to micro and small businesses, they tend to rely to innovative contracting, adapted to the inadequacies of their environments. Lenders must sustain repayment revenues when there are no credit bureaus to record credit history and when it is too costly or legally impractical to use collateral. To meet these challenges, lenders have relied on a variety of techniques, such as relationship lending, trade credit and group liability. What distinguishes intermediaries specializing in these lending technologies is that they often fall on the margins of the regulated financial system. With time however, this generally changes, as the more successful intermediaries search for broader and deeper access to financing and investment opportunities. For example, in recent years microfinance organizations have increasingly sought regulatory approval to offer household deposit accounts. This evolution raises important regulatory questions. While undoubtedly there are basic standards and principles of supervision that should apply to these new intermediaries, at the same time, simply applying the existing regulatory and supervisory structure is in many cases, inappropriate.

Capital requirements are a good example. Intermediaries that have successfully built up portfolios of unsecured loans in difficult institutional environments tend to need large amount of capital in order to satisfy regulatory capital to risk weighted asset ratios. While the exact weighting of unsecured loan assets varies by country, typically small unsecured producer loans

[2] See Aghion et al. (2005), Ayyagari et al. (2007), Beck and Demirguc-Kunt (2006) and Levine (2005).

receive some of the highest weights. Critics ask, if holding such high capital levels are necessary, why have these intermediaries have been so successful over the years holding much smaller capital levels, often maintaining negligible delinquency rates for this class of asset. Based on a survey of Latin America countries, Jansson (1997) calculates that in order to satisfy minimum capital requirements to obtain a bank license, microfinance NGOs would have to build loan portfolios that exceed the largest microfinance portfolios in the hemisphere by several magnitudes. With regard to provisioning, regulatory policy can require 100% loan loss provisioning at the time of distribution for all unsecured loans, rather than basing provisioning on days in arrears.[3] For an intermediary specializing in unsecured loans, even if delinquency rates are negligible, fulfilling such requirements can be prohibitively costly.

The argument here should not be interpreted as a view that regulations should simply be relaxed for successful intermediaries specializing in small business loans. Rather, the point is that in recent years, intermediaries have proven that innovative lending technologies can push the frontier of what exactly is a viable and prudent small business loan asset. The challenge facing regulators is to find frameworks that can integrate these new lending models while respecting the fundamental principles of safeguarding the stability of the financial system. As it stands, many policy makers agree that simply applying the current framework tends to block the integration of these intermediaries.[4] Based on a survey conducted across 74 countries, CSFI (2008) reported that inappropriate regulations was the third most important problem facing microfinance organizations, after management quality and corporate governance. It is worth emphasizing that this applies not only to smaller unregulated intermediaries, but increasingly established commercial banks and other financial institutions that are migrating into new markets, often using the lending technologies pioneered by the smaller lenders.[5]

Among the numerous different contracts that are used to facilitate micro and small business lending, one commonly comes across a strategy where lenders generate repayment incentives out of the borrower's desire to maintain future access to credit from the lender. In

[3] See Hubka and Zaidi (2005).
[4] See Christian et al. (2003) for an overview. Both Meagher (2002) and van Greunig et al. (1999) argue that existing frameworks tend to impose ineffective and overly burdensome requirements on non-bank lenders.
[5] See Baydas et al. (1997)

such a lending strategy, the lender threatens to cut off future credit unless the borrower repays the loan. For example, in a study of trade credit used among small firms in Vietnam, McMillan and Woodruff (1999) find that this ability of the lender to threaten to cutoff future access is instrumental in sustaining credit relationships in weak institutional settings. Similarly, Morduch (1999) argues that the dynamic incentives created from credible threats of credit denial are critical to the success of many microfinance organizations.

There are a number of theoretical papers that model this form of "credit denial" as a means of inducing borrowers to make repayments. See for example, Kehoe and Levine (1993), Kletzer and Wright (2000) and Bond and Krishnamurthy (2004). In our paper, we build a similar type of model in which a single lender uses credit denial to induce repayment among its borrowers. In doing so, we abstract from all other means of generating repayment incentives, such as public credit history or collateral. The lending intermediary in our model raises external funds in order to issue loans. The lender then makes a decision about costly loan monitoring, which influences the proportion of loans that go to good and bad investment projects. In this setting, a well known moral hazard problem emerges, where the interests of the lender (i.e., the equity holders) diverge from the interests of the less informed external investors.[6] In models such as Hellman et al. (2000) and Repullo (2002) the lender chooses between a prudent and gambling asset. In our model, since assets are loans, which are to a certain extent under the control of borrowers, the framework is slightly different. To model risk taking by the lender, as in Chiesa (2001) we let the lender choose the intensity with which it monitors its loans. Monitoring loans is expensive but ensures that borrowers invest in the good project. If the lender chooses a lower level of loan monitoring, this saves the lender costs but increases the risk that loans go to bad investment projects.

What we find is that when the lender relies on credit denial to induce voluntary repayment, this can minimize the moral hazard problem mentioned above. The reason for this is based on what Bond and Rai (2009) refer to as a "borrower run". In a model of credit denial, borrowers' incentive to repay their loans depends on the expected value of future access to credit. If borrowers, who are in the process of making payments on their loan, detect risk taking on the

[6] For a literature review, see Sanots (2001).

part of the lender, these informed borrowers lower the expected value of their future credit relationship with the lender. If this expected value falls below a certain level, the incentive for the borrowers to repay their loans can vanish even though they have good projects. Hence, the degree to which the lender's portfolio is composed of these "informed" borrowers plays a critical role in the lender's decision making.[7]

Bond and Rai (2009) use a static model to show how borrower runs can unfold in a model of credit denial. In their paper, the lender aims to maximize the welfare of the borrowers and the authors focus on how the lender can adjust the loan contract to raise borrower welfare. In contrast, we look at the lender under a different light. We assume that the decisions of the lender are motivated by profit maximization and that these decisions are not observable to outside investors. In this setting, we focus on the conflict of interest that emerges between investors and the lender, and how this is impacted by a lending model based on credit denial.[8]

There are a couple important regulatory implications that emerge from our model. First, we find that moral hazard problems associated with incentives of the lender verse investors will be minimized when the lender's portfolio is subject to borrower runs. When the lender relies on credit denial as the incentive for loan repayments, there is a type of substitute for capital requirements that is built into the lender's balance sheet. For this reason, financial regulation and supervision overly concerned about excessive risk taking by such lenders may be misplaced. Second, we find that the intermediary's loan portfolio may be fragile to exogenous risk. That is, a small negative exogenous shock can end up wiping out a good portion of the asset side of the lender's balance sheet. This form of risk has pointed out by others, such as Christian et al. (2003) and Bond and Rai (2009).

Both of these findings can be traced back to the nature of the lending model used by the intermediary. When borrowers' incentives to repay their loans are built on the future availability of credit, any deterioration in the current (expected) repayment rate can trigger

[7] One can interpret an informed borrower in our model as a borrower that through social connections, receives information indicating whether other borrowers are either repaying their loans or defaulting.

