Essays in Microeconomics of Banking

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Contents

Chapter 1

Introduction

This dissertation consists of three self-contained papers, which are concentrated around the topic of financial intermediation. Chapter 2 deals with the issue of concealing risk exposure by banks in the context of risk-sensitive capital requirements. Chapter 3 analyzes the role of expected income in entrepreneurial borrowing. Chapter 4 delivers a new explanation for a stigma of failure phenomenon observed on the credit markets.

1.1 How to Make the Banks Reveal Their Risks: the Case of Basel II

In Chapter 2 I analyze the incentives of banks to reveal their risk exposure under risk-sensitive capital regulation. The New Basel Accord, called Basel II, gives the banks some scope to determine their capital levels. Under the so-called IRB-approach, the banks' capital is adjusted to their risk profiles quantified using internal risk management models. However, Basel II creates an incentive to understate risk exposure as risk is banks' private information and equity capital is costly. Such a behavior harms the banks' stability because it makes capital buffers inadequate with respect to the banks' risk exposure. Hence, bank supervisors must be interested in curbing the banks' incentives to underreport their risk exposures.

I model an one-shot interaction between the bank and the supervisor, in which the bank reports the quality of its assets, and the supervisor can inspect it as well as impose penalties. When the bank is found out to be undercapitalized, the supervisor can use four tools: Recapitalization, downsizing, closure or fines. The supervisor maximizes social welfare by choosing the optimal scale of his intervention, i.e. the type of penalty and the probability of inspection.

In this framework, I receive two sets of results. The first one is concerned with the implementation of the sensitive capital requirements. First, supervisors should use fines to punish the management of undercapitalized banks. Second, if fines are not feasible, policy measures for undercapitalized banks should depend on the current situation on the capital markets. Third, supervisors should encourage recapitalization instead of asset sales to boost capital ratios.

The second set of results delivers a conclusion that eliminating risk misreporting and reducing pro-cyclicality of Basel II may not be feasible at the same time. The supervisor concerned both with the amount of credit and the stability of banking sector faces a trade-off while implementing the sensitive capital requirements. Increasing the sensitivity of the capital requirements allows the banks with high quality assets to issue more credit, but it makes misreporting for the banks with low quality assets more valuable. I argue that the tightness of this trade-off is counter-cyclical. In booms either additional equity injections are costly because shareholders demand high rate of return for forgoing alternative projects or banks possess huge cash flows which can be used to increase capital ratios rather than to pay dividends. Hence, the supervisor can increase maximally the credit supply as incentives to misreport can be eliminated by threats of costly recapitalizations. In downturns these conditions reverse and the supervisor is not able to punish the banks adequately. Hence, he has to increase capital requirements for the high quality banks in order to eliminate the misreporting incentives. Tightening of the above mentioned trade-off calls for reduction in the credit supply in downturns.

The conclusion of the paper is that recent proposals to diminish the pro-cyclicality of capital requirements can magnify the misreporting incentives of banks, increasing the probability of their defaults.

1.2 The Creditworthiness of the Poor. A Model of the Grameen Bank

Chapter 3 analyzes the role of expected income in entrepreneurial borrowing in the context of microcredit programmes. We start out with several observations about the Grameen Bank. The Grameen Bank achieves unprecedented repayment rates on their loans despite the fact that its borrowers are qualified as the poorest of the poor. The existing theoretical literature has proposed group liability as a reason for the success of the Grameen Bank. However, the recent empirical evidence on the effect of group liability is at best mixed. Moreover, the Grameen Bank ruled out explicitly the group liability from its lending rules. We provide a novel explanation for the success of the Grameen Bank.

First, we built a theoretical model, in which we study the dynamics of a monopolistic bank granting loans and taking deposits from overlapping generations of entrepreneurs with different levels of expected income. We show that poorer individuals are safer borrowers because they value more the relationship with the bank. Loss of the savings technology due to strategic default is more harmful for poor borrowers who cannot compensate the loss of consumption smoothing mechanism through high income in the next period. Moreover, we match the evidence of the Grameen Bank that a bank will focus on individuals with lower expected income, and will not disburse dividends until it reaches all the potential borrowers.

Second, we find empirical support for our theoretical results using data from a household survey from Bangladesh. We show that various measures of expected income are positively and significantly correlated with default probabilities. As measures of expected income we use gender dummy, dowry exchanged between families at the time of the borrower's marriage, and the expected wage in the non-agricultural sector in the borrower's village. Moreover, we show that the gender dummy becomes insignificant after plugging the other two measures of expected income into the regression. This hints towards an economic explanation for women being better borrowers than men: Women in Bangladesh face very low expected income. Next, we show that the Grameen Bank and other micro-finance institutions concentrate on lending to borrowers with low expected income, which is consistent with our claim that low expected income is a driving force of high repayment rates in micro-finance programs.

Our paper provides interesting policy implications. A sustainable micro-finance program should be directed towards individuals with worse outside options, i.e. poorer individuals. This allows to obtain higher repayment rates crucial for a sustainable institution. However, presence of alternative institutions that provide credit and savings to the individuals matters for a micro-finance institution. Introducing micro-finance programs in places where other institutions already offer credit and deposits will probably result in low repayment rates, and hence unsustainability, not only for the entrant but also for the institution that was present before.

1.3 Endogenizing the Scope of the Stigma of Failure

Chapter 4 deals with a phenomenon of a stigma of failure, which refers to the general public's attitude towards entrepreneurs with a failed venture. It arises on capital markets from the imperfect traceability of the reasons for previous bankruptcy. They leave failed entrepreneurs exposed to discriminating behavior on the part of investors, business partners, employees and consumers, which adversely affects the economic outcome: The fact that a fresh start will be more difficult discourages agents to become entrepreneurs. Besides, current entrepreneurs are induced to choose too low levels of business risk. A pronounced stigma of failure is therefore often blamed for hampering entrepreneurship, innovation and growth.

Anecdotal evidence points out to a difference in the degree of stigma of failure among developed economies. On the one extreme there are countries of continental Europe, in which entrepreneurs take low risks and the creditors stop to provide financing to borrowers only after one failure. On the other extreme there are the USA, where entrepreneurs seem to take riskier projects and are able to obtain new financing after more than one failure. In our paper we develop a novel explanation for these differences. The setup of the paper allows also to study the impact of the transparency on the efficiency of credit markets.

In our model an entrepreneur needs a loan for a project, which can be run with either high or low risk. Its probability of success depends both on chosen risk and on entrepreneurial skills, which are unknown to everybody. Financing is provided by competitive banking sector. Failure of the project and risk choice provide a signal about the quality of entrepreneurs: When the entrepreneur takes low risk, failure reveals her as being of low quality. Such an entrepreneur will never be financed by the banks. Failure while taking high risk yields an imperfect signal about the quality as the good entrepreneurs could have bad luck, and it may take several consecutive failures for agents to realize that the entrepreneur is of low quality. Two possible outcomes may emerge: A conservative equilibrium with one-off project financing and low risk taking, and an experimental equilibrium with fresh project financing even after a (limited and endogenously determined) number of failures with high risk taking.

Whether these outcomes emerge uniquely or as multiple equilibria depends on the degree of transparency of lending relationship. If previous risk choices are observable, there is a unique equilibrium which is welfare-maximizing. However, if risk choices are unobservable, both outcomes may coexist meaning that inefficient equilibria may arise.

These results have novel implications for policy making and capital market design. First, the results point out that small and specialized banks, which understand the business of their clients may provide the efficient form of financing. This has implications for the design of banking systems in developing countries. Second, if the credit markets are plagued by asymmetric information, change of the equilibrium outcome by manipulating the primitives of the economy will not occur without a simultaneous change in the beliefs of all banks.

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The remainder of the thesis is organized as follows. The consecutive chapters contain the above mentioned papers. The appendix contains the appendices for the papers, where proofs and regression tables can be found. References for the papers are in the last chapter of the thesis.

Chapter 2

How to Make the Banks Reveal Their Risks: the Case of Basel II

2.1 Introduction

The New Basel Accord, called Basel II, gives banks some scope to determine their capital levels. Under the so-called IRB-approach, banks are required to adjust their capital to their risk profiles, which are assessed using banks' internal risk management models. However, as risk is private information of banks, they have an incentive to understate their risk exposure in order to save on equity capital.[1] Such a behavior can lead to imbalances between risk profiles and equity capital used to cover them and, ultimately, can be detrimental to the stability of the banking systems. Hence, bank supervisors must be interested in curbing the banks' incentives to underreport their risk exposures. However, as the recent experience with the 2007 US sub-prime crisis has shown, making banks reveal their risks, before a crisis event hits, can be a challenging task: The crisis has magnified already existing concerns about the prudent use of the internal risk management models for the computation of the risk-based capital requirements (Padoa-Schioppa (2004), p. 48). Moreover, Basel II is silent about instruments to be used for supervisory reviews in risk-based capital regulation (see also Kaufman (2003)). In the light of these concerns, this paper studies the design of supervisory schemes that can be used to elicit information about the banks' riskiness.

In the paper, I analyze implementation of risk-based capital regulation à la Basel II when risk is banks' private information.[2] Capital requirements are needed to eliminate

[1] Significance of banks' misreporting incentives is highlighted by Gunther and Moore (2003). They provide evidence on the loss underreporting by banks soon after deterioration of their financial conditions, independently of their initial risk exposure.

[2] Across the paper for the easiness of the exposition, I refer to the project's quality rather than risk.

a moral hazard problem: Inside equity capital provides incentives for banks to behave prudently. However, the capital requirements are costly in welfare terms because capital could be used to finance alternative projects. The supervisor has a choice between risk-insensitive and risk-based capital requirements. Insensitive regulation requires a fixed capital level that imposes excessive capital requirements on low risk banks.

The alternative are the risk-based capital requirements. On the one hand, they allow to reduce capital level of low risk banks. On the other, their consequence is an adverse selection problem because only banks know their risk profile. This reintroduces the moral hazard issue, because high risk banks mimic low risk banks and take too little capital in order to behave prudently. The supervisor has to design a scheme making high risk banks report their risk truthfully.

In the paper, I model the interaction between the bank and the supervisor as a one-shot game, in which the supervisor can inspect and impose penalties on the bank. Inspection is costly, imperfect, stochastic and must take place early enough in order to detect misreporting. When the supervisor receives a signal that the bank is undercapitalized, he can punish the bank by using four instruments: Recapitalization, downsizing, closure or fines. The supervisor chooses the optimal scale of his intervention, i.e. the type of penalty and the probability of inspection, in order to maximize social welfare.

The supervisory instruments in my model are common in current regulation. Inspection of banks' risk is proposed in the Principle 2 of the Basel II Accord (BCBS (2004), p. 162).[3] Recapitalization is mentioned in the Principle 4 of Basel II Accord (BCBS (2004), p. 165) and in the Prompt Corrective Action (PCA) in the USA, which contains also closure as a penalty.[4] Downsizing is used to restore the banks' equity levels as an alternative for recapitalization.

In this framework, I show the following results. First, a necessary condition for the viability of risk-based capital requirements is a high quality of inspection. Otherwise, the high (low) risk bank misreports because the probability of being caught on misreporting (of being punished by mistake) is too low (high).

Second, the scope of supervisory intervention depends non-trivially on the cost of equity capital. Increase in the cost of capital fuels incentives for misreporting by making capital more expensive. However, recapitalization and downsizing as penalties become more harmful too. In the former case, injecting new equity is more costly. In the latter, assets

As this is immaterial for the results, it allows me to use the term "risk" in the introduction.

[3]Importance of supervisory inspections is highlighted by Gunther and Moore (2003), and Ashcraft and Bleakley (2006). The first paper shows that the supervisory inspections are a useful tool for detecting misreporting by banks. The second paper stresses that the supervisors have better information than market investors about banks' exposures and the banks are able to use their private information against the market.

[4]See e.g. Nieto and Wall (2006) for the overview of the PCA design.

sold by the bank become cheaper due to increased cost of financing for investors who buy them. Hence, a higher cost of capital allows the supervisor to intervene less often when punishing with recapitalization and downsizing. In the case of closure, an increase in the cost of capital has only the effect of making capital more costly. This requires more frequent supervisory intervention.

Next, I conduct a welfare analysis. The optimal supervisory scheme implementing the risk-based capital requirements is a combination of recapitalization and a fine. Recapitalization eliminates moral hazard and the fine provides truthtelling incentives. Given that fines have not yet been used to deal with undercapitalized banks,[5] I compare welfare under risk-based capital requirements implemented through recapitalization, downsizing and closure, and under risk-insensitive capital requirements. First, recapitalization yields higher welfare than downsizing. The reason is that selling the bank's assets to outside investors generates profits that are not present when injecting new equity capital. Second, the cost of capital has two effects on welfare: It affects savings on equity capital for low risk banks and the cost of the supervisory intervention. Hence, risk-based regulation with recapitalization yields the highest welfare when the cost of capital is high, the one with closure when this cost is intermediate, and insensitive regulation when it is low.

The results of my paper allow to draw several policy implications for bank capital regulation when banks' incentives to misreport their risks threaten their stability. First, supervisors should introduce fines to punish management of undercapitalized banks.

Second, if fines cannot be introduced, supervisory policies to deal with undercapitalized banks should depend on the situation on capital markets. When the cost of equity capital is high, supervisors should force undercapitalized banks to recapitalize. When this cost is intermediate, undercapitalized banks should be closed and existing shareholders substituted with new ones. When the cost of equity capital is low, risk-insensitive capital requirements should be introduced. If closures are not feasible, supervisors should introduce insensitive capital requirements for a sufficiently low cost of capital. Given the interpretation of the cost of the equity capital as the return on alternative outside opportunities (see also Parlour and Plantin (2008)), the results of the model suggest the following: Risk-based capital requirements supported by the recapitalization penalty should be introduced in booms and risk-insensitive in downturns.[6] Such an implication contrasts with proposals that advocate an increase in capital requirements in booms to dampen the expansion of credit and their decrease in downturns to reduce its contraction.

[5]Fines are mentioned neither in the PCA nor in the Basel II Accord.

[6]The cyclical behavior of the cost of capital may be backed by historical data on the return on equity for the biggest U.S. banks provided in Green, Lopez and Wang (2003). Comparing this data with the GDP growth rates in the period from 1983 to 1999 suggests that both are positively correlated.

Third, the supervisors should force undercapitalized banks to recapitalize rather than sell assets. The reason is that the latter leads to lower discipline than the former, because downsizing is a source of the banks' profits, which relax banks' incentives to report the risk truthfully.

Finally, supervisors should guarantee high quality of their inspections in order to make risk-insensitive capital requirements viable. If existing risk management models cannot distinguish between low and high risks in a timely manner (Saidenberg and Schuermann (2003)), the temptation to misreport the risk is increased because the probability of being caught on misreporting is small.

My theoretical framework is a version of the model by Holmstrom and Tirole (1997), adapted to study financing needs of a bank with insured deposits[7] and extended to adverse selection. There exist two papers concerned with optimal risk-based capital requirements when risk is banks' private information. However, in both papers the penalty for misreporting is exogenous, and the optimal design of supervisory intervention is not analyzed. Prescott (2004) obtains capital requirements increasing in risk for low risk levels and flat for high ones in the costly state verification setup studied by Townsend (1979) and Gale and Hellwig (1985). Blum (2007) assumes that the penalty for misreporting is too low to make the high risk bank report its risk truthfully. Hence, he proposes to increase capital requirements for low risk in the Basel II Accord. My paper complements this literature by the simultaneous design of optimal capital requirements and optimal supervisory schemes, allowing for a broader discussion of policy implications.

The remainder of the paper is organized as follows. Section 2.2 describes the model. In Section 2.3 the supervisory scheme for recapitalization is derived. The same is done for downsizing in Section 2.4 and closure in Section 2.5. Section 2.6 presents welfare analysis. Section 2.7 interprets the results and contains policy implications. Section 2.8 discusses possible extensions. Section 2.9 concludes the paper. The Appendix A contains proofs of the results.

2.2 Model

There are three agents: depositors, a bank and a supervisor.

Depositors: The depositors are fully insured. The net deposit rate is r_D.