[8] One can view our paper as an attempt to integrate two separate literatures. One is the theoretical literature on credit denial, such as Bond and Krishnamurthy (2004), Kletzer and Wright (2000) and Bond and Rai (2009). The second literature is the one devoted to regulatory questions about moral hazard and risk in banking, such as Repullo (2004) and Hellman et al. (2000).

large scale strategic defaults in the lender's portfolio. From a regulators perspective, the fragility of the portfolio due to borrower runs can potentially have negative implications for both investors and the wider financial system. With this in mind, we study a secondary market where the lender can sell loan assets.[9] The idea behind this strategy is to reduce the exaggerated vulnerability of asset valuations to small changes in the quality of the lender's loan portfolio. Within this framework we focus on the well know tradeoff that can plague lenders who engage in such loan sales, namely the moral hazard implications described by Pennacchi (1988). We show that the sensitivity of the lender's monitoring incentives to loan sales depends on the fraction of informed borrowers in the lender's portfolio. This finding is related to the point made by Gorton and Pennacchi (1995); namely that the moral hazard problem should be minimized if the lender can commit to holding a certain fraction of the loan. In this regard, we find that selling even a small fraction of the loan portfolio can have strong effects on the moral hazard problem.

The plan of the paper is as follows. In Section 2, we introduce the stage game for an infinite horizon economy in discrete time. The main actors consist of the borrowers and a single lending intermediary. We also describe the external investors, though these investors are modeled as uninformed investors who rely on the presence of a regulator to ensure that the intermediary behaves prudently. The regulator aims to minimize the incidence of insolvency, presumably because the regulator insures the external investors. In this sense, one can think of the external investment as household deposit accounts offered by the intermediary. In Section 3, we study the lender's one-period problem and pin down the minimum capital requirement set by the regulator. In Section 4 we describe optimal behavior of the borrowers. In Section 5 we examine the dynamic incentives of the intermediary. In this section we identify the incentive compatibility constraint governing the intermediary's choice of loan monitoring. Then in Section 7, we introduce a secondary market where the lender can sell loans. Our aim in this section is study the implications of loan sales on risk and moral hazard under the presence of informed borrowers. Finally, in Section 8 we have some final discussion of our findings.

[9] See Alarcon (2008) and Accion (2006) for discussion on the growing importance of these markets in microfinance.

2. The Model

Consider an infinite horizon economy in discrete time. The economy has a large population of agents with access to one-period investment projects. There are two types of investment projects, the *good* project and the *bad* project. Each project requires a $1 capital investment. The good project generates a certain cash flow $y > 1$. The bad project the project generates the agent a private benefit z. In order to invest in a project, the agent must obtain a loan from a lending intermediary. We assume the economy has one lending intermediary, which we refer to as the lender. To make a loan to an agent, the lender issues a $1 loan and demands that the agent repay $x > 1$. The loan repayment amount x is exogenous.

If the agent invests in the good project, then the agent has a choice whether to repay x or default and not paying anything. If the agent invests in the bad project the agent automatically defaults.[10] Any net earnings are consumed by the agent so that agents have zero retained earnings at the start of each period. The discount factor is δ, which satisfies the following.

Assumption A1 $$\frac{z - y + x}{z} > \delta > \frac{x}{y}$$

This assumption is sufficient to keep the problem between the lender and the borrower interesting. A1 ensures that δ is low enough so that the bad project is attractive to the agent, and that δ is high enough so that the lender can persuade the borrower to repay the loan if it was invested in the good project.

Before the lender issues loans, the lender first raises funds from external investors. We assume that the lender raises funds equal to F per period. In return, the investors demand that the lender makes a payment of rF at the end of the period, where r is an exogenous gross interest rate.[11] If the lender is unable to meet this obligation to the external investors, then the lender is termed insolvent and is shut down by the regulator.

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[10] One can interpret the good project as a business yielding cash flow whereas the bad project reflects personal consumption.

[11] We have made r exogenous in order to simplify the analysis. If one derives an endogenous value that accounts for risk on the equilibrium path, this will not significantly alter our results.

The lender has access to equity capital at a gross interest rate ρ. As is typically assumed in the literature, we let $\rho > x$. This implies that lender capital is costly, in that it exceeds the return on the loan repayment.[12] The lender issues loans using the external funds F and its own capital K. We assume that K satisfies a minimum capital requirement $k = K / F$, which is set by the regulator.[13] Note that since the loan size to an individual agent is exactly $1, the total number of loans issued by the lender per period is $K + F$.

In each period, the lender realizes a specific type of loan portfolio, denoted as μ_j. The value μ_j is the fraction of loans that go to borrowers who must invest in the good project and $1-\mu_j$ is the fraction of loans that go to borrowers who have a choice of projects. The portfolio type μ_j can take one of three values: $\mu_1 = 1$, $\mu_2 = 1-\varepsilon$, or $\mu_3 = \varepsilon$, where $\varepsilon > 0$ and $\varepsilon \to 0$. We refer to μ_1 as a "perfect" portfolio since all loans go to good projects. The reason for introducing three types of portfolio is to create a setting in which the portfolio is either perfect or not perfect, and if not perfect, where there is uncertainty about exactly how bad the portfolio is.

The type of portfolio realized by the lender is determined by both risk and the loan monitoring choice of the lender. The probability that the lender realizes a type μ_j portfolio in period t is $p_j(m)$, where m denotes the monitoring choice of the lender in period t. Let $m \in \{h, l\}$, where h denotes "high" monitoring and l denotes "low" monitoring. Thus, the monitoring choice amounts to selecting a probability distribution over the set of feasible portfolio types. We assume that both the investors and the regulator cannot observe the monitoring choice of the lender.

Assumption A2 $\qquad p_1(h) > p_1(l)$ and $p_i(h) < p_i(l)$ for $i = 2,3$

This assumption states that high monitoring maximizes the probability of a perfect portfolio and minimizes the probability of the other two types of portfolios.

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[12] See Hellman et al. (2000), Repullo (2004) and Myers and Majluf (1984) among others.
[13] Since we have assumed that the lender's equity capital is costly, it is clearly in the interest of the lender to minimize the use of its own capital.

High monitoring costs the lender $c > 0$ per loan issued and low monitoring costs the lender zero. The lender is assumed to pay this monitoring cost using equity capital.

Assumption A3 $\left[p_3(l) - p_3(h)\right]x - \rho c > 0$

We use A3 to ensure that the myopic lender's incentive to choose high loan monitoring improves as equity capital increases.

The last part of the model we need to specify is with regard to information. We assume that in each period some borrowers observe a signal about the quality of the lender's portfolio and some do not. Let λ denote the fraction of borrowers who do not get a signal and $1-\lambda$ denote the fraction that do.[14] The signal indicates whether the lender's portfolio is perfect or not. If borrowers observe a signal that the portfolio is not perfect, then these borrowers are uncertain about exactly how bad the portfolio is. To formalize this uncertainty, we assume that if the borrower observes a signal that the portfolio is not μ_1, then the borrower believes it is a μ_2 portfolio with probability β and believes it is a μ_3 portfolio with probability $1-\beta$.

The timing of the stage game is as follows. At the start of period t the lender issues $K+F$ loans to agents and selects a monitoring level. All agents that receive a loan invest in a project. A fraction $1-\lambda$ of the borrowers then observe a signal that indicates whether the lender has a perfect portfolio or not. Borrowers with good projects either repay their loan or default. Finally, the lender uses repayment revenue to pay external investors. As long as the investors are paid, the lender remains solvent and the game proceeds to the next period.

In our paper we focus on sustaining equilibrium where the lender chooses high monitoring every period. We refer to such an equilibrium as a *prudent equilibrium*. Also, we restrict our analysis to symmetric strategies for the agents.

3. The Lender's One Period Profit

The repayment revenue collected by the lender at the end of the period depends on the type of loan portfolio and the behavior of the borrowers. In equilibrium, we focus on sustaining behavior where if a borrower is given a choice of projects, the borrower chooses the bad

[14] Note that a borrower that observes a signal in period t does not necessarily observe a signal next period.

project. We will confirm that this behavior is optimal in the next section of the paper, but for the moment, take this to be given. Thus, if the lender has a μ_i portfolio, then fraction μ_i of the loans are invested in good projects. If agents with good projects choose to repay their loans, then the lender receives repayment revenue $\mu_i x(K+F)$. We define the lender's revenue net the obligation to external investors as net-revenue:

$$\pi\left(\mu_i\right) \equiv \mu_i x(K+F) - rF \; . \tag{1}$$

As long as $\pi\left(\mu_i\right)$ is non-negative the lender is solvent. Hence, conditional on realizing a μ_i portfolio, the lender's one-period profit from choosing high monitoring is

$$\max\left\{0, \pi\left(\mu_i\right)\right\} - \rho K - \rho(K+F)c \; . \tag{2}$$

Clearly, the lender's profit is maximized when $\mu_i = \mu_1$ and minimized when $\mu_i = \mu_3$, assuming again that agents with good projects choose to repay. For the intermediate portfolio μ_2, fraction μ_2 of the borrowers invest in the good project. Among these agents, fraction $1-\lambda$ receive a signal indicating that the portfolio is not μ_1. We refer to these agents as "informed" and the rest as "uninformed".

In general, the repayment decision by agents with good projects in any given period will be conditional on whether they are informed or not in that period. In equilibrium we focus on sustaining borrower behavior where agents with good projects always repay their loans, unless they receive a signal indicating that the portfolio is not perfect. For the moment, suppose agents behave exactly like this. Note that this applies to uninformed agents as well as informed agents who receive a signal that the portfolio is perfect.

This leaves informed agents who receive a signal that the portfolio is not perfect. The question is how these agents respond to the negative signal. Suppose these agents choose to repay their loans. The total repayment revenue for the lender is then $\mu_2 x(K+F)$. Since μ_2 is arbitrarily close to 1, the lender's net-revenue with a μ_2 portfolio is arbitrarily close to $\pi\left(\mu_1\right)$. On the other hand, if the informed agents do not repay, conditional on knowing the portfolio is not perfect, then the lender's repayment revenue is only $\lambda\mu_2 x(K+F)$. Whether this revenue covers the lender's external obligation depends on the value of the parameter λ.

The interesting case is where λ is low enough so that the lender cannot cover the external obligations. For the remainder of the paper we will focus our attention on precisely this case; that is, $\lambda\mu_2 x(K+F) < rF$. What is interesting about this case is that the lender goes insolvent even though the actual fraction of loans that were allocated to bad projects is very small. Recall that under a μ_2 portfolio almost all loans go to agents with good projects. The problem is that once informed borrowers detect that the lender's loan portfolio is not perfect, they are uncertain about exactly how bad it is. Under this uncertainty, if the agents find it optimal to default, the lender not only loses repayment revenue from bad projects but also from the informed borrowers with good investment projects.

Now we can calculate the lender's one-period *expected* profit as a function of the monitoring decision. Keep in mind that in a one-shot game the agents would never actually choose to repay their loans. Nonetheless, it is constructive to establish a benchmark using a one-period problem. Again, for the one-shot game assume agents repay their loans unless they receive a signal that the portfolio is not perfect.

The profit earned by the lender depends on what informed agents do if the portfolio is not perfect. Hence, there are two cases to consider, one where they repay their loans and one where they do not. Rather than consider the two cases separately, we can generalize the analysis by using the notation $q(m) \in \{p_1(m), p_1(m) + p_2(m)\}$ for $m = h, l$. Also, given that $\mu_2 = 1-\varepsilon$ and $\varepsilon \to 0$, we focus on the limit value where $\mu_2 = \mu_1$.

The lender's one-period expected profit from choosing high monitoring is

$$q(h)\left[x(K+F) - rF\right] - \rho K - \rho(K+F)c \ . \tag{3}$$

If informed agents repay their loans, then the lender is solvent for both a μ_1 and μ_2 portfolio and hence, $q(h) = p_1(h) + p_2(h)$. If informed agents default, conditional on a negative signal, then the lender is solvent only with a μ_1 portfolio and hence, $q(h) = p_1(h)$. The lender's one-period expected profit from low monitoring is

$$q(l)\left[x(K+F) - rF\right] - \rho K \ . \tag{4}$$

As K increases, the expected profit under high monitoring falls at the rate $q(h)x-\rho-\rho c$, and the expected profit from low monitoring falls at the rate $q(l)x-\rho$. Assumption A2 and A3 imply that the payoff from low monitoring falls at a relatively faster rate for either $q(m)$.

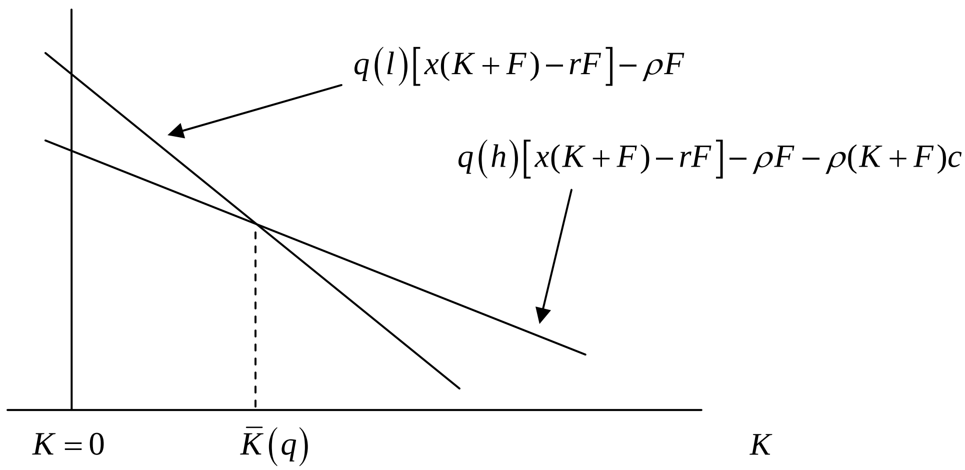

Figure 1.