Bank: The bank is owned and managed by risk neutral shareholders protected by limited liability. Instead of investing in the bank, the shareholders can invest in an alternative

[7]Models which use insured depositors instead of uninsured as it is done in the paper by Holmstrom and Tirole (1997) are also provided by Rochet (2004), and Cerasi and Rochet (2008).

project yielding a net return $\delta > r_D$.[8] This assumption is common in the banking literature (see e.g. Hellman, Murdock and Stiglitz (2000) and Repullo (2004)). Deposits are cheaper because they provide special services to depositors (not modelled here), like liquidity, not available by holding stocks.[9]

The bank can invest in a project of size 1 financed with equity capital k and deposits $1-k$. The project can be of two types $i = H, L$ determined by nature, where H occurs with probability π. i is a bank's private information. The gross return on project i is deterministic and denoted as $1 + r_i$, with $r_H > r_L > 0$. Hence, both projects have positive net present value and H is more valuable than L. The model can be easily extended to random project returns with no change in the results.[10]

Instead of operating the project i, the bank can earn private benefits b, which are socially inefficient: $1 > b$.[11] In such a case the project of the bank fails.

The timing is as follows. First, nature chooses i. Second, the bank learns i, determines the level of inside equity k, and raises deposits $1-k$. Third, the bank decides, whether to operate the project i or to earn private benefits. Fourth, the returns are realized.[12]

The unregulated bank finances itself only with deposits because they are cheaper than equity capital. This will be the source of a moral hazard problem when the deposit rate is too high. The unregulated bank prefers private benefits if the profits from the project i are lower than b:

$$1 + r_i - (1 + r_D) = r_i - r_D < b. \tag{2.1}$$

From now on, (2.1) is assumed to hold for both i.[13] Furthermore, I assume that operating each project i is profitable under 100% equity financing:

$$r_i - \delta > 0, i = H, L. \tag{2.2}$$

[8] From now on, terms bank and shareholders mean the same.

[9] Microfoundations for the assumption about deposits being cheaper than equity capital are given by Van den Heuvel (2008).

[10] I could assume the following return structure: The project yields $1 + r$ with probability $1 - p_i$ and $1-\lambda$ with p_i, where λ is the loss given default. The projects H and L would differ in p_i. Such a structure could be interpreted as a reduced form of a model underlying the Basel II capital requirements. For a full description of this model see Repullo and Suarez (2004). This extension would allow to use the term "risk" explicitly.

[11] Alternatively, I could assume that the bank can engage in inefficient excessive risk taking. The results remain unchanged.

[12] The steps 1 and 2 could be reversed. This would make solving the model more complex without affecting its qualitative results.

[13] (2.1) is a simplified version of equation (3) in Holmstrom and Tirole (1997), which introduces the need for financing the bank with inside equity.

Supervisor: The behavior of the unregulated bank resulting in its default makes the deposit insurance liable against the depositors and leads to social costs. These costs encompass systemic consequences of a bank failure like disruptions in payment systems or contagion effects. Given the presence of insured deposits, there arises a need for regulation of the bank, which aims at avoiding these social costs of its failure. The power to regulate the bank belongs to a supervisor, who maximizes social welfare. The supervisor cannot observe whether the bank operates the project i, but he can observe the bank's capital level.[14] He can use this ability to eliminate the moral hazard problem by introducing capital requirements. When the shareholders' stake k in the bank is high enough the bank chooses to operate the project i. Formally, the profits from operating the project i cannot be lower than b:

$$1 + r_i - (1 - k)(1 + r_D) \geq b.$$

Solving this inequality yields the following Lemma, which establishes the minimum capital requirements eliminating the moral hazard problem.

Lemma 1 The minimum capital requirements eliminating the moral hazard problem are $k_i = \frac{b - r_i + r_D}{1 + r_D}$. It holds that $k_H < k_L$.

The minimum capital requirements depend on i and it holds that $k_H < k_L$, because the project L yields a lower return, for which private benefits are more desirable. k_i increases, when b and r_D increase, and r_i decreases. Each change of the parameters making the project i less attractive against b requires increase in k_i.

The supervisor maximizing social welfare would like to set the lowest possible capital requirements, because equity financing is socially costly. It is so because instead of financing the alternative project yielding δ the shareholders invest in the bank. However, introducing the minimal capital requirements, k_H and k_L, would lead to an adverse selection problem because i is bank's private information. In such a case, the bank L would save on capital by choosing k_H and appropriate b. The bank H would choose k_H and operate the project H.

The supervisor can mitigate the adverse selection problem in two ways. The first one is to introduce an insensitive capital requirement of k_L. This eliminates moral hazard, but it is burdensome for the bank H. The second possibility is to implement a supervisory scheme, which would allow to implement capital requirements based on i (I call them "sensitive capital requirements").[15] The supervisory scheme consists of two instruments:

[14] Of course, the supervisor would observe ex post that the bank has failed but then it is too late.

[15] As I do not introduce formally the notion of riskiness, calling these capital requirements "risk-based" would be an abuse. Using the structure proposed in the footnote 10 would allow for this.

An inspection taking place upon the bank's report of i and a penalty. Inspection has a cost m, is stochastic and noisy. Without loss of generality, I focus on the case in which the supervisor inspects with probability q when the bank reports H and there is no inspection when the bank reports L. The supervisor detects the true i with probability $\gamma > 1/2$ and receives a false signal with probability $1-\gamma$.[16] When the supervisor receives a signal contrary to the bank's report, he can impose a penalty on the bank. In the next three sections I study the following types of penalties: Recapitalization, downsizing and closure. Later I allow for optimal penalty design. Moreover, I assume that the supervisor designs the supervisory scheme taking the minimum capital requirements k_i as given. Hence, I abstract from the general problem of designing capital requirements and supervisory scheme at the same time.

The timing of the moves under regulation is as follows. First, the supervisor announces and commits to the supervisory scheme consisting of the probability of inspection q and a penalty. Second, nature chooses $i = L, H$. Third, the bank learns i, raises financing and reports i to the supervisor. Fourth, inspection is conducted, when the report is H. The supervisor punishes the bank when he receives a signal contrary to the report. Fifth, the bank decides whether to operate the project i or earn private benefits. Sixth, the returns are realized.

Finally, I introduce the following notation. If the bank operates the project i under the capital level k_i, V_i denotes its value and is equal to

$$V_i = 1 + r_i - (1 - k_i)(1 + r_D) - k_i(1 + \delta) = r_i - r_D - (\delta - r_D)k_i.$$

2.3 Recapitalization as penalty

When the supervisor penalizes the bank L for misreporting with recapitalization, he orders to increase the capital level from k_H to x. When the truthful reporting is guaranteed the supervisor punishes the bank H with probability $q(1-\gamma)$. The bank H loses the difference between the cost of equity and of deposits on this additional capital level, $(\delta - r_D)x$.[17] Social welfare is the expected value of the bank minus the implementation cost of the sensitive capital requirements:

$$W_1 = \pi V_H + (1 - \pi)V_L - \pi \left[q(1 - \gamma)(\delta - r_D)x + qm\right].$$

[16] In a general case the probability of mistake would differ across i, but it is not essential for the results.

[17] Increase of equity capital means on the one hand that the bank has to repay less deposits, but it has to forgo the return on the alternative project.

The implementation cost (the term in the square brackets) is the sum of social cost of punishing the bank H and the expected inspection cost.

The incentive compatibility (IC) constraints for truthful reporting depend on the level of x. If $x \in (0; \Delta k)$, where $\Delta k = k_L - k_H$, the IC constraint for the bank L reads

$$V_L \geq b - k_H(1+\delta) - q\gamma(1+\delta)x.$$

The right hand side of the constraint is the value of the bank L if it misreports. It always appropriates b because it is either not caught on misreporting, or misreporting is detected with probability $q\gamma$ but the increase in capital level to $k_H + x < k_L$ is not sufficient to make it operate the project L. The last constraint is equivalent to $x \geq \frac{\Delta k}{q\gamma} > \Delta k$, which is not compatible with $x \in (0; \Delta k)$.[18] Hence, the punishment cannot be lower than Δk. Furthermore, x cannot be higher than $1 - k_H$ following the assumption that the supervisor punishes only with recapitalization.[19] For $x \in [\Delta k; 1 - k_H]$ the IC constraints read

$$V_H - q(1-\gamma)(\delta - r_D)x \geq r_H - r_D - (\delta - r_D)k_L,$$

and

$$V_L \geq (1 - q\gamma)\left[b - k_H(1+\delta)\right] + q\gamma\left[V_L - (\delta - r_D)(x + \Delta k)\right]. \tag{2.3}$$

The first (second) constraint is for the bank H (L). The left hand side of each constraint is the bank's value under the truthful report of i. In such a case the bank H is punished with probability $q(1-\gamma)$. The constraints' right hand side is the bank's value in case of misreporting. If the bank H reports L, it operates the project H under the equity level of k_L. The bank L can earn b with probability $1 - q\gamma$ and operates the project L under the capital level of $k_H + x$ with probability $q\gamma$. Both constraints can be rewritten as:

$$\frac{\Delta k}{q(1-\gamma)} \geq x \tag{2.4}$$

for the bank H and

$$x \geq \frac{\Delta k}{\delta - r_D}\left(\frac{1+\delta}{q\gamma} - (1 + r_D)\right) \tag{2.5}$$

[18] Simplification is obtained by using the definition of k_i from Lemma 1.

[19] In a more general setup the penalty would be bounded by the participation constraint. This is explored in Subsection 2.8.1.

for the bank L. x has to be high enough to make the bank L report its true type. However, it has to be bounded from above in order not to discourage the truthful report by the bank H, which may be punished if it reports truthfully. Formally, the supervisory scheme induces truthful reporting for both types, when x lies in the interval implied by (2.4) and (2.5). This interval is not empty if the upper bound on x from (2.4) is not smaller than the lower one from (2.5). This is equivalent to the following restriction on q:

$$q \geq \frac{1}{1-\gamma}\left(1 - \frac{2\gamma - 1}{\gamma}\frac{1+\delta}{1+r_D}\right) \equiv \widehat{q}. \tag{2.6}$$

Moreover, the IC constraints intersect at $q = \widehat{q}$ and the IC constraint for the bank L is steeper than for the bank H. Thus, in order to preserve the truth-telling incentives, marginal decrease of q requires higher increase in x for the bank L than for the bank H. The reason is that by misreporting the bank L not only saves on capital but is able to appropriate b not available for the bank H. The incentive compatible set $(q; x)$ is depicted by the grey area in Figure 2.1.

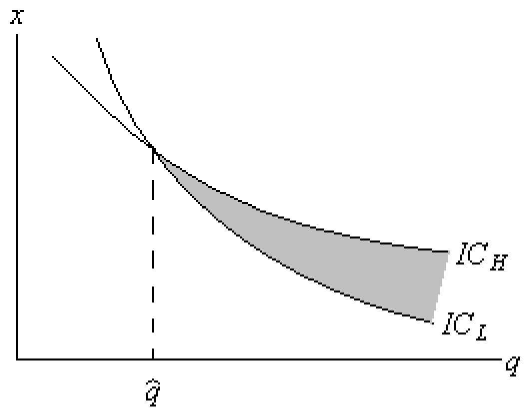

Figure 2.1: The incentive compatible set of $(q; x)$ is depicted with grey. IC_H and IC_L are the incentive compatibility constraints for the bank H and L.

Incentive compatible combinations of $(q; x)$ are feasible if they satisfy $q \in [0; 1]$ and $x \in [\Delta k; 1 - k_H]$. Otherwise, the sensitive capital requirements are not viable, as the available tools (inspection and recapitalization) are not sufficient to eliminate incentives for misreporting. The following Lemma delivers the necessary condition for implementation of the sensitive capital requirements with recapitalization as penalty.

Lemma 2 The necessary condition for implementation of the sensitive capital requirements with recapitalization as penalty is a sufficiently high quality of inspection γ.

Proof. See Appendix A.

Quality of inspection has to be high enough in order to make the sensitive capital requirements with recapitalization feasible. Otherwise either 100% equity financing ($x = 1 - k_H$) is not enough to discipline the bank L or the bank H finds misreporting better when it is punished too harsh.

Moreover, the supervisor can be constrained in the choice of q by (2.6), if for any γ satisfying Lemma 2 the intersection of (2.4) and (2.5) lies in the region $q \in [0;1]$ and $x \in [\Delta k; 1 - k_H]$. The following Lemma establishes necessary and sufficient condition for which the supervisor can ignore (2.6) while choosing the optimal q, given that the sensitive capital requirements are feasible.

Lemma 3 The supervisor is not constrained by (2.6) if and only if the return on the project H or the quality of inspection is high enough.

Proof. See Appendix A.

The last Lemma is stronger than the previous one, because it makes (2.4) redundant.

The participation constraints can be ignored, because they are implied by the IC constraints.

When parameters satisfy conditions of Lemma 3 holds the supervisor solves the following program while choosing the optimal supervisory scheme:

$$\max_{q,x} \; W_1, \text{ s.t.: } (2.5),\, q \in [0;1],\, x \in [\Delta k; 1 - k_H].$$

As (2.5) binds at the optimum, it can be inserted into W_1, and after ignoring the terms independent of q and x, what yields an expression to be maximized under the remaining constraints: $q\,(\overline{m} - m)$, where $\overline{m} \equiv (1-\gamma)(r_H - r_L)$. When the cost of inspection is higher (lower) than $\overline{m}$, it is optimal to choose the lowest (highest) possible q. The result is summarized in the following Lemma.

Lemma 4 If the conditions of Lemma 3 are satisfied, the optimal supervisory scheme with recapitalization as penalty is

$$(q_1; x_1) = \begin{cases} \left(1; \left[\left(\frac{1}{\gamma} - 1\right)\frac{1+\delta}{\delta - r_D} + 1\right]\Delta k\right), & \text{if } m \leq \overline{m} \\ \left(\frac{1}{\gamma}\frac{\Delta k(1+\delta)}{\Delta k(1+\delta) + (\delta - r_D)(1-k_L)}; 1 - k_H\right), & \text{if } m > \overline{m} \end{cases}$$

Comparative statics of the optimal solution is intuitive as every change of parameters undermining the bank L's truth-telling incentives (increases in r_H, b and r_D as well as decreases in δ, r_L and γ) requires increase in q_1 for $m > \overline{m}$ and in x for $m \leq \overline{m}$. The most interesting comparative statics result concerns the change in δ. Although higher δ increases the incentives to misreport in the first place because equity financing becomes more expensive, it makes also penalty more expensive. This effect diminishes incentives of the bank L to misreport its type and allows the supervisor to decrease the scope of his intervention.

2.4 Downsizing as penalty

The alternative possibility to adjust the capital structure of the bank, after the supervisor has received a signal contrary to report, is to make the bank reduce its size (downsize) to at least s_A by selling part of its project.[20] In order to increase the capital ratio through downsizing the bank has to repay at least part of the deposits using the proceeds from selling. I introduce new agents into the model: Risk-neutral investors interested in buying the bank's project, which has not matured yet. Timing of the moves is modified as follows. First, the supervisor announces q and s_A. Second, nature chooses i. Third, the bank learns i, finances itself and reports i to the supervisor. Fourth, the supervisor inspects with probability q upon receiving report of H and orders downsizing to at least s_A when he receives signal contrary to the report. Fifth, the bank chooses how much of the project it sells, $(1-s) \geq (1-s_A)$. Sixth, the investors pay $(1+p)$ for every unit of the project. Seventh, the bank decides whether to operate the project i or earn private benefits. Eighth, the returns are realized.

The investors operate on a competitive market and have the cost of capital δ like the bank's shareholders, but they do not have any access to the insured deposits and finance themselves with their own wealth. The investors are able to observe s_A, q, the bank's initial capital level and the project's size $(1-s)$ the bank wants to sell. They have homogenous prior beliefs about the type of the bank, equal to the probabilities according to which the nature draws the bank's type. After observing the relevant variables, the investors build their beliefs β_i about the type i of the bank that offers to sell $(1-s)$.[21] Given the beliefs, the investors pay a price $(1+p)$ (p is called a premium) for unit of the sold project such that their participation constraint is binding, i.e. the expected cash flow from one unit of the project they buy covers their cost of financing:

$$1 + \beta_H r_H + \beta_L r_L = (1+p)(1+\delta).$$

[20] I assume that the project is perfectly divisible.

[21] For the ease of exposition, I suppress in the notation the fact that the investors' beliefs are a function of what they observe. The bank's initial capital level is irrelevant for the investors' beliefs, because the investors are concerned about the bank's type only if the bank sells, and this may occur only when the initial capital level is k_H.

The premium is then

$$p = \frac{\beta_H r_H + \beta_L r_L - \delta}{1+\delta}.$$

The punished bank raises $(1-s)(1+p)$ from selling of $(1-s)$ of the project. From these proceeds, $(1-s)$ has to be used to repay the deposits at par (as they have not yet matured) if $s \in (k_H;1]$. If $s \in [0;k_H)$, the bank has to repay all deposits $(1-k_H)$ and return $(k_H - s)$ to the shareholders. The rest, $(1-s)p$, is invested into the alternative project yielding δ. Downsizing can be used to increase the capital ratio in absence of other instruments only if $p \geq 0$, which is guaranteed by (2.2).[22] When the bank sells $(1-s)$ of the project and operates it, it earns $s(1+r_i)$ on the remaining part of the project and $(1-s)p(1+\delta)$ from investing of the remains of the proceeds in the alternative project. If $s \in [0;k_H)$, the bank is fully equity financed and, moreover, the shareholders invest the returned $(k_H - s)$ in the alternative project too. If $s \in (k_H;1]$, the bank's profit from operating the project i after downsizing is:

$$\begin{aligned} & s(1+r_i) + (1-s)p(1+\delta) - (s-k_H)(1+r_D) \\ = \quad & s\left[r_i - r_D - (\beta_H r_H + \beta_L r_L - \delta)\right] + \beta_H r_H + \beta_L r_L - \delta + (1+r_D)k_H. \end{aligned}$$

If $\beta_H r_H + \beta_L r_L - \delta > r_i - r_D$, the bank would sell the whole project. I assume that this is precluded for any type of the bank and for any beliefs. This condition guarantees that the downsizing ordered by the supervisor constitutes a penalty for the bank if $s \in (k_H;1]$. The sufficient condition for this is

$$r_L \geq \delta > r_D + (r_H - r_L). \tag{2.7}$$

(2.7) is not empty if and only if

$$r_H < 2r_L - r_D. \tag{2.8}$$

(2.7) and (2.8) assumed from that point on. If $s \in [0;k_H]$, the bank's profit after downsizing is

$$\begin{aligned} & s(1+r_i) + (1-s)p(1+\delta) + (k_H - s)(1+\delta) \\ = \quad & s(r_i - (\beta_H r_H + \beta_L r_L)) + \beta_H r_H + \beta_L r_L - \delta + (1+\delta)k_H. \end{aligned}$$

[22]See Section 2.8.4 for the discussion of the case when the bank's assets are specific in the sense that the outside investors cannot generate their full value after having purchased them.

The bank H is penalized by downsizing if $\beta_H < 1$, but is indifferent for $\beta_H = 1$. However, the bank L finds it profitable to be downsized if $\beta_L < 1$ or is indifferent if $\beta_L = 1$.

Furthermore, I establish levels of s for which moral hazard does not exist after downsizing. I assume that the private benefits are proportionate to the size of the bank. After downsizing the bank L does not engage in the moral hazard if:

$$s(1+r_L)+(1-s)p(1+\delta)-(1+r_D)(s-k_H) \geq \max[sb; sb+(1-s)p(1+\delta)-(1+r_D)(s-k_H)].^{23}$$

s preventing moral hazard has to fulfill:

$$0 \leq s \leq \frac{p(1+\delta)+k_H(1+r_D)}{p(1+\delta)+k_L(1+r_D)} \equiv s_{MH}(p).^{24}$$

$s_{MH}(p)$ depends on the investors' beliefs about the type of the selling bank through p.

The model is solved as follows. After the supervisor's announcement of q and s_A, the bank engages in a game with the investors, in which it chooses a profile of strategies prescribing the report and the amount of project sold, $(1-s) \geq (1-s_A)$.[25] The investors build their beliefs upon observing q, s_A and s, and pay $(1+p)$ consistent with the bank's optimal strategies. The bank's optimal strategy profile has to be consistent with the investors' beliefs. I define a Bayesian Nash Equilibrium of this game as follows[26]:

Definition A Bayes-Nash Equilibrium given q and s_A is characterized by:

- The bank's optimal reporting, $\widetilde{i} = H, L$, and selling strategies, $s \leq s_A$, given the investors' beliefs β_H and β_L, and
- The investors' conditional beliefs β_H and β_L about the bank's type that are consistent with the banks' optimal strategies, and the premium $p = \frac{\beta_H r_H + \beta_L r_L - \delta}{1+\delta}$.

This game has many equilibria, which can be categorized according to the bank's reporting strategies: Both types (i) report truthfully, (ii) report L, (iii) misreport, and (iv) report H. In equilibria of the last two types, the bank L fails with some probability. Given the assumption that the cost of bank failure is high enough to make the supervisor prevent this, I do not discuss these equilibria. I concentrate on those of the type (i) and (ii), and use the intuitive criterion to narrow the set of equilibria. From then on,

[23]For $s \in [0; k_H]$ moral hazard problem does not exist.
[25]As the supervisor commits to q and s_A he is not an active player in the game.
[26]I restrict myself only to equilibria in pure strategies.

I call the equilibria of type (i) "truth-telling equilibrium" and of the type (ii) "pooling equilibrium".

In the truth-telling equilibrium, the only type that may sell is H and the amount that it sells is precisely $(1-s_A)$ because it is not profitable to sell more. Then, q and s_A have to be such that the bank L does not misreport. In such a case, the investors observing s_A, q and a bank selling $(1-s_A)$ set $\beta_H = 1$ and $\beta_L = 0$, and offer the premium $p_H = \frac{r_H - \delta}{1+\delta}$. Unlike in the case of recapitalization, the IC constraints have three different forms depending on s_A. If $s_A \in [0; k_H]$, both types are fully equity financed and for $s_A \in (k_H; s_{MH}(p_H)]$ they retain some deposits. In both cases, the bank L would operate the project L if it mimicked H. If $s_A \in (s_{MH}(p_H); 1]$, both types still retain some deposits, but the bank L would appropriate b after downsizing. The IC constraints have familiar form (for the bank H and L respectively):

$$[1-q(1-\gamma)]\,V_H + q(1-\gamma)V_H(s_A) \geq V_H - (\delta - r_D)\Delta k \tag{2.9}$$

and

$$V_L \geq (1-q\gamma)(b-(1+\delta)k_H) + q\gamma V_L(s_A), \tag{2.10}$$

where

$$V_H(s_A) = \begin{cases} s_A(r_H - \delta) + (1-s_A)p_H(1+\delta), \text{ for } s_A \in [0; k_H) \\ s_A(r_H - r_D) + (1-s_A)p_H(1+\delta) - (\delta - r_D)k_H, \text{ for } s_A \in [k_H; 1] \end{cases}$$

and

$$V_L(s_A) = \begin{cases} s_A(r_L - \delta) + (1-s_A)p_H(1+\delta), \text{ for } s_A \in [0; k_H) \\ s_A(r_L - r_D) + (1-s_A)p_H(1+\delta) - (\delta - r_D)k_H, \text{ for } s_A \in [k_H; s_{MH}(p_H)] \\ s_A b - (1+\delta)k_H, \text{ for } s_A \in (s_{MH}(p_H); 1] \end{cases}$$

Finding constellations of s_A and q for which the truth-telling equilibrium exists, i.e. constellations satisfying (2.9) and (2.10) that are feasible, follows the analog pattern as in Section 2.3. Hence, I obtain an analogue of Lemma 2.

Lemma 5 For each interval $s_A \in [0; k_H]$, $s_A \in (k_H; s_{MH}(p_H)]$ and $s_A \in (s_{MH}(p_H); 1]$ the truth-telling equilibrium exists if the quality of inspection is sufficiently high.

Proof. See Appendix A.

Moreover, for $s_A \in [k_H; s_{MH}(p_H)]$, the regulator may be constrained in the choice of q by the intersection of the IC constraints as for the recapitalization. The following Lemma provides the conditions when this is irrelevant.[27]

Lemma 6 When the truth-telling equilibrium exists, the supervisor is not constrained in the choice of q if and only if the quality of inspection is sufficiently high.

Proof. See Appendix A.

The pooling equilibrium can be supported by the beliefs $\beta_L = 1$, i.e. when the investors observe that a bank sells $1 - s_A$, they attach the type L to it. The following Lemma establishes the conditions under which the pooling equilibrium exists.

Lemma 7 Pooling equilibrium always exists for $s_A \in [k_H; 1]$. There is no pooling equilibrium for $s_A \in [0; k_H)$.

Proof. See Appendix A.

Furthermore, there are constellations of s_A and q in which the truth-telling and pooling equilibria coexist.[28] Under $\beta_L = 1$ selling is less attractive for both types of the bank, hence reporting H gets less attractive for some s_A for which the truth-telling equilibrium arises. However, the pooling equilibrium does not survive the intuitive criterion in the region where both equilibria coexist. The reason is that the bank H can deviate by reporting its type and this is not profitable for the bank L.

When the conditions from Lemmas 5 and 6 hold, the supervisor solves the following problem:

$$\max_{q,s_A} \; W_2 = \pi\left[(1-q(1-\gamma))V_H + q(1-\gamma)V_H(s_A) - qm\right] + (1-\pi)V_L.$$

s.t.:

$$(2.10),\ s \in [0;1] \text{ and } q \in [0;1].$$

The optimal solution is given by the following Lemma.

Lemma 8 When the conditions from Lemmas 5 and 6 hold, the optimal supervisory scheme with downsizing as penalty is

$$q_2 = \begin{cases} \frac{1}{\gamma}\frac{1+\delta}{1+r_D}\frac{b+r_D+r_H-r_L-\delta}{b}, & \text{if } m \le \overline{\overline{m}} \\ \frac{1}{\gamma}\frac{\Delta k(1+\delta)}{(\delta-r_D)-k_H(\delta-r_D+r_L-r_H)}, & \text{if } m > \overline{\overline{m}} \end{cases} \quad \text{and } s_A = \begin{cases} s_{MH}(p_H), & \text{if } m \le \overline{\overline{m}} \\ k_H, & \text{if } m > \overline{\overline{m}}. \end{cases}$$

[27] For the case of downsizing it is not easy to combine the conditions from Lemma 5 with the conditions for which the supervisor is not constrained in the choice of q as it is done in the case of recapitalization.

[28] It is easy to verify by simply comparing the IC constraints for both equilibria.

Proof. See Appendix A.

The comparative statics of the optimal solution is the same as for the case of recapitalization. Higher δ allows to decrease the scope of the supervisory intervention because the higher cost of financing for the investors is passed onto the bank in the form of a lower premium, increasing the disciplining effect of downsizing.

2.5 Closure as penalty

An alternative way of punishing the bank for misreporting is to intervene and transfer it to new shareholders. The new shareholders run the bank with the capital level of k_L preventing reoccurrence of the moral hazard problem. I assume the closure and the transfer have social cost of S. The supervisor maximizes

$$W_3 = \pi \left[V_H - q(1-\gamma)(S + (\delta - r_D)\Delta k) - qm\right] + (1-\pi)V_L.$$

Social cost of the penalty amounts to S and to the increase in the capital requirements to k_L. Because the penalty is fixed and W_3 is decreasing in q the supervisor chooses the smallest q that is incentive compatible.

The incentive compatibility (IC) constraints read (for the bank H and L respectively)

$$\left[1 - q(1-\gamma)\right] V_H \geq V_H - (\delta - r_D)\Delta k \text{ and } V_L \geq (1 - q\gamma)\left[b - k_H(1+\delta)\right].$$

The constraints differ from (2.3) only in one detail. The bank H (L) receives nothing with probability $q(1-\gamma)$ when it reports truthfully ($q\gamma$ when it misreports).

As the IC constraint for the bank L is binding the optimal probability of inspection is

$$q_3 = \frac{1}{\gamma}\frac{\Delta k(1+\delta)}{V_H}.$$

q_3 cannot be higher than 1 and has to be incentive compatible for the bank H. Both conditions are fulfilled if

$$\gamma \geq \max\left\{\frac{\Delta k(1+\delta)}{r_H - r_D - (\delta - r_D)k_H}; \frac{1+\delta}{1+2\delta - r_D}\right\}.^{29} \tag{2.11}$$

This condition is the analogue of Lemma 3.

[29] The first term comes from the condition $q_2 \leq 1$. The second arises after inserting q_2 into the incentive compatibility constraint of the bank H.

There is one difference in the comparative statics results for q_3 with respect to the previous two cases: q_3 is increasing in δ. The reason is that in case of closure the only effect that δ has on the incentives to misreport is the effect on the cost of bank's financing with equity. If δ increases, equity financing becomes more expensive making the bank L more willing to misreport. This requires increase in the probability of inspection.

2.6 Welfare analysis

This section starts with welfare comparison of the sensitive capital requirements with recapitalization and downsizing as penalties, which leads to the following Lemma.

Proposition 1 If the conditions from Lemmas 3, 5 and 6 are satisfied, the sensitive capital requirements with recapitalization as penalty deliver strictly higher welfare than those with downsizing as penalty.

Proof. See Appendix A.

The reason why recapitalization as penalty delivers higher welfare is that downsizing is a less severe penalty. As downsizing creates profits in the form of positive premium for the bank, the IC constraint for the bank L tightens requiring an increase in the scope of the supervisory intervention.

Next, I consider the insensitive capital requirements of k_L for both banks. Social welfare from this type of regulation is

$$W_0 = \pi V_H + (1-\pi)V_L - \pi(\delta - r_D)\Delta k.$$

The last term is social cost of the insensitive capital requirements: The bank H bears too high equity cost. First, I compare this type of capital requirements with the sensitive ones with recapitalization as penalty. The difference in social welfare between them is

$$\Delta W_1 = W_1 - W_0 = \pi\left[(\delta - r_D)\Delta k - q_1(1-\gamma)(\delta - r_D)x_1 - q_1 m\right].$$

ΔW_1 is the difference between social benefits of lowering the regulatory burden on the bank H and the implementation cost of the sensitive capital requirements with recapitalization. The following Proposition establishes constellations of γ and δ for which $\Delta W_1 > 0$.

Proposition 2 For each $\delta \in (r_D; r_L)$ there is $\gamma_1(\delta) > 1/2$ such that the sensitive capital requirements with recapitalization yield strictly higher welfare than the insensitive capital requirements for $\gamma > \gamma_1(\delta)$, and strictly lower welfare otherwise. The function $\gamma_1(\delta)$ is strictly decreasing in δ.

Proof. See Appendix A.

The Proposition 2 states that the sensitive capital requirements with recapitalization dominate in welfare terms the insensitive ones when the inspection quality γ and the cost of equity δ are sufficiently high. Higher γ is beneficial because the bank H is punished less frequently and it allows to decrease the scope of the supervisory intervention. Higher δ translates to higher savings for the bank H on equity capital and to a stronger disciplining effect of recapitalization as penalty. The positive effects of γ and δ on ΔW_1 create a trade-off between them, which is reflected in $\gamma_1(\delta)$ being strictly decreasing. The result from Proposition 1 is depicted in Figure 2.2. The line $\gamma(\overline{m})$ separates the two cases arising in Lemma 3: The case with $m > \overline{m}$ is relevant above this line and $m < \overline{m}$ below. The region above of $\gamma_1(\delta)$ represents constellations of δ and γ, for which the sensitive capital requirements deliver higher social welfare than the insensitive ones. Below $\gamma_1(\delta)$ the opposite holds.

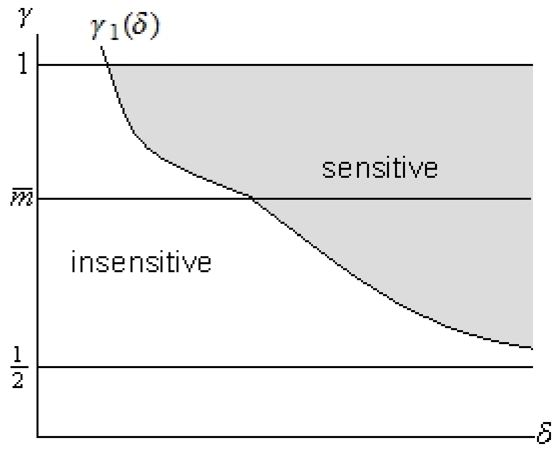

Figure 2.2: The dominance region of the sensitive capital requirements with recapitalization is depicted in grey.

Second, I compare welfare from the insensitive and the sensitive capital requirements with closure as penalty. The difference in social welfare is

$$\Delta W_3 = W_3 - W_0 = \pi \left[(\delta - r_D)\Delta k \left[1 - q_3\left(1-\gamma\right)\right] - q_3\left(m + S(1-\gamma)\right)\right].$$

The following Proposition summarizes the result of the comparison.