To find the level of K where the lender's one-period expected profits are equal, we set equation (3) equal to equation (4) and solve for K, giving us

$$\bar{K}(q)=\frac{\left(q(h)-q(l)\right)[r-x]F+\rho cF}{\left(q(h)-q(l)\right)x-\rho c}. \tag{5}$$

As long as K is not less than this critical value, the myopic lender prefers high monitoring over low monitoring. Note that A2 and A3 imply that the denominator in $\bar{K}(q)$ is positive. However, the sign of the numerator may be positive or negative. If the capital constraint is negative then the regulator would impose a minimum capital constraint of zero. See Figure 1. for an illustration of a case where the capital constraint is positive.

Lemma 1. In the one-shot game, the regulator should choose a capital requirement k such that $k\geq\max\{0,\bar{K}(q)/F\}$.

The minimum capital requirement ensures that the lender's one-period expected profit is maximized under high loan monitoring. Note that the capital requirement depends on how informed borrowers behave. Evaluating $\bar{K}(q)$ at the two different feasible values of q, one can confirm that A2 implies that the minimum capital requirement is lower if informed borrowers default when the portfolio is not perfect. In the one-shot game the presence of informed borrowers imposes added discipline on the lender. In this sense, the regulator's capital requirement and the presence of informed borrowers can be viewed as substitutes for one another.

Another important role of capital is to cushion against a decline in repayment revenue. While this question is tangential to our primary focus, it is worthwhile commenting on this second role of capital requirements. Recall that in order to avoid insolvency for a μ_2 portfolio, it is necessary that $\lambda\mu_2 x(K+F) > rF$. Clearly this inequality is more likely to hold the higher the lender's capital is.

Corollary 1. In order to avoid insolvency for a type $i = 2,3$ *portfolio,* $K \geq K(\lambda) = \dfrac{rF}{\lambda\mu_i x} - F$ *.*

As with the capital requirement to avoid moral hazard, the amount of capital necessary to avoid insolvency is dependent on the fraction of informed borrowers in the lender's portfolio. When $\lambda = 1$, this inequality holds at $K = 0$ for a μ_2 portfolio, but as λ falls, the lender must holder higher levels of capital to cover against bad portfolios. This finding coincides with what Christian et al. (2003) argue in their policy paper; namely that a microfinance portfolio can deteriorate with surprising speed and for this reason, microfinance institutions should be subject to a higher capital adequacy percentage than is applied to normal banks. However, if λ is low, this lower bound on capital investment can be extremely costly for the lender. It is precisely these kinds of issues that make appropriate policy design a challenge.

4. Borrower Behavior

In our model, agents may face a couple choices. One choice is whether to repay the loan to the lender. In the absence of collateral, the incentive to repay the loan comes from the lender's ability to deny the agent future access to credit. To model this, we adopt a standard trigger strategy in which the lender repeatedly offers loans to the agent as long as the agent always repays the loan. Once the agent does not make a loan payment, the lender never loans to the agent again. In this event, next period, the lender allocates the funds to a new agent drawn from the population of agents with no history of borrowing from the lender. Since the lender can always initiate a relationship with a new agent, the punishment strategy used by the lender imposes no cost on the lender. This aspect of our model allows us to avoid renegotiation problems.

If an agent with a good project chooses to default on the loan, the agent's payoff in the game is simply y, since the agent can no longer borrow. The payoff from choosing to repay the loan depends on among other things, what the borrower knows about the portfolio. First, consider borrowers that have not received a signal indicating the current loan portfolio is having problems. This includes agents who receive no signal at all as well as informed agents who receive a signal that the portfolio is perfect.

Lemma 2. In a prudent equilibrium, unless borrowers receive a signal that the lender's portfolio is not perfect, the borrowers choose to repay their loans.

Proof. See appendix.

As mentioned earlier, this result is driven by assumption A1. The discount factor must be high enough such that the borrower's expected valuation of future credit access is sufficient to keep the borrower from strategically defaulting on the loan repayment. If the lender cannot induce the borrower to repay under these "good conditions", then the borrowers will never repay their loans and consequently, the lender would never issue any loans.

Lemma 3. If given a choice of projects, the borrower always chooses to invest in the bad project.

Proof. See appendix.

As long as the discount factor isn't too high, or alternatively, as long as z is assigned a high enough value, the borrower will opt for the bad project. Assumption A1 guarantees this. With this result, unless borrowers are properly monitored by the lender, they make investment choices that lead to default.

The last question we need to look at is whether informed borrowers repay their loans in the event they receive a signal that the lender's portfolio is not perfect. Conditional on receiving this signal, the borrower can either repay the loan or default. If the borrower defaults then the borrower's payoff is y. If the borrower repays the loan, the borrower makes $y-x$ in the current period, but the future payoff depends on what portfolio the lender actually has. If the portfolio turns out to be μ_3, then the lender will go insolvent, and hence, the borrower's payoff is simply $y-x$. However, if the lender's portfolio turns out to be μ_2 and all informed borrowers choose to repay their loans, then the lender remains solvent and the game proceeds to the next period.

First, we need to calculate the borrower's payoff from paying the loan, given that it turns out the lender holds a μ_2 portfolio. To make this calculation we assume all borrowers repay their loans if they don't receive a signal that the portfolio is not perfect, as Lemma 2 states. In period t the informed borrower makes $y-x$. In period $t+1$ the borrower's net-income depends on the quality of the period $t+1$ portfolio. With probability $p_i(h)$ the agent expects to make $\mu_i(y-x)+(1-\mu_i)z$, for $i=1,2,3$. Note that if $i=1$ the agent makes $y-x$, as the portfolio is perfect, but if $i=2$ or 3, then the agent's income depends on whether the agent invests in the good or bad project. For these latter two portfolio types, with probability μ_i the agent must invest in the good project, otherwise the agent has a choice.

Given that the lender holds a μ_2 portfolio in period t, the informed borrower's discounted expected payoff from always repaying the loan is

$$v_1 \equiv y-x+\delta\left\{\sum_{i=1}^{3} p_i(h)\left[\mu_i(y-x)+(1-\mu_i)z\right]\right\}$$
$$+\delta^2\left(p_1(h)+p_2(h)\mu_2\right)\left\{\sum_{i=1}^{3} p_i(h)\left[\mu_i(y-x)+(1-\mu_i)z\right]\right\}+\cdots$$

$$= y - x + \frac{\delta\Lambda}{1-\delta\mathrm{P}}, \quad (6)$$

where $\Lambda = \sum_{i=1}^{3} p_i(h)\left[\mu_i(y-x)+(1-\mu_i)z\right]$ and $\mathrm{P} = p_1(h) + p_2(h)\mu_2$. Note that in period $t+2$ the agent borrows if either, the $t+1$ portfolio was perfect, which occurs with probability $p_1(h)$, or the $t+1$ portfolio was μ_2 and the agent chose a good project, which occurs with probability $p_2(h)\mu_2$.