Proposition 3 For each $\delta \in (r_D; r_L)$ there is $\gamma_2(\delta) > 1/2$ such that the sensitive capital requirements with closure yield strictly higher welfare than the insensitive capital requirements for $\gamma > \gamma_2(\delta)$, and strictly lower welfare otherwise. The function $\gamma_2(\delta)$ is first decreasing and then increasing in δ.

Proof. See Appendix A.

The increasing cost of capital has two countervailing effects on ΔW_3. The first effect leads to higher savings on equity for the bank H. The second effect is increase in q_3 due to stronger incentives to misreport. The result may be a non-monotonic frontier separating the dominance regions as depicted in Figure 2.3.

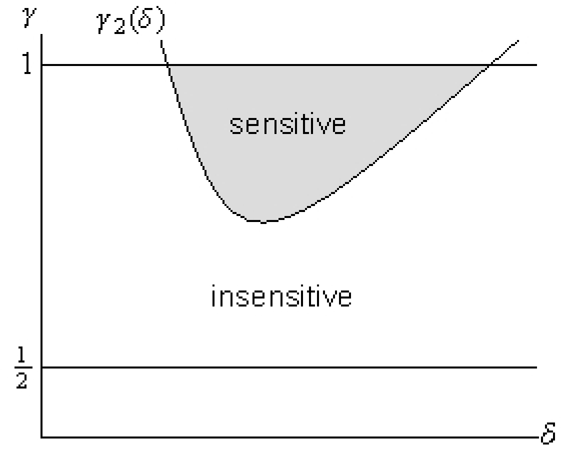

Figure 2.3: The dominance region of the sensitive capital requirements with closure is depicted in grey.

Finally, I compare social welfare for the sensitive capital requirements with recapitalization and closure as penalty.[30] The difference in social welfare is

$$\Delta W_{31} = W_3 - W_1 = \pi \left[(q_1 - q_3)m + (1-\gamma)(\delta - r_D) \left[q_1 x_1 - q_3 \Delta k \right] - (1-\gamma) q_3 S \right].$$

Closure is less socially costly when $S < \overline{S}$, where

$$\overline{S} \equiv \left(\frac{q_1}{q_3} - 1 \right) \frac{m}{1-\gamma} + (\delta - r_D) \left(\frac{q_1}{q_3} x - \Delta k \right).$$

$\overline{S}$ consists of the differences in the expected inspection cost (the first term) and in the social cost of increase in capital requirements (the second term) between these two penalties. The derivation of the last expression with respect to δ delivers the following proposition.

[30] I skip the comparison of the sensitive capital requirements with downsizing because they provide lower welfare than those with recapitalization.

Proposition 4 For $m > \overline{m}$ $\overline{S}$ is decreasing function of δ. For $m < \overline{m}$ $\overline{S}$ is first increasing in δ and then decreasing in δ.

Proof. See Appendix A.

The intuition behind Proposition 4 is as follows. First, $\overline{S}$ decreases with δ due to the different impact of increase in δ on the truth-telling incentives: q_3 increases, while q_1 either decreases (for $m > \overline{m}$) or does not change (for $m \leq \overline{m}$). This affects both terms in $\overline{S}$ negatively. Second, $\overline{S}$ increases with δ due to welfare loss from increased difference between the cost of capital and deposits, $(\delta - r_D)$. It turns out that for sufficiently high m the former effect on $\overline{S}$ is always stronger leading to $\overline{S}$ decrease with δ. For low m $\overline{S}$ increases and then decreases with δ.

The last three propositions allow for a general conclusion that the sensitive capital requirements with recapitalization as penalty deliver the highest welfare when δ is high, the one with closure for intermediate δ and the insensitive ones for low δ. This result can be obtained analytically only for $m > \overline{m}$. A frontier yielding $\Delta W_{31} = 0$ in the $(\delta; \gamma)$-diagram, $\gamma_{31}(\delta)$, is increasing and recapitalization delivers higher welfare for constellations below of this frontier for sufficiently high S.

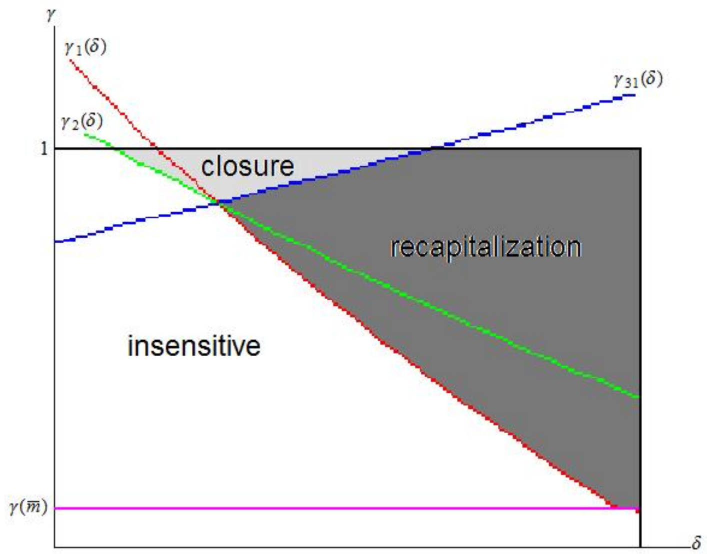

Figure 2.4: The dominance regions of the three different types of capital requirements. The dominance region of the capital requirements with recapitalization is depicted with dark grey, the ones with closure with light grey and the insensitive ones are without color.

Figure 2.4 depicts the results of the last three propositions for the case $m > \overline{m}$.[31] It highlights also the importance of high γ for welfare yielded by the sensitive capital

[31] I do not provide a figure for the case $m < \overline{m}$ as it is similar to Figure 2.4.

requirements with closure. If γ is too low, it precludes that closure yields the highest welfare because the bank is closed too often.

2.7 Interpretation of the results and policy implications

2.7.1 Quality of inspection

A necessary condition for the viability of the sensitive capital requirements is sufficiently high γ (see Lemma 2, 5 and (2.11)). Under Basel II, γ corresponds to the ability of supervisors to assess how well the internal risk management models reflect banks' risk exposures. However, these models may not be suitable for credit risk (Saidenberg and Schuermann (2003)). As default events are rare, especially in booms, such models may fail to deliver conclusive results about risks borne by banks. Only in downturns, when the defaults tend to cluster, supervisors may distinguish between banks with low and high risk. Similar situation occurred in the period prior to the 2007 US sub-prime crisis. Risk management models had failed to reveal what risks the banks had had on their books, before the crisis event hit. The implication for supervisors is to improve qualifications of its personnel in detecting such flawed risk management models and to encourage banks to work on improving them. In what follows it is take for granted that the supervisor is able to make the banks reveal their risks.

2.7.2 Downsizing

Supervisors should encourage undercapitalized banks to recapitalize rather than to downsize. The former constitutes a harsher punishment for banks than the latter due to the adverse selection issue in case of selling to the outside investors and allows for lower scope of supervisory intervention. This constitutes an additional argument for recapitalization rather than asset sales in order to boost capital ratios. In the current crisis, the asset sales conducted to protect banks' capital ratios have been said to have contagious effects between the banks.

2.7.3 Optimal capital requirements and economic cycles

The welfare analysis of the previous Section implies that the capital requirements should depend on the cost of equity capital, which influences both the incentives to reveal risks and the social cost of capital regulation. Sensitive capital requirements deliver the highest welfare for upper levels of δ, provided they are supported with recapitalization for high δ or with closure for intermediate δ. Otherwise, the supervisor should introduce insensitive capital requirements for low δ, because the burden from high capital requirements for the banks with high-quality assets is negligible with respect to the cost of implementation of the sensitive scheme.

δ is interpreted as the overall profitability of the projects in the economy, suggesting that δ is higher in booms than in downturns.[32] Hence, supervisors should support sensitive capital requirements with recapitalization during booms, when additional equity injections mean a loss of highly profitable investment opportunities alternative to the banks projects. During downturns, either sensitive capital requirements with closures or insensitive capital requirements (if closures are not feasible) should be introduced. Making capital requirements sensitive in booms and insensitive in downturns opposes current proposals to increase them in booms and lower in downturns in order to eliminate magnification of the economic cycles.

In order to gain more perspective on the link between the supply of credit and the misreporting incentives across the cycle, in what follows I endogenize the size of the bank.

2.7.4 Endogenous credit supply

An extension of the basic model

I consider the following modification of the model presented in Section 2.2. The shareholders of the bank have A of equity capital like in Rochet (2004). Moreover, at the time of the report of the type by the bank to the supervisor the bank receives short-term profits d (Tirole (2006), p. 201-202).[33] I assume that when d occurs there are no other opportunities of investing it in the bank. Only if d is paid out as a dividend to the shareholders it can deliver the return $1 + \delta < 1 + r_L$.[34] d is independent of i, which is not crucial for the results. The private benefits b are proportional to the size of the bank. The timing of events is as follows. First, the supervisor announces the probability of inspection q and the equity injection r in case if the bank is found to be undercapitalized.[35] Second, the nature reveals i to the bank, the bank raises D_i of deposits to finance I_i of loans, where $I_i \leq A + D_i$.[36] Third, the supervisor inspects the bank and

[32] For a similar interpretation see Parlour and Plantin (2008) and for the evidence on the pro-cyclical behavior of the cost of equity capital for the U.S. banks see Green, Lopez and Wang (2003).

[33] Sources of these short-term profits can encompass revenues from other business lines of the bank which are unspecified here.

[34] An equivalent assumption is to allow for additional lending opportunities, which are less profitable than the existing project.

[35] I discuss the other forms of punishment later in the Section.

[36] I assume that deposits pay a rate of return 0.

forces equity injection r using short-term profits if the signal upon inspection is contrary to the report.[37] Fourth, there is moral hazard problem. Finally, the returns are realized.

I interpret the bank in the modification of the model as being representative for the whole banking sector. This allows me to interpret the bank's size as an overall credit supply in the banking sector.[38]

The setup is analog to the one presented in the Section 2.3 with the difference that the amount of shareholders' wealth which can be used as equity capital is bounded. Hence, the supervisor chooses the size of the bank depending on i given A and d. The program of the supervisor reads:

$$\max_{I_i,D_i,q,r} \pi\left[(1+r_H)I_H - D_H + d(1+\delta) - q(1-\gamma)\delta r - qm\right] \\ +(1-\pi)\left[(1+r_L)I_L - D_L + d(1+\delta)\right]$$

s.t.:

$$(1+r_L)I_L - D_L + d(1+\delta) \geq (1-q\gamma)\left[bI_H + d(1+\delta)\right] \\ +q\gamma\left[\max\left[(1+r_L)I_H - (D_H - r); bI_H\right] + (d-r)(1+\delta)\right]$$

$$(1+r_H)I_H - D_H + d(1+\delta) - q(1-\gamma)\delta r \geq (1+r_H)I_L - D_L + d(1+\delta)$$

$$(1+r_i)I_i - D_i \geq bI_i \text{ for } i = H, L$$

$$I_i \leq A + D_i \text{ for } i = H, L$$

$$r \leq d$$

The objective function is expected social welfare. The injection of r as equity capital is socially costly because the shareholders loose return on the dividends. The next two expressions are the truthtelling constraints for the bank L and H respectively. The following two expressions represent the moral hazard and balance sheet constraints for both types. The last constraint is the upper bound on the equity injection. This constraint could be relaxed by allowing for outside financing through additional equity or a partial sale of the existing project. I discuss these possibilities later. The solution to the program is summarized in the following Proposition.

Proposition 5 For high monitoring cost m, the socially optimal supply of credit is $I_i = \frac{A}{b-r_L}$ for both types of bank. Otherwise, the socially optimal supply of credit I_i depends on i in the following way. For the bank L it is always $I_L = \frac{A}{b-r_L}$. For the bank H it is:

[37] Here the equity injection is equivalent to retention of dividends.

[38] A very interesting extension of the model involves strategic interaction between banks in their choice of reporting strategies. This extension is my current work in progress.

- $I_H = \frac{A}{b-r_H}$if the short-term profits d are sufficiently high,
- otherwise I_H has to be restricted and smaller than $\frac{A}{b-r_H}$.

Proof. See Appendix A.

The proposition states that the optimal size of the bank depends on the ability of the supervisor to punish the banks for misreporting.[39] If the short term profits d are sufficiently high, a loss from retaining dividends is large and the incentives to misreport are low. Hence, the supervisor allows both banks to issue credit up to a level at which they become indifferent between the project i and the private benefits. However, if d is low and the shareholders do not have much too loose by retaining the dividends, the supervisor restricts the supply of credit for the bank H in order to reduce the incentives to misreport.

It is plausible to argue that the short-term profits are pro-cyclical. In such a case the supervisor concerned about the amount of credit in the economy and the stability of the banking system has to compromise between these two objectives. The consequence in downturns is a restriction of the credit supply for the banks with high-quality assets ($i = H$) aimed at removing incentives to misreport for the banks in worse conditions ($i = L$). The trade off between the supply of credit and banks' stability relaxes in good times, when the supervisor is able to threat banks with high penalties for misreporting, and tightens in downturns, when the sources for recapitalization are scarce. In the latter case, the supervisor has to restrict the supply of credit issued by the banks in better conditions. Furthermore, the severity of a downturn determines the degree of the reduction of the credit supply. If the downturn is not too severe the decrease in I_H with respect to $\frac{A}{b-r_H}$ will not be too strong. However, if the downturn is very strong, making d very low, the credit supply will be independent of the banks' asset quality and restricted to $\frac{A}{b-r_L}$.

The main conclusion is that: (i) in booms the supervisor should implement sensitive capital requirements, and (ii) in recessions the sensitivity of capital requirements should be reduced. Relaxing the capital requirements in order to boost the credit supply in recessions is not compatible with the increased temptation of banks with the lower asset quality to misreport their type.

The most important caveat to the above conclusion is that once the supervisor is able to implement sensitive capital requirements the increase in the credit supply by the banks H in booms has only a positive effect on the social welfare. It is sometimes argued that expansion of credit in booms may endanger the macroeconomic stability. In order to address these arguments, one has to study mechanisms underlying them within the

[39] This result is similar to the main result in Blum (2008). He shows that when the penalty for misreporting is very low, the supervisor may introduce leverage ratio restriction.

model presented here.[40] I comment on these arguments in two ways.

First, one could show in the model that rewarding banks with lower capital requirements for high quality loans in booms may lead to increase in the stability of banking system. This could be shown by adding to the existing model risk and imperfect correlation between the types of loans. Sensitive capital requirements in booms result in an increase of the share of high quality loans with respect to the ones of low quality when compared with the case of the insensitive capital requirements. Due to the imperfect correlation the increased amount of loans of type H would provide a buffer against the losses from the loans of type L.[41]

Second, there is some concern that in booms the banks relax their lending standards. Hence, allowing them to expand the credit supply by making capital requirements sensitive to risk would relax these standards even further. However, if the supervisors are able to make the banks report risks truthfully this argument is not so obvious any more. As the sensitive capital requirements punish taking higher risks with an increase in capital requirements, relaxing lending standards maybe be dampened or even reversed. Consider the following extension of the above model. Before the nature reveals i, the bank can influence the probability of occurrence of H, π, by exerting effort with a cost $\frac{1}{2}c\pi^2$. The bank chooses π in order to maximize the following expression:

$$\begin{aligned}\max_{\pi} \pi\left[(1+r_H)I_H - D_H + d(1+\delta) - q(1-\gamma)\delta r\right]\\ +(1-\pi)\left[(1+r_L)I_L - D_L + d(1+\delta)\right] - \frac{1}{2}c\pi^2.\end{aligned}$$

π chosen by the bank increases with I_H, and decreases with I_L, q and r. The program of the supervisor becomes a little more complicated as π is now a function of the supervisory scheme. However, the crucial thing is that the sensitive capital requirements would encourage banks to increase effort in order to become of type H, making sensitive capital requirements in booms even more attractive for the supervisor. This conclusion hints towards an idea that the anti-cyclicality of capital requirements embedded in Basel II may not have necessarily adverse effects as banks would be encouraged to look for assets of high quality and their share would increase in the banks' portfolios.[42]

I will discuss now the possibility of punishing the bank with other measures.

First, downsizing is again the less efficient way to punish the bank than recapitalization

[40] See Gordy and Howell (2006) for the presentation of these arguments.

[41] For the impact of imperfect correlation between different types of loans on the capital buffers see Martinez-Miera (2009), and Martinez-Miera and Repullo (2009).