Finally, we return to the original question of whether the informed borrower will repay the loan if the borrower observes a signal that the portfolio is not perfect. In this event, the borrower believes the portfolio is type μ_2 with probability β and is μ_3 with probability $1-\beta$. Hence, the borrower's discounted expected payoff from repaying the loan is $\beta v_1 + (1-\beta)(y-x)$. Choosing to not make the loan repayment yields a payoff of y.

Lemma 4. In a prudent equilibrium, conditional on knowing the portfolio is not perfect, the informed borrower repays the loan if $\beta \geq (1-\delta\mathrm{P})x(\delta\Lambda)^{-1}$*, otherwise the borrower defaults.*

The repayment decision of the informed borrower is based on the belief about the quality of the lender's portfolio. As long as the informed borrowers attach a high enough probability to the portfolio being type μ_2, it is in their interest to repay their loans even when they know the portfolio has problems. If $\beta < (1-\delta\mathrm{P})x(\delta\Lambda)^{-1}$, then the informed borrower will deviate and choose to default on the loan. This decision is a strategic default, in that the borrower has the revenue to cover the loan repayment but decides that default is in their best interest.

5. The Prudent Equilibrium and Moral Hazard

From a regulator's perspective, it is clearly optimal for the lender to choose high monitoring. Such a choice minimizes the probability of insolvency, regardless of how the informed borrowers behave in equilibrium.[15] The question is whether the lender will have an incentive to behave prudently and choose high monitoring. As we noted earlier, the payoff to the lender is dependent on the decisions of informed borrowers when they find out that the lender does not have a perfect loan portfolio.

First, consider the case where $\beta \geq (1-\delta \mathrm{P})x(\delta\Lambda)^{-1}$. With these beliefs, all borrowers with good projects always repay their loans. Hence, the lender remains solvent for all portfolios except μ_3. By choosing high monitoring every period, the lender's discounted expected payoff is

$$\begin{aligned}\Pi_1 &\equiv \sum_{i=1}^{2} p_i(h)\pi(\mu_i) - \rho K - \rho(K+F)c \\ &+\delta\left(p_1(h)+p_2(h)\right)\left\{\sum_{i=1}^{2} p_i(h)\pi(\mu_i) - \rho K - \rho(K+F)c\right\} + \cdots \\ &= \frac{1}{1-\delta(p_1(h)+p_2(h))}\left\{\sum_{i=1}^{2} p_i(h)\pi(\mu_i) - \rho K - \rho(K+F)c\right\}. \end{aligned} \quad (7)$$

If the lender deviates in a single period by choosing low monitoring, the lender's discounted expected payoff is

$$\sum_{i=1}^{2} p_i(l)\pi(\mu_i) - \rho K + \delta\left(p_1(l)+p_2(l)\right)\Pi_1 . \quad (8)$$

Note that the deviation allows the lender to avoid monitoring costs for one period but raises the probability of realizing a type μ_3 portfolio and going insolvent. Hence, the one-period profit for the lender is higher under the deviation, as long as the lender is actually solvent, but the probability of being solvent falls, which reduces the likelihood of earning positive profit in the current period and all future periods.

The second case to consider is where $\beta < (1-\delta \mathrm{P})x(\delta\Lambda)^{-1}$. Now, if informed borrowers receive a signal indicating the lender's portfolio is not perfect, these borrowers choose to default on their loans. This implies that the lender will be insolvent for every portfolio except μ_1. By choosing high monitoring every period, the lender's discounted expected payoff is

[15] This is implied by A2.

$$\Pi_2 \equiv \frac{1}{1-\delta p_1(h)}\left\{ p_1(h)\pi(\mu_1) - \rho K - \rho(K+F)c \right\}. \tag{9}$$

If the lender deviates in a single period, the lender's discounted expected payoff is

$$p_1(l)\pi(\mu_1) - \rho K + \delta p_1(l)\Pi_2. \tag{10}$$

Based on our analysis up to this point, we can now assert the following.

Proposition 1. Let $\lambda\mu_2 x(K+F) < rF$ *. There is a prudent equilibrium if*

(i.) $p_1(h)\pi(\mu_1) - \rho K - \rho(K+F)c \geq 0$

(ii.) $\Pi_1 \geq (8)$ *if* $\beta \geq (1-\delta\mathrm{P})x(\delta\Lambda)^{-1}$ *&* $\Pi_2 \geq (10)$ *otherwise.*

The first condition in Proposition 1 requires that the lender's one-period expected profit be non-negative and the second condition requires that the lender have an incentive to choose high monitoring. The incentive compatibility constraint depends on the borrowers' beliefs about how bad the lender's portfolio is in the event the portfolio is having problems. If β is high, the lender avoids insolvency for all but the worst type of loan portfolio. However, if β is low, then informed borrowers strategically default when the portfolio is not perfect and hence, the lender faces insolvency for all portfolio types other than a perfect one. In this latter case, the lender's portfolio is subject to borrower runs.

In an earlier part of the paper, we calculated the minimum capital requirement necessary to induce the lender to choose the prudent action in the one-shot game. It turns out that in the dynamic setting, raising the capital requirement does not necessarily encourage prudent behavior. As pointed out by Hellman et al. (2000), as capital increases, since capital is costly, this lowers the future per period profit for the lender. For a farsighted lender then, the incentive to choose the prudent action can decline as capital increases. In the following result, we restrict our attention to the case where raising capital does in fact encourage high monitoring. Formally, we consider discount factor that is low enough such that

$$p_3(l)x - \rho c > \delta\rho\left[p_3(l) - (1-p_3(l))c \right]. \tag{11}$$

Note that at $\delta = 0$ this condition collapse to A3, if $p_1(h) = 1$, but at $\delta = 1$, the inequality reduces to $p_3(l)(x - \rho - \rho c) > 0$, which is not true because $x < \rho$, i.e., capital is costly. Hence, one can interpret this condition as a requirement that the lender is sufficiently myopic.

Corollary 2. Given that $p_1(h)$ is close enough to 1, $r > \delta\rho$, and (11) holds, the minimum capital requirement is relatively lower if there are borrower runs in the prudent equilibrium.

Proof. *See appendix.*

Similar to what we found in the one-shot game, in the repeated game the presence of informed borrowers relaxes the moral hazard problem and allows for a lower capital requirement, assuming β is low. The reason for this has to do with borrower runs. While the lender faces some risk of insolvency from borrower runs on the equilibrium path, this risk is higher when the lender engages in imprudent behavior such as low loan monitoring. It is off the equilibrium path where the lender is most likely to encounter problems with the loan portfolio. Since any deterioration in portfolio quality, regardless how minor it is, leads to insolvency, the incentive to deviate and thereby raise the risk of realizing an imperfect loan portfolio is minimized. In a sense, the informed borrowers punish the lender severely for engaging in risky behavior. Thus, as we mentioned earlier, the borrower runs in the lender's portfolio work as a substitute for capital, or alternatively stated, the informed borrowers serve to exaggerate the disciplinary role of equity capital.

The findings in our paper suggest that optimal capital requirements for intermediaries that rely on credit denial can be quite different depending on the regulatory objective. With regard to the role capital plays in incentives, as studied in the literature of Hellman et al. (2000) and Repullo (2004), we find intermediaries relying on credit denial require relatively low minimum capital requirements. However, with regard to the role capital plays as a cushion against falling repayment revenue, lenders can require much higher minimum capital levels. It turns out that for the same reason that moral hazard is minimized, the lender's balance sheet turns out to be rather fragile to exogenous risk. A small deterioration in portfolio quality can trigger widespread strategic default which drives a significant portion of the lender's asset valuation to zero.

Because capital is expensive, Christian et al. (2003) and others have suggested that while tightening capital adequacy for this class of intermediary helps insure investors against volatile repayment rates, this will discourage the industry and create an uneven playing field. An alternative to raising additional external capital is to diversify the portfolio. The problem of course is that these intermediaries hold a comparative advantage in issuing and servicing a specific type of loan. Shifting resources into other types of investment is likely to lower returns. However, a lender may find that it can strike a balance between these two concerns by continuing to issue and service loans and then to sell a portion of the loan portfolio in a secondary market.

6. Selling Loan Assets To Reduce Fragility

One means of reducing the fragility of the lender's portfolio to exogenous risk is to transform loan assets into an alternative type of asset. In this section, we model a secondary market where the lender sells some of the loans and then invests the proceeds in a risk-free asset. Our objective is to study how loan sales impact fragility and the moral hazard problem in a model of credit denial. In doing so, we should clarify two things up front. First, we do not look at whether the lender will want to sell loans or not. Second, we abstract from adverse selection problems. Our analysis is limited to the question of how the lender's monitoring incentives are impacted by a contract where the lender agrees to sell a fixed fraction of the loan portfolio every period. In an approach similar to that of Pennachhi (1988), we focus on a moral hazard problem, though our interest is on the effects of borrower runs.

Buyers in the secondary market are assumed to be unable to observe the monitoring choice of the lender. Furthermore, we assume there is no recourse on the seller associated with the performance of the loan assets. Risk neutral buyers in the secondary market simply pay a price equal to the discounted expected cash flow on a loan. Denote the loan price as w. Given that the lender chooses high monitoring, the present value of the expected cash flow is

$$w = r^{-1}\left[p_1(h)\mu_1 + p_2(h)\mu_2\lambda + p_3(h)\mu_3\lambda \right] x. \tag{12}$$

When the lender sells a loan at the price w, we assume the lender then invests the proceeds in a risk-free asset that earns the rate of return r.

In our paper, the motivation for loans sales is to reduce the lender's exposure to risk. This form of risk management has been studied in a number of papers, such as Demsetz (1999) and Cebenoyan and Strahan (2004). It is also well understood that loan sales can aggravate a moral hazard problem. As Pennacchi (1988) demonstrated, loan sales, unless properly contracted, will reduce the incentive of the lender to engage in costly monitoring of the loans. The question we focus on is how this basic tradeoff between loan sales and moral hazard is impacted when the lender uses a credit denial model of lending.

We need to examine how loan sales impact incentives and risk. Let ϕ denote the fraction of loans that the lender contracts to sell each period. We focus on a situation where $p_1(h)$ is arbitrarily close to 1. This implies that if the lender chooses high monitoring, the portfolio is nearly always perfect. At the limit, the lender's one period revenue is $[\phi wr + (1-\phi)x](K+F)$ and the loan price is $w = r^{-1}x$. Plugging this loan price into revenue, one can see that revenue is independent of ϕ. Hence, for $p_1(h) \to 1$, the change in the lender's equilibrium payoff due to a change in ϕ is arbitrarily close to zero. Hence, the equilibrium payoff is essentially constant.

Now consider the lender's payoff from a deviation. As a benchmark, we first consider the case where $\lambda = 1$. That is, there are no informed borrowers. Lemma 2 implies that the lender is solvent for both a μ_1 and μ_2 portfolio. Hence, given that $\mu_2 \simeq \mu_1$, the lender's one period repayment revenue is arbitrarily close to $[\phi wr + (1-\phi)x](K+F)$, conditional on realizing a μ_1 or μ_2 portfolio. As noted above, since $w = r^{-1}x$, revenue is independent of ϕ. However, as ϕ increases, eventually the revenue from the loan sales will be high enough to cover the lender's obligation to external investors even if the portfolio turn out to be μ_3. That is, at the limit,

$$\left[\phi wr+(1-\phi)(\mu_3=0)x\right](K+F)=rF \text{ , or}$$

$$\bar{\phi}\left(\lambda=1\right)=\frac{F}{w(K+F)}. \tag{13}$$

At $\phi>\bar{\phi}\left(1\right)$ the lender never goes insolvent. Hence, in order to reduce risk of insolvency, the lender must sell at least $\bar{\phi}\left(1\right)$ of the loans.[16] However, if the lender never faces risk of insolvency, then the lender is better off by choosing low monitoring. This is the basic tradeoff between loan sales and monitoring that we mentioned earlier.

The question at hand is what happens to $\bar{\phi}$ when $\lambda<1$? In particular, if the portfolio is subject to borrower runs, what happens when the lender begins selling loans in the secondary market? Consider a low value of λ where $\lambda x(K+F)<rF$. If $\phi=0$, the lender is insolvent in both a μ_2 and μ_3 portfolio. Suppose the lender's incentive compatibility constraint holds when $\phi=0$. As ϕ increases, consider what happens to the lender's payoffs. First of all, note that for $p_1\left(h\right)\to 1$, the change in the lender's equilibrium payoff due to a change in either ϕ or λ is arbitrarily close to zero. This is because λ only impacts revenue when the portfolio is not perfect. Hence, the lender's equilibrium payoff is essentially constant.

Now consider the payoff from a deviation. If the lender selects low monitoring, then the expected profit in the current period is

$$p_1\left(l\right)\left[\phi wr+(1-\phi)\lambda x\right](K+F)-rF-\rho K. \tag{14}$$

Note that since $\lambda<1$, now $w>\lambda r^{-1}x$.[17] Consequently, as ϕ rises, the one-period expected profit increases. Thus, as ϕ rises, either the incentive compatibility constraint binds at some positive ϕ value, or alternatively, ϕ reaches a point where the lender avoids insolvency for a μ_2 portfolio. This latter possibility occurs when

$$\left[\phi wr+(1-\phi)\lambda x\right](K+F)=rF \text{ , or}$$

$$\bar{\phi}\left(\lambda\right)=\frac{rF-\lambda x(K+F)}{(wr-\lambda x)(K+F)}. \tag{15}$$

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[16] Recall that when there are no informed borrowers, insolvency only occurs with a μ_3 portfolio.

[17] This is because the loan price is calculated on the assumption that the lender chooses high monitoring every period.