[42] It may be possible that the supervisor makes the capital requirements for the bank L non-binding in order to encourage more efforts to screen the borrowers.

due to adverse selection issues.[43] One way in which the downsizing may dominate recapitalization is that it is not constrained by the amount of short term profits received by the bank.

Second, another possibility of recapitalization is to use outside equity. Outside equity makes recapitalization attractive for two reasons: No explicit bound on the amount of equity injected such as d may exist, and outside financing does not create a social loss, as it is a transfer between inside and outside shareholders. However, outside equity tightens the moral hazard constraint of the bank L as the inside shareholders' return on the project is diluted. This dilution restricts the ability of the supervisor to enforce truthtelling. Moreover, the outside investors require a sufficient injection of inside equity by the existing shareholders because otherwise the moral hazard constraint will be violated. Hence, the overall impact of outside equity financing on the social welfare is not clear, and it can only be better than pure inside recapitalization when d is high.

Market discipline, capital requirements, and economic cycles

In this subsection I comment on the impact of the Pillar 3 of the Basel II on the misreporting incentives. The Pillar 3 incorporates the market discipline as a factor which could incentivize the banks to report truthfully their risks. Such a provision could be successful if the investors receive reliable information about the quality of banks' assets in a timely manner. However, the evidence on the positive effect of market discipline on the banks' behavior is mixed as reported by Ashcraft and Bleakley (2006). In accordance with their results I assume that the outside investors are not able to discipline the banks. They show that the supervisors possess in the short run better information than the market, and the banks are able to use this information to exploit the outside investors. Moreover, Gunther and Moore (2003) provide evidence for the usefulness of the supervisory review process in detecting misreporting of information by the banks.

I take the following stance about the combination of all three pillars of the Basel II. The outside investors provide additional capital for banks to issue new loans and the supervisor ensures that the banks provide reliable information by means of inspecting and punishing the banks. In such a setup the market discipline impact as described above is not present. However, the market plays still a crucial role in the enforcement of the sensitive capital requirements. If the supervisor commits to the inspection and penalty, and they are sufficiently high to discourage misreporting, the outside investors will provide amount of capital that is sensitive to the information provided by the banks.

[43] When the bank is told to decrease its leverage by Δ through selling of S assets, the investors pay $\frac{1+r_H}{1+\delta}$ for each \$ of the assets in the truthelling equilibrium. Misreporting is less costly for the bank L than in case of recapitalization as the cost of punishment is partly shifted to the outside investors.

Hence the banks with high quality assets will be able to issue more credit than the banks with low quality assets because the market will require lower share of the inside equity from the former than from the latter.[44] If the outside investors do not believe in the supervisory power to enforce Basel II, the sensitive capital requirements cannot be implemented and the market enforces own capital requirements, which are insensitive and correspond to the ones for the banks of low quality.

The immediate implication is that the success of the implementation of the Basel II using outside investors depends on the supervisory ability to make the banks reveal their risks. This conclusion has consequence for the ability of the supervisors to change the degree of sensitivity of the capital requirements. As long as the outside investors believe that the supervisor is able to recognize quality of banks' assets they will provide financing sensitive to the information provided by the banks. However, if this ability is not guaranteed, the outside investors will judge the banks by the worst quality and will require high amounts of inside equity to support additional injections of outside financing. This will mean that all banks could issue only limited amount of credit. Hence, any trials to boost credit supply from the side of the supervisors by reducing the sensitivity of capital requirements will be fruitless as the market will not allow the banks to issue more credit than it finds to be appropriate under the current circumstances. This hints again on the trade-off between making the capital requirements less sensitive to risk and misreporting incentives, which relies on the ability of the supervisor to enforce truthtelling on the side of the banks.

The last conclusion is supported by the anecdotal evidence from the current financial crisis. First, the investors have been judging during the crisis the strength of the banks by the simple leverage ratio abandoning any risk-weighted measures of equity capital structure after losing confidence in the valuation and risk assessment of banks' assets (IMF (2008), p. 20). Second, the Financial Times from the 21st of January 2009 reports that "some investors say the FSA's decision [to allow the banks to use over-the cycle-ratings rather than point-in-time ones to calculate Basel II capital requirements] will merely add to suspicions that banks are using questionable calculations to hide bad loans". Hence, the market may prevent the banks from issuing more credit than the supervisor may wish as it fears that misreporting can be even more severe especially when the risk positions of the banks remain unknown.

[44] The formal model is presented in Appendix A and it is a straightforward extension of Holmstrom and Tirole (1997) to adverse selection. The difference to the model presented in Section 2.2 is that this time the investors are as in the original paper by Holmstrom and Tirole, i.e. they are not protected by deposit insurance.

Summary of the results

The results from the latter subsection are the same as from the former one: In a crisis the ability of the supervisor to boost credit supply is limited by the increased temptation for misreporting. In both cases, the crisis situation is characterized by the limited ability of the supervisor to enforce the truthtelling. In the former case, the consequence is that the supervisor has to reduce the sensitivity of the capital requirements by limiting the amount of credit issued by low risk banks in order to decrease the incentives to misreport. In the latter, the outside investors do not trust the bank's information and provide financing according to the worst quality available on the market, thereby prohibiting low risk banks to issue high amount of credit. The consequence is that a supervisor concerned about the amount of credit in the economy and about the probability of default of the bank may be trapped in a trade off between these two in a crisis situation. Issuing high volume of credit may not be possible, if the misreporting incentives are strong.

2.8 Extensions

2.8.1 Fine as a penalty

Formally, closure equals to making the payoff of the existing shareholders to 0. This could also be achieved through a combination of recapitalization, downsizing and a fine f, without involving cost of closure. Theoretically, there are many other ways to decrease the payoff of the owners of the bank (e.g. banning them from the banking business for life-time), but I concentrate on the pecuniary measures that have been used by the supervisors until now. Proposition 2 allows to disregard downsizing. Given (2.2), recapitalization cannot lead to taking away all the profits from the shareholders, hence it has to be complemented with the fine. The fine has a different disciplining effect than recapitalization. In the latter case the bank looses only the difference between the cost of capital and deposits, $\delta - r_D$, on the additional equity financing. In the former case the bank's shareholders loose their wealth in the amount f and its opportunity cost δ. Moreover, the fine has to be levied at the time of inspection, because a fine collected after the returns have been realized does not harm the bank L, which goes bankrupt. However, the fine cannot substitute fully recapitalization as a penalty. The reason is that the fine does not eliminate the moral hazard problem as it has to be paid before the bank decides whether it operates the project i or appropriates b.

The supervisor solves the following program:

$$\max_{q,x,f} \pi \left[V_H - q(1-\gamma)((\delta - r_D)x + \delta f)) - qm\right] + (1-\pi)V_L$$

s.t.:

$$r_L - r_D - (k_H + x)(\delta - r_D) - f(1+\delta) \geq b - (k_H + x)(1+\delta) - f(1+\delta),$$

$$V_L \geq (1 - q\gamma)\left[b - k_H(1+\delta)\right] + q\gamma\left[r_L - r_D - (k_H + x)(\delta - r_D) - f(1+\delta)\right],$$

$$r_L - r_D - (k_H + x)(\delta - r_D) - f(1+\delta) \geq 0,$$

$$0 \leq q \leq 1.$$

The first constraint eliminates the moral hazard problem. The second constraint is the truth-telling constraint of the bank L and the third is its participation constraint. I assume here that parameters are such that the IC constraint for the bank H is satisfied and the supervisor is not constrained in choice of q (analogue of Lemma 3 holds). The program delivers the following optimal solution:

Lemma 9 The optimal supervisory scheme implementing the sensitive capital requirements is a triple $(q; x; f)$, such that

$$\begin{cases} \left(\frac{1}{\gamma}\frac{\Delta k(1+\delta)}{r_H - r_D - (\delta - r_D)k_H}; \Delta k; \frac{V_L}{1+\delta}\right), \text{ if } m \geq (1-\gamma)r_D\Delta k \\ \left(1; \Delta k; \frac{1-\gamma}{\gamma}\Delta k\right), \text{ if } m < (1-\gamma)r_D\Delta k. \end{cases}$$

Proof. See Appendix A.

The optimal contract implementing the sensitive capital requirements is a combination of recapitalization and fine.[45] Recapitalization eliminates the moral hazard problem and the fine is used to contain the misreporting incentives. Interestingly enough, the participation constraint binds only if the cost of inspection is sufficiently high ($m \geq (1-\gamma)r_D\Delta k$).

2.8.2 Constrained supervisor

Sometimes the supervisor may be allowed to choose freely only q, given an exogenously prescribed level of penalty. In such a case, it may happen that the penalty may be too low to be incentive compatible for the bank L, even for $q = 1$. Blum (2007) suggests that an increase in the capital requirement for the bank H could resolve this problem by decreasing gains from misreporting and restoring incentives for truth-telling. However

[45] The contract is only constrained-efficient given the requirement that the set of penalties encompasses only the ones observed in the reality.

in my setup, it is not clear whether this measure should be better than the insensitive capital requirements, which are optimal when the incentive compatibility of the sensitive ones cannot be reached. Increasing the capital requirements for the bank H can make the sensitive capital requirements viable again, but it still needs penalties that are socially costly, making this solution not necessarily better than the insensitive capital requirements.

2.8.3 No commitment case

Assumption that the supervisor is able to commit ex ante to a certain probability of inspection may seem sometimes unrealistic. Moreover, ex ante commitment scheme is ex post inefficient, because the bank L behaves prudently in equilibrium and the bank H is punished. Lack of commitment to q requires that the supervisor chooses it after the bank's report. This induces a standard inspection game (see e.g. Khalil (1997)) which may have an equilibrium in mixed strategies in inspection and misreporting of the bank L. The no commitment case is tedious to analyze as there are cases in which equilibria in pure strategies arise.[46] However, the qualitative results remain unchanged. Furthermore, in my setup no commitment always delivers lower social welfare than commitment. The reason is that the bank L sometimes goes bankrupt as it misreports with a positive probability, what does not occur in the commitment case.

2.8.4 Asset-specificity

Acharya and Yorulmazer (2007) argue that the outside investors may be inefficient users of assets purchased from banks for the following reasons. First, the investors may be unable to generate full returns because they lack expertise in the acquired assets. Second, assets' sales may suffer from "fire-sale" discounts especially when many banks fall into distress at the same time. Formally, both possibilities could be modelled by introducing a discount $\lambda > 0$ on the net return earned by the investors purchasing the bank's project. This discount has two effects on welfare. On the one hand, social welfare decreases because the value of the project i is lower. On the other hand, the supervisor can decrease the scope of his intervention because $\lambda > 0$ makes downsizing more harmful for the banks as p decreases. This latter effect makes downsizing more attractive as a penalty relative to recapitalization. Indeed, one can prove the following Proposition.[47]

Lemma 10 If $\lambda \in (r_H - r_L; r_H - \delta]$, the sensitive capital requirements with downsizing as penalty yield strictly higher welfare than those with recapitalization. If $\lambda \in$

[46]The note with the full analysis of this case can be obtained on request.

[47]The proof of this result is omitted as it follows the lines of the proof of the Proposition 2.

$[0; r_H - r_L)$, the opposite is true. If $\lambda = r_H - r_L$, both yield the same welfare.

The upper bound on λ, $r_H - \delta$, comes from the fact that selling of the project can be used to reduce the bank's size as long as $p \geq 0$.[48] Hence, sufficiently high λ makes downsizing a viable solution for implementation of the sensitive capital requirements. The question arises how relevant $\lambda > 0$ is in this model. James (1991) provides empirical evidence for significant decrease in the value of sold assets during liquidations of failed banks. However, my model considers the case of selling the assets by banks that are allowed to continue. In reality, such banks have some time to sell their assets, hence the fire-sale discounts may not be so severe and recapitalization may still be better than downsizing. Moreover, during a severe distress when many banks have to sell their assets simultaneously, λ may be so high that downsizing as a measure to recapitalize may not be feasible at all ($p < 0$).

2.9 Conclusions

The paper has been concerned with the design of supervisory schemes under risk-based capital requirements à la Basel II, when bank's risk and actions are its private information. The supervisor punishes the bank, when the signal received during inspection is different from the bank's risk report. Conditions for viability of Basel II and several policy implications have been derived.

The necessary condition to make the banks report their risk truthfully is high quality of inspection. High cost of capital increases incentives for truthful risk reporting under recapitalization and downsizing. This is surprising because the higher the cost of capital is, the stronger banks' incentives to understate their riskiness are. In the case of closure, only this latter effect exists and incentives to reveal risk decrease with the cost of capital. Moreover, asset sales to boost capital ratios lead to lower discipline than injections of inside equity capital. The optimal way to support risk-based capital requirements is to punish undercapitalized banks with recapitalization and a fine.

If closures and fines are not feasible, measures supporting Basel II should depend on the current situation in the economy. The paper points out that capital requirements for the low risk banks may increase in recessions, which means that they should move in a manner similar to "anti-cyclical": Risk-sensitive in booms supported by recapitalization, and risk-insensitive in downturns. This conclusion contrasts with proposals to reduce the pro-cyclicality effect of Basel II and highlights complexity of issues arising due its introduction. In consequence, reducing risk misreporting incentives and the pro-cyclical impact of Basel II may not be possible at the same time. The recent 2007 subprime

[48] $\lambda \leq r_H - \delta$ guarantees that $p_H \geq 0$.

crisis has shown that, both, risk misreporting and pro-cyclicality of credit supply, are important factors undermining the stability of banks. This observation and the implications of the paper suggest that Basel II may fall short of its target, which is to increase resilience of the banking systems.

Chapter 3

The Creditworthiness of the Poor. A Model of the Grameen Bank

3.1 Introduction

Muhammad Yunus and the Grameen Bank he created in 1983 were awarded the Nobel Peace Prize in 2006. The Grameen Bank's main activity consists on granting loans to poor people in Bangladesh. Leaving aside the social implications of this activity, the most striking feature of this bank is the unusually high reported repayment rate, 98%, compared to that achieved in the US banking sector, 96%.[1] Although this repayment rate may be due to different accounting and reporting standards, the actual repayment rate of micro-finance institutions, 92%, is high relative to other lending institutions in Bangladesh, 75%.[2]

Many empirical and theoretical studies have focused on group liability as the main reason for high repayment rates in microfinance programs. Borrowers from microfinance programs have been usually organized in groups, whose members are liable for each other's default. Group liability has been argued to increase borrowers' incentives to screen, monitor and repay the loans, exploiting their knowledge about the local conditions. It must be highlighted that, from a theoretical perspective, group liability also introduces a free rider problem in the repayment of the loan. Overall, evidence concerning the performance of group liability contracts is at best mixed.[3] It is important to note that, nowadays, the Grameen Bank and other microfinance institutions explicitly rule out group liability.[4]

[1] Sources: www.grameen-info.org and www.fdic.com.

[2] Source: Household Survey of the Bangladesh Institute of Development Studies.

[3] See Morduch (1999), Armendariz de Aghion and Morduch (2005), and Gine and Karlan (2006) for a summary of the empirical evidence.

[4] As it is stated on Grameen Bank's web page "there is no form of joint liability, i.e. group members

Leaving aside group liability, our paper highlights a novel explanation for the high repayment rate of the microfinance programs. We build on the observation that borrowers in these programs have one common characteristic: they are poor individuals living in rural areas. This has two important implications: (i) current and future income of poor individuals is low and (ii) as they live in rural areas, accessing savings technologies from urban banks is not possible. A microfinance bank lending and taking deposits increases the current income of the individuals by giving them the opportunity of undertaking investment activities by borrowing, and also increases their future income as it provides them with a savings technology that allows individuals to transfer part of their current income to the future.

We argue that deposit taking is an important, and frequently overlooked, side of the relationship between the microfinance bank and the poor individuals.[5] In rural areas of Bangladesh saving outside the banking sector has been argued to be not profitable due to causes such as the high probability of natural disasters, inflation, and theft.[6] We claim that poorer individuals in the population are the ones that value more the opportunity to increase their low future income by depositing their savings in the microfinance bank. From here we conclude that poorer individuals must have higher repayment rates on their loans in order to maintain their relationship with the microfinance bank and benefit from the savings mechanism.

We propose a theoretical model with overlapping generations of individuals living for three dates. Individuals receive a loan from the bank when they are young, and repaying the loan allows them to access the savings technology offered by the bank and increase their income when old. Our first theoretical result states that borrowers with worse future prospects (henceforth low outside options) are those most likely to repay the loan because accessing the savings technology is more valuable to them. Borrowers endowed with better outside options are more prone to default, as saving is less valuable for them and defaulting on the loan increases their current income.

Building on this result on borrowers' repayment behavior, we study its implications in an infinitely lived, risk neutral, monopolistic banking sector. We characterize the transition to steady state of a financially constrained bank financing its lending only with deposits taken from its borrowers and from retained earnings. During transition to steady state the bank does not disburse any dividends and reinvests all the profits in increasing the loan supply. Our results closely match the evidence that the Grameen Bank has not to paid out dividends since its foundation, and are in line with the high growth it has achieved. The first year in which the Grameen Bank paid dividends was 2006. At the end of this year the Grameen Bank was present in more than 95% of all the villages in

are not responsible to pay on behalf of a defaulting member."

[5]One exception is the empirical study by Kaboski and Townsend (2005).

[6]See Banerjee and Duflo (2006).

Bangladesh.

Our second theoretical result highlights that a bank able to distinguish between borrowers' groups with different distributions of outside options obtains higher profits by lending to groups whose distribution is worse. It is straightforward to reason that in the context of our model the best performing borrowers, those with the worse distribution of their outside options, would be individuals from rural areas, and more specifically women from those rural areas. Individuals in rural areas of Bangladesh face a higher unemployment rate that those living in urban areas, and earn lower wages once they find a job. Among the rural inhabitants, women are the ones who face the lowest wages and the biggest difficulties in finding a job. The fact that currently 98% of all Grameen Bank's borrowers are women from rural areas supports our theoretical prediction regarding the composition of the bank's borrowers.

After stating our theoretical results we conduct an empirical analysis using data from a quasi experimental survey jointly conducted by the World Bank and the Bangladesh Institute of Development Studies during 1998 and 1999. In order to test our theoretical result about the effect of borrowers' future income prospects on the probability of loan repayment, we use three proxies for the future prospects of the borrower: The borrower's gender, the average wage by gender in the village in which the borrower lives, and the dowry received by the borrower's family at the time of the borrower's marriage.

First, we find evidence consistent with the idea that women repay more often than men. We claim that the fact that women face higher unemployment rates and lower wages than men drives this observation. Second, we find that the average wage by gender in the village is positively and significantly correlated with the default probability. Moreover we find that including this measure of expected income reduces the estimated gender gap in loan repayment between female and male borrowers. This is consistent with our claim that gender is a proxy of the economic conditions faced by the borrower. Finally, we argue that dowry is a good exogenous proxy for the future prospects of a borrower as higher dowries are positively associated with the wealth of the family.[7] Consistent with our theory, the amount of dowry is found to be positively and significantly related to the probability of default, reflecting that individuals with better prospects are more prone to default on their loans.

Next, we analyze the composition of borrowers by the different groups of lenders. We find that the Grameen Bank and other microfinance institutions lend to a higher fraction of women and to those individuals with lower levels of dowry than other lenders. This backs our prediction that a bank that lends to individuals with poor prospects obtains higher repayment rates. However, we do not find that microfinance institutions lend in villages with lower average wages. We argue that microfinance institutions offer an

[7] See Anderson (2007) and references therein.

option to poor individuals which increases their wages. Hence the observed wage in the village increases when the microfinance institution is present.

Finally, we analyze the effect of the presence of competing banks on the probability of default of a borrower. In our theoretical model increasing the number of banks allows the individuals to access a profitable savings technology independently of defaulting on their current loan. Hence, increasing the availability of banks increases the default rate of borrowers. We find that borrowers that have access to other banks have, in fact, a higher probability of default.

Our paper provides a novel reason for the success of the microfinance programs abstracting from group liability issues and highlighting the deposit side of microfinance programs. Moreover, empirical evidence supports our main theoretical results. Our theoretical setup embeds the reasons of loan default in a dynamic equilibrium model with overlapping generations of households that borrow and save, which is a novel approach in the literature on banking for the poor. Moreover, we analyze the dynamics of a financially constrained bank in the context of microfinance lending.

The remainder of the paper is structured as follows. Section 3.2 presents the theoretical model. Section 3.3 analyzes the equilibrium of the model. Section 3.4 presents the theoretical results on the optimal composition of bank's borrowers. Section 3.5 presents the data that we use in our empirical analysis. Section 3.6 presents the empirical results. Finally Section 3.7 concludes. The Appendix B contains proofs of the results and the regression tables.

3.2 The Model

Consider a discrete time, infinite horizon economy where dates are denoted by $t = 0, 1, 2...$ The economy consists of an infinitely lived agent called the banker and overlapping generations of individuals living for three dates.

3.2.1 Individuals

At each date t, a continuum of measure N of penniless individuals are born. They all have the same preferences for consumption at dates $t+1$ and $t+2$ described by the function

$$u(c_{t+1}) + \delta u(c_{t+2})$$

where $u(c)$ satisfies $u'(c) > 0$ and $u''(c) < 0$, and $\delta < 1$ is an intertemporal discount factor.

Each individual i is characterized by a parameter θ_i which is constant during the individual's life and unobservable by third parties. The distribution of θ among the newborns is described by a time invariant, continuous distribution function $F(\theta)$ with support $[\underline{\theta}, \overline{\theta}]$. Let $f(\theta) = F'(\theta)$ denote the corresponding density function. Parameter θ_i should be understood as individual i's potential (labor or informal) income. To simplify the presentation we assume $u(\underline{\theta}) = -\infty$.

The date in which they are born, individuals have the possibility of investing in a project that has a unit cost and yields a time invariant deterministic return $1+\alpha$ at the following date. In order to undertake the project, they require a unit loan from a bank at a (net) loan rate l.

At date t, newborn individuals decide whether to borrow in order to undertake the project or obtain their specific alternative income θ_i.[8] At date $t + 1$ individuals decide whether to repay the loan and the amount of savings to deposit in the bank. At date $t + 2$, individuals consume θ_i and the proceeds from savings if they have saved. Hence, parameter θ_i captures two different types of income. At date $t + 1$, it captures the potential income the individual could obtain from the labor market, so this can be understood as the outside option of individual. At date $t + 2$, it mainly captures the family care the individual expects to receive when old. Although θ_i could potentially be different in both periods, it is reasonable to assume that it will be positively correlated. Richer families give better opportunities to their young members and also provide better family care when old. In order to simplify the notation, we assume that this correlation is equal to one and, hence, θ_i is the same at dates $t + 1$ and $t + 2$. The model delivers the same qualitative results if we assumed positive correlation between θ_i at both dates. Henceforth, we will simply refer to θ_i as the outside option of individual i.

Defaulting on the loan increases the individual's current income as her earnings are $1+\alpha$ instead of $\alpha - l$. However, by defaulting the individual loses the opportunity to access the savings technology offered by the bank and use it to increase her consumption when old. The opportunity to save is lost because (i) the defaulting individual will not deposit her savings in the bank in order to avoid their seizure, and (ii) saving other than through bank deposits is not possible.[9] Hence, when the individual does not repay the loan, her income when old is equal to θ_i.

Formally, an individual with outside option θ does not default on the loan if the utility

[8] To lighten notation subindex i that identifies the borrower will be dropped when unnecesary.

[9] This assumption is supported by empirical findings in Banerjee and Duflo (2007). They note that savings out of the banking system are not profitable in poor countries because of events such as inflations, natural catastrophes and thefts by strangers or by (male) family members. Our model could incorporate a cost of saving outside of the banking sector, $1 - \lambda$. Parameter λ should be understood as the probability of losing the savings when saving outside of the banking industry. For exposition purposes we assume $\lambda = 1$. Appendix C presents a model with competing savings alternative.

from repaying the loan and saving at a net deposit rate d, $U_r(l,d,\theta)$, is higher than the utility from default, $U_n(\theta)$. The utility of defaulting on the loan is

$$U_n(\theta) = u(1+\alpha) + \delta u(\theta)$$

The utility from repaying the loan is obtained by solving the following program:

$$U_r(l,d,\theta) = \max_{s\geq 0} \left[u(\alpha - l - s) + \delta u(\theta + s(1+d))\right]$$

where s are borrowers' savings invested in bank deposits. The first term of the objective function is the utility from current consumption after the savings decision has been made. The second term is the discounted utility from consuming θ and the proceeds from savings tomorrow.

In order to simplify the analysis we assume that the gross return of the investment project is smaller than the gross discount rate, $1+\alpha < 1/\delta$. Since in equilibrium the deposit rate d, will not exceed the loan rate l, which in turn will not exceed the net return of the project α, this implies $1+d < 1/\delta$. From here it follows that $u'(\theta) \geq \delta(1+d)u'(\theta)$, so individuals that do not borrow will not want to save. We also assume that the upper bound of the support of the distribution satisfies $\overline{\theta} \leq 1+\alpha$. This guarantees that all individuals want to borrow from the bank because by doing so they can always get $U_n(\theta) = u(1+\alpha) + \delta u(\theta)$, which is greater than $u(\theta) + \delta u(\theta)$.

In Section 3.3 we show that there is a threshold $\widehat{\theta}(l,d)$ such that $U_n(\theta) \leq U_r(l,d,\theta)$ for all $\theta \leq \widehat{\theta}(l,d)$. In other words, poorer individuals, those with $\theta \leq \widehat{\theta}(l,d)$, are those who repay the loan. Hence, the fraction of performing loans is given by $F(\widehat{\theta}(l,d))$. Finally let $s(l,d,\theta)$ denote the optimal savings of individuals with $\theta \leq \widehat{\theta}(l,d)$.

3.2.2 The banker

The banker is assumed to be risk neutral and has an initial wealth $W < N$, which prevents him from lending to all individuals at the initial date $t = 0$. The banker maximizes the discounted stream of dividends

$$\sum_{t=0}^{\infty} \beta^t C_t$$

where β is the banker's intertemporal discount factor and C_t are the bank's dividend payments at date t.

At date $t = 0$ the banker sets up a bank by providing initial capital with his wealth. The bank supplies loans and offers interest bearing deposits to individuals. The bank operates in an economy with no other external sources of financing. Hence, it can finance loans only with deposits and accumulated reserves.

At each date t, the bank sets a loan rate l_t, and a deposit rate d_t, issues loans in amount L_t and collects deposits D_t. Loans are supplied to newborns and deposits are the total amount of savings from those who were granted a loan at date $t-1$ and repaid it at date t. When setting loan and deposit rates the banker takes into account that both variables affect the optimal decision of repayment and savings of its borrowers.[10] The banker also decides the amount of loans it grants at every date taking into account that, by the cash flow constraint, granting an additional loan he reduces the amount of money he is able to disburse as dividends.

Hence, the bank's problem at any date t can be stated as

$$\max_{\{L_t, l_t, d_t\}_{t=\tau}^{\infty}} \sum_{\tau=t}^{\infty} \beta^{\tau-t} C_t$$

subject to the following constraints

$$\begin{aligned}
C_t &= (1+l_{t-1})F(\widehat{\theta}(l_{t-1,}, d_t))L_{t-1} + D_t - (1+d_{t-1})D_{t-1} - L_t, \\
D_t &= L_{t-1} \int_{\underline{\theta}}^{\hat{\theta}(l_{t-1}, d_t)} s(l_{t-1}, d_t, \theta) f(\theta) d\theta, \\
L_0 &\leq W, && (3.1) \\
C_t &\geq 0. && (3.2)
\end{aligned}$$

The first constraint is the cash flow constraint. At any date t, dividend payouts C_t must be equal to the proceeds from loan repayments, plus the new deposits that the bank obtains, minus the deposit repayments the banker has to meet, and minus the new loans that the bank grants.[11]

The second constraint defines bank's deposits at every date as the optimal savings of the individuals who repay the loans granted the previous date. Finally, the third and fourth constraints state that at the initial date $t = 0$ the bank cannot grant more loans than the banker's initial wealth, and that at any given date t the banker cannot pay a negative dividend.

[10] The characterization of how the optimal decision of individuals are affected by loan and deposit rates is presented in Section 3.3.

[11] Recall that $F(\widehat{\theta}(l_{t-1,}, d_t)$ is the fraction of loans that do not default at date t.

3.3 Equilibrium

The equilibrium of the model is defined as a sequence of loan and deposit rates, the total loans at each date t that maximizes the discounted stream of dividends of the bank given the optimal decisions of the individuals.

3.3.1 Individuals' optimal decisions

Individuals when deciding if they default on the loan or not take into account the amount of savings they deposit in the bank in the case of not defaulting. Hence in this subsection we first characterize the amount of savings individuals would deposit in the bank if they repay and, once we characterize the optimal savings decision in the case of not defaulting, we analyze the decision of defaulting on the loan or not.

As previously described, optimal savings $s(l, d, \theta)$ result from the optimization problem of those individuals that repay the loan

$$s(l, d, \theta) = \underset{s \geq 0}{\arg\max} \ [u(\alpha - l - s) + \delta u(\theta + s(1 + d))]$$

Optimal savings are implicitly defined by the following first order condition

$$u'(\alpha - l - s) = \delta(1 + d)u'(\theta + s(1 + d)).$$

Let θ_s denote the level of θ for which optimal savings are 0, that is θ_s is the value of θ for which $u'(\alpha - l) = \delta(1 + d)u'(\theta)$ holds. Using the implicit function theorem it is direct to show that for individuals with $\theta < \theta_s$ we have

$$\frac{\partial s(l, d, \theta)}{\partial \theta} = -\frac{\delta(1 + d)u''(\theta + s(1 + d))}{u''(\alpha - l - s) + \delta(1 + d)^2 u''(\theta + s(1 + d))} < 0.$$

When θ decreases individuals increase their savings as savings are used to smooth lifetime consumption and those individuals with lower θ have higher differences in their earnings.

Once we have determined the optimal savings decisions when individuals repay the loan, we focus on determining the fraction of borrowers that repay the loan, which in turn defines the amount of bank deposits.

Taking into account that an individual decides to default when the utility of repaying, $U_r(l, d, \theta)$, is lower than the utility of defaulting on the loan, $U_n(\theta)$, we obtain the following result.

Proposition 1 There exists a threshold, $\widehat{\theta}(l,d)$, for which the individuals with lower θ repay the loan and the individuals with higher θ do not. Moreover, it holds that $\widehat{\theta}(l,d) < \theta_s$.

Proof. See Appendix B.

Proposition 1 states that individuals with low future income θ, do not default on their loans. This is because these individuals are the ones that value more an increase in their future consumption. In order to achieve this they have to deposit their savings in the bank, and if they do not repay the loan the bank will seize their deposits as a way to have their loan repaid.[12]

When setting loan and deposit rates the bank takes into account how they affect the repayment behavior of its borrowers. Comparative static results for the threshold that determines the default rate, $\widehat{\theta}(l,d)$, are summarized in the following Lemma.

Lemma 1 The threshold $\widehat{\theta}(l,d)$, and consequently the fraction of non defaulting loans in the economy $F(\widehat{\theta}(l,d))$, is decreasing in the loan rate l, and increasing in the deposit rate d.

Proof. See Appendix B.

Lemma 1 states that the individuals with higher θ start to repay their loans when the loan rate decreases or the deposit rate increases. In such cases the profitability of repayment increases making it more attractive for the individuals to pay back the loan. The bank will take into account this effects when setting the equilibrium loan and deposit rates.

3.3.2 Bank's optimal strategy

To derive the optimal strategy of the banker we rely on the existence of two commitment devices. The first of them is that the banker is able to commit not to receive deposits from those individuals that do not repay the loan. The second is that the banker repays those deposits that have been deposited in the bank.

Concerning the first commitment, it can be argued that it is not optimal for the banker to repay deposits from individuals that defaulted on their loan. The banker when receiving deposits from those individuals, has the right not to repay them, as the individual has a debt with the bank, and by doing so the banker increases his revenues. Hence, if the

[12]In the context of our model the only way an individual can only increase his future income by saving. Another approach which yields the same qualitative results would be the assumption of infinetly lived individuals who receive a loan whenever they do not default on their previous loan. This setup would however complicate the solution for the bank optimal decision of loan and deposit rates.

individual has not repaid the loan he would not deposit in the bank to avoid the seizure of her deposits.

The second commitment device relies on the assumption that at any given date the continuation value of the bank is higher than the amount of deposits it has to repay. When a banker does not repay its deposits the borrowers will not deposit their savings in the bank as they anticipate that in future dates the bank will do the same. This leads to all individuals defaulting if the bank does not pay back the deposits, so continuing with the bank will not be profitable.[13] Hence, we assume that at any given date the banker is better off by continuing with the bank than by defaulting on its deposits repayment obligations.