At $\phi > \overline{\phi}(\lambda)$, the lender avoids insolvency for a type μ_2 portfolio. Hence, in order to reduce fragility, the lender needs to sell at least fraction $\overline{\phi}(\lambda)$ of the loan portfolio. However, once the lender sells this fraction of the portfolio, as we show below, this turns out to significantly alter the lender's incentive to monitor the loans.

Note that the change in the lender's equilibrium payoff is arbitrarily small. For the deviation payoff this is not true. At $\phi < \overline{\phi}(\lambda)$, the lender is insolvent unless the portfolio is perfect, and so, the expected payoff from a deviation is

$$p_1(l)\left[\phi wr + (1-\phi)\lambda x\right](K+F) - rF - \rho K + p_1(l)\delta\Pi_3, \tag{16}$$

where Π_3 is the lender's discounted equilibrium payoff, calculated at the limit:

$$\Pi_3 = \frac{1}{1-\delta}\left\{\left[\phi rw + (1-\phi)x\right](K+F) - rF - \rho K - \rho(K+F)c\right\}. \tag{17}$$

At $\overline{\phi}(\lambda)$, the lender is only insolvent for a μ_3 portfolio, and so, the expected payoff from a deviation is

$$(p_1(l) + p_2(l))\left[\phi wr + (1-\phi)\lambda x\right](K+F) - rF - \rho K + (p_1(l) + p_2(l))\delta\Pi_3. \tag{18}$$

Clearly there is discontinuity in the deviation payoff, where at $\overline{\phi}(\lambda)$, the payoff jumps to a higher value due the fact that the lender now remains solvent for a μ_2 portfolio. The point is, at $\overline{\phi}(\lambda)$, when the risk of insolvency drops there is a significant tightening of the lender's incentive compatibility constraint.

One can easily confirm that the following holds.

Lemma 5. $\overline{\phi}(1) > \overline{\phi}(\lambda)$.

As we explained earlier, when the lender's portfolio holds a significant percentage of informed borrowers, the lender risks insolvency from the slightest deterioration in portfolio quality. Selling a sufficient amount of loans in the secondary market reduces the vulnerability of the lender's balance sheet to borrower runs. However, shifting this risk of default off the balance sheet aggravates the well known moral hazard problem associated with loan monitoring. We find that this moral hazard problem will precipitate at a lower fraction of loan sales relative to a model where there are no borrower runs. This is because of the disciplinary role that informed borrowers have on the lender's monitoring decisions. What this suggests is that if the intermediary transforms loans assets into alternative assets to reduce fragility, it may be necessary to raise minimum capital standards to counter the disincentive on loan monitoring. This finding is related to the suggestion by Gorton and Pennachhi (1995), whereby to minimize agency problems associated with selling loans, the seller should retain a portion of the loan. The idea is that the greater the portion of the loan held by the bank, the greater will be its incentive to monitor the borrower. In our model, this is equivalent to choosing a higher fraction $1-\phi$. In this regard, we find that the presence of informed borrowers creates disincentives for the lender to monitor at relatively low levels of participation in the secondary market.

7. Final Discussion

In 2008 the Reserve Bank of India tightened capital adequacy standards for a class of non-banking finance companies, under which most microfinance intermediaries are classified. The Reserve Bank had up to that point required that these intermediaries maintain a minimum capital to risk assets ratio of 10%. This minimum ratio was set to rise to 12% within one year and to 15% with two years (RBI, 2008). The rational for the policy change was based on concerns about risks associated with highly leveraged borrowings and reliance on short term funds to fund long gestation assets. Following the announcement, several microfinance organizations protested that the tightening was based on a misunderstanding of the relevant risks and that the immediate response by some organizations would be to sell part of their loan portfolios to other banks.[18]

Within the framework of our model, raising capital adequacy can have sound justification when intermediaries rely on credit denial rather than collateral. As noted by Chrisen et al. (2003), in a lending model based on credit denial, outbreaks of delinquency can be contagious,

[18] See "MFIs under pressure to raise funds" Business Standard, April 21, 2008.

which can decapitalize an intermediary rather quickly. If an intermediary raises capital by selling loans, this can alter the incentives regarding prudent behavior. In our model, we find this to be especially relevant. In a lending model based on credit denial, the presence of informed borrowers on the balance sheet serves to exaggerate the downside of any risky behavior on the part of the lender. Once the lender removes these assets from the balance sheet, this can aggravate the moral hazard problem more severely than it would for a typical intermediary. Hence, if an intermediary relying on credit denial begins selling loan assets to raise capital, this can very quickly alter the incentives facing the lender. If the lender then optimally chooses to relax its loan monitoring, this is more likely to generate repayment problems which in turn, will be absorbed by the capital set aside from the initial loan sales. In this sense, tightening capital adequacy can be self-fulfilling.

The successes intermediaries have had in using innovative lending technologies to extend loans to small business should be viewed as a valuable part of the broader effort to deepen credit markets in the emerging economies. While there is a strong case for top down approaches such as liberalizing banking markets and reforming the institutions that shape credit markets, it is certainly worthwhile for policy makers to also pay attention to the successes that some intermediaries have carved out in these markets. The credit denial model is one example. As we have shown in our paper, the mechanisms by which this lending model works can have unique regulatory implications. Without a proper examination of exactly how standard regulatory tools such as capital requirements impact these intermediaries, it will be difficult to thread the needle between safeguarding the financial system while encouraging lenders to find solutions to missing credit markets.

Appendix

Proof of Lemma 2. Consider an agent with a good project in period t. The equilibrium payoff to this type of agent from choosing to repay the loan is $y-x+V$, where V is some non-negative discounted income stream. If $y-x+V$ exceeds y, then the borrower will choose to repay the loan. When this is true, it must always be optimal for the borrower to repay the loan conditional on not observing a signal that the portfolio is having problems (i.e., not μ_1). Hence, for every future period, in the event the lender realizes a perfect portfolio, the agent will have a good project and optimally repay the loan.

Based on this observation, we can calculate a lower bound for the borrower's payoff from choosing to repay the loans. Assign the borrower a net-income of $y-x$ in the current period. For future periods, assign the borrower $y-x$ as long the lender has always realized a perfect portfolio. In all other future states of the world, assign the borrower a net income of zero. This gives the borrower a discounted stream of income

$$u_1 \equiv y-x+\delta p_1(h)(y-x)+\delta^2 p_1(h)^2 (y-x)+\cdots = \frac{y-x}{1-\delta p_1(h)}. \tag{19}$$

Note that u_1 applies to a borrower who knows the period t portfolio is perfect. For the borrower who is uninformed in period t, the discounted income stream is

$$u_2 \equiv y-x+\delta p_1(h)^2 (y-x)+\delta^2 p_1(h)^3 (y-x)+\cdots = y-x+\frac{\delta p_1(h)^2 (y-x)}{1-\delta p_1(h)} \tag{20}$$

In this case, note that the uninformed borrower makes $y-x$ in period t, just as the informed borrower does, but makes $y-x$ in period $t+1$ only if both the period t and the $t+1$ portfolios turns out to be perfect, which occurs with probability $p_1(h)^2$.