The optimal strategy of the bank is defined by the amount of loans it grants at each date as well as the loan rates and deposit rates it sets. The first decision concerns the optimal amount of loans, which in turn defines the optimal dividend policy as the cash flow constraint establishes that by granting an additional unit loan the banker decreases his current dividend by one unit. It must be taken into account that, due to the banker's intertemporal discount factor, keeping cash without disbursing it in order to disburse it in the future is not optimal. This results in all cash that is not used in granting new loans being paid as dividends for the banker.

When the bank considers granting a loan to a newborn at date t it acknowledges that this decreases the dividends at date t, but has two additional effects on future earnings. First, at date $t+1$ the bank has higher revenues from loan repayment as a higher number of individuals obtained a loan. Second, as more individuals get loans the aggregate supply of deposits at date $t+1$ is higher at the given rates, which has a negative impact at date $t+2$ because the bank has to repay a higher amount of deposits.

The marginal effects on banker's payoff of increasing the supply of loans to newborns is then given by

$$-1+\beta\left[F(\widehat{\theta}(l_t,d_{t+1}))(1+l_t)+(1-\beta(1+d_{t+1}))\int_{\underline{\theta}}^{\widehat{\theta}(l_t,d_{t+1})}s(l_t,d_{t+1},\theta)f(\theta)d\theta\right] \tag{3.3}$$

Note that the value of expression (3.3) does not depend on the amount of loans granted, and that the existence of the bank is conditional on it being positive. If (3.3) were negative then the banker would refrain from investing any of its initial wealth in the bank. Hence, as expression (3.3) is positive when the bank exists, then it is optimal for the bank to increase the loan supply as long as it has the opportunity of granting a loan

[13] Note that if this condition does not hold the bank would not be established. Individuals would anticipate bank behaviour and, by backwards induction, the result would be that individuals would never deposit in the bank, which would make the bank not profitable in the initial date.

to a newborn. This results in constraint (3.2) in the banker's problem being binding whenever $L_t < N$. Constraint (3.1) is also going to be binding, as initially the bank cannot grant loans to all of the newborns (because $W < N$).

Once the bank grants loans to all of the young generation N, no further loan disbursement is profitable as the bank can only grant additional loans to old individuals, who always default as they have no incentives to repay. Hence, whenever the available funds once bank's deposits are repaid are higher than the amount needed for granting loans to the new generation, $(1 + l_{t-1})F(\widehat{\theta}(l_{t-1}, d_t))L_{t-1} + D_t - (1 + d_{t-1})D_{t-1} > N$, the bank will grant N loans to the newborns and pay out the rest of the revenues as dividends.

We can summarize this discussion in the following result:

Proposition 2 As long as there are growth opportunities, $L_t < N$, dividends are equal to 0. Once the growth opportunities are exhausted, $L_t = N$, dividends are positive.

Proposition 2 establishes that when growth opportunities are exhausted (steady state) the bank is going to have positive cash flows, which it will pay out as dividends. These dividends are defined by the following equation:

$$C = (1 + l^*)F(\widehat{\theta}(l^*, d^*))N - (1 + d^*)D - N + D$$

where l^* and d^* are the equilibrium loan and deposit rates in steady state. In order to determine the optimal dividends we solve the optimal loan and deposit rates the bank sets at every date.

The Euler equation that characterizes the equilibrium loan rate l_t set at each date t is:

$$\left[(1 + l_t)\frac{\partial F(\widehat{\theta}(l_t, d_{t+1}))}{\partial l_t} + F(\widehat{\theta}(l_t, d_{t+1}))\right] L_t + (1 - \beta(1 + d_{t+1}))\,\frac{\partial D_{t+1}}{\partial l_t} = 0. \tag{3.4}$$

When setting l_t the banker internalizes that increasing the loan rate decreases the repayment rate of loans, the first term in square brackets, but also increases the payoffs from those individuals which repay, the second term in square brackets. Moreover, increasing the loan rate also affects the amount of deposits the bank obtains in the next period, which it has to repay two periods after, the last term in equation (3.4).

The Euler equation that characterizes the equilibrium deposit rate d_t set at each date t is:

$$\left[(1 + l_{t-1})\frac{\partial F(\widehat{\theta}(l_{t-1}, d_t))}{\partial d_t}\right] L_{t-1} + (1 - \beta(1 + d_t))\,\frac{\partial D_t}{\partial d_t} - \beta D_t = 0 \tag{3.5}$$

When setting d_t the bank internalizes that increasing the deposit rate increases the repayment of loans granted at $t-1$, which increases its revenues at date t, the first term in equation (3.5). The bank also takes into account that increasing the deposit rate affects the amount of deposits it receives at a given date and also the amount it has to repay at the following date.

The first term in equation (3.5) highlights an interesting feature concerning the complementaries between loan and deposit rates in this model. As highlighted in Proposition 1, deposit rates have an incentivizing effect for the repayment of the current loans. This matches the observed empirical finding that the Grameen Bank offers a higher deposit rate to its borrowers than the rate offered by traditional banks in Bangladesh. The Grameen Bank reports to pay 8.5% deposits to its borrowers when the average deposit rate for deposits in the Bangladesh banking sector is 5%.[14] According to our model, the reason behind this fact is that the Grameen Bank obtains higher repayments using deposit rates as an incetivizing device. We argue that traditional banks in Bangladesh, as they operate in a more competitive environment (urban areas) in which individuals are able to deposit savings in other banks, do not benefit from this effect and, hence, set a lower deposit rate.

Equations (3.4) and (3.5) establish that the optimal loan and deposit rates are constant during bank's lifetime and hence, independent of the dividend payout policy. Recall that $D_t = L_{t-1} \int_{\underline{\theta}}^{\hat{\theta}(l_{t-1},d_t)} s(l_{t-1}, d_t, \theta) f(\theta) d\theta$ and hence, equations (3.4) and (3.5) do not depend on L_t and L_{t-1} respectively. Hence, the bank solves the same system of two equations with two unknowns at each date t. The main objective when jointly setting l_t and d_t is to maximize the revenue of the bank independently of the final use of this revenue. We can summarize this discussion in the following result

Proposition 3 Loan rates and deposit rates are constant during bank's lifetime and, hence, independent of the dividend payout policy.

The fact that loan and deposit rates are constant sets expression (3.3) to be constant, which in turn results in an exponential growth of the bank. Recall that as long as growth opportunities are present the bank invests all of the revenues in increasing the loan supply.

This section has shown that a financially constrained profit maximizing bank will not pay any dividends. This is important to be highlighted as precisely the non disbursement of dividends has been argued to be evidence that the Grameen Bank was not a profit maximizing agent. The conclusion that when profitable investment opportunities are available dividends are equal to zero, closely matches the fact that the Grameen Bank did not disburse dividends until 2006. From 1983, the year of its establishment, until 2006

[14] Sources: Central Bank of Bangladesh and Grameen Bank.

the Grameen Bank has had an increasing presence in the rural villages of Bangladesh. By the end of 2006, the Grameen Bank was present in over 95 % of the rural villages of Bangladesh. Hence, it can be argued that at this point the Grameen Bank had covered all of its objective market, and therefore exhausted all of the profitable investment opportunities. In line with our theoretical prediction, at the end of 2006 the Grameen Bank for the first time in its history paid dividends. Consistent with our predictions, dividends were also disbursed at the end of 2007.

Another important issue that our theoretical model highlights is the reinforcement effect that the deposit rates have on loan repayment. When such an effect is taken into account, the optimal deposit rate is higher which can account for the fact that the Grameen Bank pays a higher deposit rate than other banks in Bangladesh. This reinforcement effect, added to the importance of deposits in a financially constrained bank, highlights the importance of analyzing lending and borrowing decision at the same time in a relationship banking setup.

3.4 Heterogenous distributions of outside options

Our previous analysis has assumed that the outside option θ of all individuals was drawn from the same cumulative distribution function $F(\theta)$. It may be argued that in fact there are different distributions of outside options among different types of individuals, for example men and women, or landowners and landless. As we show in this section being able to differentiate among type of individuals with different distributions of outside options can be the key to bank's survival, as only banks that focus on individuals with lower expected income are going to be profitable. We also discuss the difference between repayment rates and profitability when the bank grants loans and at the same time offers deposits.

In this section we relax the assumption of a unique distribution function and assume that there are two different distributions of outside options.[15] We assume that a fraction γ of individuals have their outside option drawn from a distribution F_1 and a fraction $1 - \gamma$ from F_2. We assume that F_2 first-order-stochastically dominates F_1, hence $F_1(\theta) > F_2(\theta)$ for all θ. This fact, together with the results from the previous section, gives the following two Propositions.

Proposition 4 For given l and d a banker who focusses on individuals whose distribution of θ is first-order-stochastically dominated will have higher repayment rates.

Proof. See Appendix B.

[15] The qualitative results hold if we assume a higher number of distribution functions.

At this point the difference between repayment rates and profits must be studied. Although Proposition 4 establishes that repayment rates are higher for banks that grant loans to individuals under F_1 the profits per loan of the bank focussing on such individuals may not be higher. Let $\pi_1(l,d)$ denote the the average profits per loan from individuals of type F_1. Using the exposition of Section 3.2 we can define $\pi_1(l,d)$ as

$$\pi_1(l,d) = -1 + \beta\left[(1+l)F_1(\widehat{\theta}(l,d)) + S_1\right] - \beta^2(1+d)S_1, \tag{3.6}$$

where $S_1 = \int_{\underline{\theta}}^{\hat{\theta}(l,d)} s(l,d,\theta)f_1(\theta)d\theta$ are the average savings per unit of loan and f_1 is the density function of F_1.

We have shown that the repayment rates, for given l and d, increase when the bank focusses on individuals of type F_1, which in turn increases the profits of the bank . However, by focussing on such individuals, the deposits the bank has to repay also increase, recall that poorer individuals save more. This effect may in turn decrease the profits of the bank that focusses on individuals with worse outside option.[16] Hence, when analyzing the profitability of microfinance institutions the repayment rate is not be the only variable to be taken into account. Attention should also be paid to the effect that deposits have on the profits.

When deposits have a positive effect on the profits of the bank, it is obvious that focussing on individuals of type F_1 is optimal as repayment rates increase and also deposits increase. However, when deposits decrease the profits of the bank, the bank should impose a maximum amount of deposits per borrower equal to $s(l,d,\hat{\theta})$. This will not decrease his repayment rates, as individuals with $\theta < \hat{\theta}$ will continue to repay their loan, this follows immediately from the proof of Proposition 1, and it will decrease the amount of deposits it obtains. When this measure is taken into account, it is direct to show that focussing in individuals with worse distribution of outside options increases the profitability of the bank.

Let l_2, d_2 denote the equilibrium loan and deposit rates that maximize $\pi_2(l,d)$. By the previous exposition, when deposits decrease the profits of the bank, the bank would set a maximum deposit amount equal to $s(l,d,\hat{\theta}(l_2,d_2))$. From equation (3.6) a bank focussing on distribution F_1 and setting the same loan and deposit rates, and the same maximum amount of deposits per individual will have higher profits. Note that his repayment rate increases and the amount of deposits per individual S_1, does not vary.[17] Hence we can conclude that by focussing on individuals with worse outside option the banker will increase his profits.

From the previous discussion we can conclude that the ability of distinguishing between

[16] This occurs when in equilibrium $\beta(1+d) > 1$.

[17] Also it must be take into account that the banker can always set the deposit rate to be 0 and not lose in deposits.

different types of individuals plays a crucial role in the existence of a bank. When F_1 and F_2 are not observable by the banker, the banker faces a distribution

$$F_m(\theta) = \gamma F_1(\theta) + (1-\gamma)F_2(\theta).$$

Following the previous exposition, there may be cases in which a banker that focusses on F_1 has positive profits but the banker focussing on F_m has negative profits. In this cases the banker able to distinguish between $F_1(\theta)$ and $F_2(\theta)$ will set up a bank and lend only to individuals whose θ comes from $F_1(\theta)$. The banker who observes only $F_m(\theta)$ would not find profitable to set up a bank. This can be an important issue when establishing a microfinance program. For the microfinance program to be profitable, the banker must have the ability of distinguishing those individuals with worse outside options. The banker with such ability will focus on individuals with low outside options and by doing so increase the profits of his bank.

3.5 Data description

To conduct our empirical analysis, we use data from a quasi experimental survey conducted jointly by the World Bank and the Bangladesh Institute of Development Studies. The survey's main purpose is to provide data for analyzing three microfinance programs in Bangladesh: the Grameen Bank, the Bangladesh Rural Advancement Committee, and the Rural Development-12 program of the Bangladesh Rural Development Board. We analyze the information from the 1998-1999 wave containing information on 15,553 individuals from 2,599 randomly chosen households. These households come from 96 villages of 32 thanas.[18] A detailed description of the survey can be found in Khandker (1998). The main characteristic that must be highlighted is that it is a cross section, and hence, we cannot apply panel data techniques to our data.

The survey contains details on personal and financial characteristics of the individuals in the surveyed households, as well as on the social and economic characteristics of villages in which these households live. For the purpose of our empirical analysis we mainly focus on those households which report taking loans. From the total number of 7,396 loans in the sample, we are able to use information regarding 6,385 loans. The main reason for this reduction is lack of information on the date of maturity of these loans, which precludes qualifying the loan as defaulted or not. We classify a loan as defaulted when one of the following conditions holds: (i) the borrower reported a reason for default, or (ii) the loan has not been repaid in full 3 months after the due date.[19] According to this

[18]Thana is an administrative unit consisting of several villages.

[19]The standard period after which the loan is classified as defaulted is 3 months. Our results are robust to changes in the number of months that classifies a loan as defaulted.

definition, we classify 768 loans as defaulted in our sample. We conduct our analysis with a base number of 6,385 observations, which vary depending on the control variables we use.

For the loans in our analysis, we have detailed information on the features of these loans, e.g. amount given and repaid, loan rate, dates when they were taken, due and repaid, the lender type, as well as on the personal and financial characteristics of the borrowers, like age, education, gender, number of people providing income in the household, income and savings. It must be taken into account that reported loans were taken in years ranging from 1993 to 1999. Personal characteristics of the borrowers (except of age) are available only for loans taken in 1997 and later, as the survey was conducted in 1998 and 1999, and only information regarding the 12 months preceding the survey was obtained. This reduces the sample when introducing personal characteristics in our regressions.

3.6 Empirical evidence

This section provides empirical evidence in favor of Proposition 1, which states that borrowers with lower outside options are more creditworthy, and Proposition 4, which states that banks focussing on individuals with lower outside options exhibit higher repayment rates.

3.6.1 Higher outside options result in higher defaults

In this subsection, we present evidence on the importance of outside options in determining loan repayment. Using a logit model with robust standard errors we estimate the impact of three proxies of borrowers' outside options on the probability of default. As proxies of outside options we use the borrower's gender, the average wage in the borrower's village by gender, and the amount of dowry received by the borrower's family at the time of the borrower's marriage.

When indicated we control in our regressions for the following variables: borrower's age and education, the borrower's and other household members' income, the ratio of household members without income to those providing it (called the dependency ratio), the number of children the borrower has and the source of loan. The full description of the variables is in Appendix A. The descriptive statistics are in Table 1.

Gender and expected wages

We claim that in Bangladesh the borrower's gender is a strong predictor of an individual's outside option. Being born a woman in rural areas of Bangladesh results in lower wages and lower chances of finding employment.[20] This allows us to conclude that the borrower's gender is a good proxy of the outside option in our model of loan default. We construct a dummy variable taking value 1 for female borrowers. Consistent with our theory we expect female borrowers to have lower probabilities of default.

Column (1) in Table 2 reports the estimates of the logit regression of default on the borrower's gender. As expected, the gender's coefficient is negative and significant. This finding is in line with the majority of studies on microfinance stating that female borrowers are more creditworthy.[21] Although several studies have documented this result before, these studies lack an economic explanation for the underlying causes of this effect. Various studies have stressed intrinsic characteristics of women, such as being more risk averse than men. In contrast, we argue that different economic conditions lead to different repayment behavior by female borrowers. More specifically, lower outside options imply higher repayment rates.