Since the borrower makes non-negative income in all other states of the world, these two discounted income streams form lower bounds on the borrower's equilibrium payoff. Thus, $y-x+V$ exceeds both of these discounted income streams. Furthermore, one can see that

$$u_1 > u_2 > \frac{p_1(h)(y-x)}{1-\delta p_1(h)}. \tag{21}$$

Finally,

$$\frac{p_1(h)(y-x)}{1-\delta p_1(h)} > y \text{ if } \delta > \frac{y-p_1(h)(y-x)}{p_1(h)y}. \tag{22}$$

This is implied by A1. QED

Proof of Lemma 3. Consider a borrower who has a choice of projects in period t. Note that at the time of the project choice the borrower does not know what type of portfolio the lender has, nor whether they will turn out to be an informed borrower or not. If the borrower chooses the bad project, the payoff is z. If the borrower chooses the good project, the borrower's net-income in period t will be either $y-x$ or y, depending on the strategy and the state of the world. The expected payment in period t is then $\phi(y-x)+(1-\phi)y$, where $\phi\in[0,1]$ can be calculated in equilibrium. For example, if the strategy is to always repay regardless, then $\phi=1$ and so on. Note ϕ must be constant from one period to the next.

If the borrower optimally elects to choose the good project in period t, then the borrower will do the same in every future period. Hence, the discounted equilibrium payoff from choosing to repay the loan is $(1-\delta)^{-1}[\phi(y-x)+(1-\phi)y]$. The borrower will choose the bad project if

$$z > (1-\delta)^{-1}[\phi(y-x)+(1-\phi)y]. \tag{23}$$

One can easily confirm that A1 implies that the right hand side of this inequality is maximized at $\phi=1$. Furthermore, A1 also states that $z>(1-\delta)^{-1}(y-x)$. QED

Proof of Corollary 2. Our proof relies on the fact that payoffs are linear in capital (see Figure 1.). We make our calculations at the limit values, where $p_1(h)=1$ and $\mu_2=\mu_1$.

The equilibrium expected payoff to the lender from choosing high monitoring is

$$(1-\delta)^{-1}[x(K+F)-rF-\rho K-\rho(K+F)c].^{19} \tag{24}$$

[19] When $p_1(h)=1$ the portfolio is always perfect and hence, the decisions of informed borrowers is not relevant to the equilibrium payoff.

As K increases, this payoff falls at the rate $(1-\delta)^{-1}\left[x-\rho-\rho c\right]$. When there are no borrower runs, the lender's expected payoff from a one period deviation is

$$\left(p_1(l)+p_2(l)\right)\left[x(K+F)-rF\right]-\rho K+\left(p_1(l)+p_2(l)\right)\frac{\delta}{1-\delta}\left\{x(K+F)-rF-\rho K-\rho(K+F)c\right\}.$$

(25)

As K increases, this payoff falls at the rate

$$\left(p_1(l)+p_2(l)\right)x-\rho+\left(p_1(l)+p_2(l)\right)\frac{\delta}{1-\delta}\left\{x-\rho-\rho c\right\}. \quad (26)$$

The deviation payoff falls at a relatively faster rate if

$$p_3(l)x-\rho c>\delta\rho\left[p_3(l)-(1-p_3(l))c\right], \quad (27)$$

which is identical to condition (11) . When there are borrower runs, the expected payoff from a one-period deviation is

$$p_1(l)\left[x(K+F)-rF\right]-\rho K+p_1(l)\frac{\delta}{1-\delta}\left\{x(K+F)-rF-\rho K-\rho(K+F)c\right\}. \quad (28)$$

As K increases, this payoff falls at the rate

$$p_1(l)x-\rho+p_1(l)\frac{\delta}{1-\delta}\left\{x-\rho-\rho c\right\}. \quad (29)$$

The deviation payoff with borrower runs falls at a relatively faster rate than the deviation payoff without borrower runs if $x-\delta\rho-\delta\rho c>0$, which is true since we can rewrite condition (11) as $p_3(l)\left[x-\delta\rho-\delta pc\right]>(\rho-1)c$, where we know $\rho>1$.

If we set the equilibrium payoff equal to the deviation payoff and solve for capital we get

$$\bar{K}(q;\delta)=\frac{(q(h)-q(l))(r-x)F+\rho cF+(q(h)-q(l))\frac{\delta}{1-\delta}\left[q(h)(r-x)+\rho c\right]F}{(q(h)-q(l))x-\rho c+(q(h)-q(l))\frac{\delta}{1-\delta}\left[q(h)x-\rho-\rho c\right]} \quad (30)$$

First, note that A3 and condition (11) imply that the denominator of $\bar{K}(q;\delta)$ is positive for both $q(m)=p_1(m)+p_2(m)$ and $q(m)=p_1(m)$. Given that $p_1(h)=1$, this implies $p_2(h)=p_3(h)=0$ and hence, one can confirm that if there are borrower runs, $\bar{K}(q;\delta)$ is less relative to the case where there are no borrower runs, as long as

$$\bar{K}\left(p_1(h);\delta\right) < \bar{K}\left(p_1(h)+p_2(h);\delta\right) \text{, or}$$

$$\begin{aligned} 0 < (Q-R)rF\rho c + FR(r-x)Q(\Phi\Gamma - \tilde{\Phi}\Delta) + QRx(\tilde{\Phi}\Psi - \Phi\Omega) + \rho Fc(Q\Phi\Gamma - R\tilde{\Phi}\Delta) \\ + pc(Q\Phi\Omega - R\tilde{\Phi}\Psi) + Q\Phi R\tilde{\Phi}(\Gamma\Psi - \Omega\Delta) \end{aligned} \tag{31}$$

where, to ease the exposition, we have defined the following: $Q = p_1(h) - p_1(l)$,

$R = p_1(h) + p_2(h) - p_1(l) - p_2(l)$, $\Phi = \dfrac{\delta}{1 - p_1(h)\delta}$, $\tilde{\Phi} = \dfrac{\delta}{1-(p_1(h)+p_2(h))\delta}$,

$\Gamma = p_1(h)x - \rho - \rho c$, $\Delta = (p_1(h)+p_2(h))x - \rho - \rho c$, $\Psi = (p_1(h)+p_2(h))(r-x)F + \rho cF$,

$\Omega = p_1(h)(r-x)F + \rho cF$.

Since $p_1(h) = 1$, $\Phi = \tilde{\Phi}$, $\Gamma = \Delta$, and $\Psi = \Omega$. The inequality then collapses to

$$0 < (Q-R)rF\rho c + \rho Fc(Q\Phi\Gamma - R\tilde{\Phi}\Delta) + pc(Q\Phi\Omega - R\tilde{\Phi}\Psi) \text{, or} \tag{32}$$

$$0 < r - \delta\rho. \quad \text{QED}$$

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