In order to better assess the importance of gender, we provide in column (2) of Table 2 estimates from a regression with an extended set of control variables. In this case our sample is reduced to 3,790 observations, mainly because we are able to use only those loans for which we have the data on the controls, i.e. only for loans taken from 1997 onwards. The set of control variables includes the borrower's age, education, her/his income and of other members of her/his household, the dependency ratio and her/his number of children.

The impact of gender is still negative and significant reflecting, according to our proposed interpretation, the effect of women's lower outside options. Borrower's education, which can be regarded as a proxy for skills, also has a positive and significant impact on the default probability. The income generated by the borrower and by the other members of the borrower's household as well as the dependency ratio are meant to control for individual and household exposure to specific shocks such as natural catastrophes or medical needs. The coefficients on income variables are not significant. The coefficient on the dependency ratio is positive and significant, reflecting that higher fraction of members not generating income makes the borrower more vulnerable to negative shocks such as a medical expenditure and more likely to default. Finally, we also introduce the number of children as a control variable, although it is not significant.

As we have previously argued, women have lower wages than men in rural Bangladesh, and this can be one important factor explaining the gender gap in loan repayment. To further address this issue, we create a variable which is the average wage that the indi-

[20]Table 1 shows that the average female wage is smaller than the average male wage. We do not have data on the unemployment rate in each village needed to compute the expected wage. Statistics from the World Bank state that female unemployment in rural Bangladesh is 50% higher than male unemployment.

[21]See Armendariz and Morduch (2005) for a survey of this literature.

viduals receive in each village by gender. This measure is a proxy for the expected wage of the borrower and by construction it is no longer borrower specific as all borrowers of the same gender who live in the same village are imputed the same wage. All individuals surveyed, independently of having borrowed or not, report the wages they earned while working as employees in the non-agricultural sector. By averaging these wages by gender in each village we construct a proxy for the outside option of the borrower.

Column (3) in Table 2 reports the results of the regression of default on the average wages in the village while preserving the gender dummy. It shows that for both men and women the coefficient on the average wage is positive and significant, which is in line with our Proposition 1. The following regression reported in column (4) confirms the previous results when we add the controls used in previous regressions. In this regression the education loses its positive and significant sign. It may well be that education proxies, at least to some extent, for the effect of wages. It is reasonable to assume that villages with high wages will also have more education, as wages and education are known to be positively correlated.

As we have just shown, introducing economic factors such as borrower's expected wage in the village helps to explain the gender gap in loan repayment. This is consistent with our explanation of gender being a proxy for the outside option of the borrowers, and differs from other informal explanations in the literature.

Dowry

In order to better assess the importance of borrowers' outside options for their repayment behavior we use the dowry exchanged in the marriage. The literature concerning dowry has documented that wealthier families pay higher dowries and that the dowry received by the borrower's family increases with her/his expected income.[22] In the context of our model, coming from a wealthier family would increase the outside option of the borrower as wealthier families are able to provide better prospects for their relatives. This ranges from offering better labor opportunities to providing monetary and in kind transfers in case of need.

Our dowry variable is constructed in such a way that both spouses in the marriage have the same imputed dowry. Hence, it is not going to be suitable to explain the gender gap. However, it is suitable to test Proposition 1 regarding the importance of the outside options in loan repayment behavior.

Column (1) in Table 3 reports the estimates from a regression of default on dowry. The sample is reduced to 5421 loans as only for this number of loans we have reports on the amount of dowry exchanged. It must also be taken into account that not all borrowers

[22] See Anderson (2007) for a survey of the literature.

are married. In this regression we also include the gender dummy. The coefficient on the dowry is positive and significant. As reported in column (2) of Table 3 this result is robust to including the controls used in the previous regressions.

As we have previously argued, dowry can be interpreted as a measure of the expected future income of the individuals. Following such reasoning the current income of the individuals can be instrumented by dowry in order to control for unobservable shocks that are related to current income and default, like robbery and natural catastrophes. In such case dowry would capture the part of the individuals income which is not affected by the shocks, which can be seen as the expected outside option of the borrower. Column (3) shows the result of a probit estimation in which the variable income has been instrumented by the dowry exchanged by the individuals.[23] The results of such estimations is that higher income, once instrumented, leads to higher default.

Robustness check concerning dowry

One concern while using dowry as a proxy for outside options is the high percentage of reports of no dowry being received. Marriages reporting no dowry received account for around 50% of the sample. In order to control for different explanations why no dowry was given, such as being extremely poor and not being able to raise money for dowry or having different marriage traditions, we run our regression on a constrained sample of borrowers reporting a positive dowry. Column (4) in Table 3 shows the results of this robustness check. It can be seen that restricting our sample only to individuals with positive dowry does not change our results.

Another concern regarding the dowry is the possible existence of misbehavior by the borrowers receiving dowry. Dowry exchange is illegal in Bangladesh meaning that a person engaging in such a practice may be also prone to commit other illegal acts which may positively correlate with default, including strategic defaults. In order to test this explanation we generate a dummy reflecting whether dowry was actually exchanged. This dummy proxies for the possibility that the individual may be prone to other misbehavior. We run a regression of default with the usual controls and including the dowry dummy. Results are reported in column (5). The coefficient on the dowry dummy is insignificant, meaning that the effect of dowry is related to the levels of the variable and not to the existence or not of dowry. This allows us to conclude that the channel through which dowry affects repayment rates is related to the outside options of the borrowers.

Although dowry exchange is nowadays illegal in Bangladesh, we do not expect to have a mismeasurement of the variable dowry. As the survey was not conducted by organi-

[23] Due to programming difficulties we could not conduct a logit estimation with instrumental variables. It must be highlighted that results of probit estimations do not have quantitative impact on the value of our regressors.

zations capable of punishing the individuals, the incentives to lie are not clear. One of the main effects of having misreporting of dowry is that it would bias the coefficient of dowry towards 0, making it more difficult to find positive effects. The biggest concern would be that only individuals with high levels of dowry reported low levels of dowry and those with intermediate levels did not misreport. We argue that this is not the case in our sample as individuals have the same incentives to misreport independently of their dowry, and hence, we should not have non monotonicities in the misreporting. As we use the dowry mostly as a ranking mechanism the important assumption is that if misreporting of dowry exists in the survey, this does not affect the ranking. Hence, if misreporting exists, we assume that on average individuals with higher dowry have higher reported dowry.

All proxies

In the last column of Table 3 we report the estimates of a regression including all proxies for outside options and all controls. All coefficients used as proxies of outside options preserve their signs. The most important result of that regression is that the impact of the gender dummy is strongly reduced and it looses its significance. The loss in significance backs further our result that being a female borrower translates into low outside options. This supports Proposition 1 and goes against the informal explanations addressing the gender gap in repayment behavior. The loss of significance is in line with a claim posed by Armendariz and Murdoch (2005) who argue that having controlled for sufficient amount of borrowers' characteristics, gender will not matter for the repayment behavior of the borrowers.

3.6.2 Borrowers' composition depends on institutions

Next, we focus on empirical evidence consistent with section 3.4. In order to support this result we conduct a test of difference in means concerning the percentage of female borrowers, the level of dowry of the borrowers and the expected wages by gender in the village. We also test if microfinance institutions have a lower fraction of defaulting loans.

Table 4 shows that, as predicted by our model, we find that the Grameen Bank exhibits higher repayment rates and focuses on borrowers with lower outside options. The microfinance institutions have a statistically significant higher amount of female borrowers and the average dowry exchanged by a borrower in the microfinance institution is lower than for the other lenders. Concerning the expected wage in the village, we see that the microfinance institutions do not focus on villages with lower wages. This however may a result of the lending practices of the microfinance institutions. By lending in those villages the supply of cheap labor is reduced and the equilibrium wage of the village is increased.

Controlling for the lender type

It can be argued that, due to the different selection procedure followed by the institutions, our previous proxies for the outside options of the borrower were in fact proxies for the lender type, mainly those regarding female and dowry. The problem of selection in the microfinance programs has been previously treated in the microfinance literature by authors such as Khandker.[24] In order to test whether our results are stable after controlling for the lender type, we introduce a dummy indicating the type of the lender. There are several sources of lending indicated in the sample and we pool them into six groups, which indicate the common features of these lenders. These groups are microfinance institutions, relatives, moneylenders, cooperatives of credit, traditional banks and non governmental agencies. Table 5 presents estimates of four regressions: for each of the measures of outside options alone and one that contains all of them. We conclude that our results do not change. In all regressions the gender coefficient becomes small in absolute value (and looses significancy in all but one regression), which can be attributed to the fact that the majority of borrowers of microfinance institutions are women.

In order to assess the importance of all of our regressions only for the Grameen Bank borrowers we report the results of our estimations when only the borrowers of the Grameen Bank are taken into account. Table 6 shows how the qualitative results remain unchanged. Interestingly, the signs of age and education do change because when individuals become older they receive a higher loan and also they receive education. Hence, these variables can be seen as predictors of being a previous Grameen Bank borrower and not having defaulted on the loan before. In order to study this point, we include the size of the loan, which increases with the years of membership and previous repayment behavior, and we see how these coefficients loose significance. Results of including the loan amount are shown in column (3) of Table 6

3.6.3 The impact of competition

The theoretical predictions about the repayment behavior in our model are based on the sole existence of a monopolistic bank. The enforcement mechanism which guarantees loan repayment relies on the existence of one unique source of profitable saving technology. In our model the inclusion of a second bank offering a savings technology results in a lower repayment rate of the original bank.[25] Individuals would default on the loan and

[24] See Khandker and Pitt (1998).

[25] For a theoretical model that supports this claim see the Appendix C.

deposit their savings in the other bank. Hence, our model predicts that in the case of the microfinance industry when additional channels of profitable savings are available, the repayment rate decreases.

Empirically the effect of bank competition on the repayment behavior of individuals can be tested by generating an indicator of the availability of profitable saving technologies in a given village. In order to proxy for the availability of another bank, we construct a dummy that takes the value 1 if any individual in the village took a loan from a traditional bank. Implicitly we are assuming that traditional banks offer deposits at a competitive rate to all individuals that are willing to deposit their savings in the bank. This allows us to proxy for villages that have access to other sources of saving technology than those of the microfinance institutions. Our model predicts villages with other sources of profitable saving technology should have higher default rates than those with out such options.

Consistent with our theory we find how living in villages with accessibility to bank services has a positive and significant effect on the probability of failure of the individuals. These results are reported on Table 7.

3.6.4 Further tests

Our theoretical setup has other testable implications that can be tested in the data. To test these implications we conduct difference in means tests for such cases. Results of this tests are reported in Table 8.

One empirical prediction of our model is that individuals who default would have lower savings as they will not deposit their savings in the bank to avoid seizure. This pattern is observed in the data as those individuals that default have on average lower savings than those who do not. Our model also predicts that defaulting borrowers have higher income in the date they default. This is an important feature which distinguishes our theoretical model of strategic default from competing explanations. If defaults were only due to exogenous shocks, we would expect borrowers receiving a negative shock, i.e. disease or bad climate, would default but also have low income. In our model, those that default strategically have higher income than those that do not default.

The empirical finding concerning the income of defaulting borrowers supports our model, as the income of those who default is on average higher than of those that repay. The data shows that borrowers that committed default in years before 1998 (the year when the survey was conducted) have higher income in the years after their default (1998 or 1999) than those who do not default. This is in line with our theoretical setup as we show that borrowers with better outside options in the following years are more prone to default.

Consistent with our theory, and previous theories regarding borrowing and lending behavior, when individuals have options of depositing their savings, or receiving new credit, from other institutions defaulting on the loan affects less their future income. We find how among individuals that default, those who have access to alternative banks have higher income than those who do not have such options.

Also consistent with such theories when an individual does not default on the loan from the microfinance institution, the existence of other sources of credit does not affect its income as it continues to use the original source.

Regarding savings we find that those individuals that receive a loan by microfinance institutions have higher average savings than those who do not, this is also consistent with our theory as microfinance institutions have higher deposit rates and also focus on those who have higher needs of savings. Also we find how the savings profile of the individuals follows the pattern predicted by our model. Young individuals accumulate savings that are used when they are old. This prediction is not new, as numerous studies studying the life cycle profile of savings predict such pattern.

Another important result is that those individuals that are members of a microfinance program generally save inside such a program. In our sample 70% of those that are members have all their savings inside the program. It is interesting to note how, when other banks are available, the amount of savings of the microfinance programs' members out of the program increases. Moreover, individuals who did not repay their loans have a higher amount of their savings out of the microfinance programs. In addition, those that do not save at all inside the microfinance program possess high savings too. Such individuals can be characterized as being rich with better options of savings inside the traditional banking system.

3.7 Conclusions

Microfinance programs achieve high repayment rates although their borrowers are extremely poor and do not provide collateral. Recent studies have stressed that group liability, which has been the most common explanation for this observation, does not have an impact on microfinance repayment rates. Our paper provides a simple and tractable model of borrowers with different expected labor or informal income, henceforth outside option, and a monopolistic bank facing asymmetric information. We identify the optimal default strategy for borrowers and the optimal lending and deposit taking strategy for the bank. Then, we exploit theoretical predictions from our model to design empirical tests addressing two hypotheses: (i) does the probability of default increases with the borrowers' outside option? and (ii) do lenders with higher repayment rates focus on individuals with worse outside options? We test these hypotheses using the data from a quasi experimental survey from Bangladesh.

From a theoretical perspective we show how in a dynamic model in which the bank takes deposits and grants loans to the same set of individuals, the deposit rate plays a crucial role in enhancing loan repayment. Borrowers that repay are those with lower expected future income as they value more the increase in future consumption that savings provide. Hence, higher deposit rates increase the profitability of the savings mechanism which increases the incentives for the borrowers to repay, as in the case of defaulting they will not have access to bank's deposits.

Empirically we find that those individuals with worse outside options are in fact those with higher repayment rates. We use three proxies of the outside options of individuals that are borrower's gender, the average wage by gender in the village, and the dowry exchanged in the borrower's wedding. We also find that, consistent with our theoretical model, microfinance institutions focus on borrowers with lower outside options and obtain higher repayment rates.

Our paper provides interesting policy implications. When designing a sustainable microfinance program the policy maker should be able to identify and focus on those individuals with worse outside options, which in turn are poorer individuals. By doing so the microfinance institution will obtain higher repayment rates which is crucial in obtaining a sustainable institution. However, depending on the equilibrium deposit rate, the microfinance institution may need to establish a maximum amount of deposits per borrower in order to increase his profits without decreasing his repayment rates

The placement of the microfinance program should take into account the existence of alternative institutions that provide credit and savings to the individuals as we show how such presence reduces the repayment rate of the individuals. This highlights the risks that the expansion of microfinance may have on their profitability. Introducing microfinance programs in places where other institutions already offer credit and deposits will probably result in low repayment rates, and hence unsustainability, not only for the incumbent but also for the institution that was present before.

Chapter 4

Endogenizing the Scope of the Stigma of Failure

4.1 Introduction

Imperfect traceability of the reasons for business failures attaches a "stigma of failure" to bankrupt entrepreneurs. When trying a fresh start, they are often left discriminated by business partners, employees, and in particular investors. Despite extensive research, it still remains unclear why the extent of this discrimination varies across countries, sectors and over time. European and Japanese financiers, for instance, are perceived to be more reluctant to finance a failed entrepreneur's restart than their American counterparts. It therefore became commonplace to praise the US' lower "stigma of failure" as the source of its higher entrepreneurship rates[1] and consequently of its competitive edge in terms of the ability to innovate, commercialize and grow.[2]

In this paper, we study to what extent different scopes of the "stigma of failure" (captured by the maximal number of times a failed entrepreneur is able to get fresh start financing) can simultaneously be equilibrium outcomes. Our main result is that as soon as the riskiness of failed projects cannot be evaluated by investors, two types of equilibria may coexist: a *conservative equilibrium*, where a once-failed entrepreneur is excluded from further finance, or *experimental equilibria*, where she can start projects even after a (limited and endogenously determined) number of failures.

In our model, a wealthless entrepreneur seeks funding from a competitive banking sector[3] in order to launch a project. This project can be run with high or low risk of failure. Its

[1] GEM (2008) reports that in 2007, 10.8% of adults were engaged in early-stage entrepreneurship in the US as compared to only 5.4% in the EU or 5.4% in Japan.

[2] See Bottazzi et al. (2003), EU Commission (2000), SME Agency (1999) or Wennekers et al. (2006).

[3] The results can also be applied to alternative forms of entrepreneural finance.

probability of success does not only depend on this risk, but also on the entrepreneur's inherent skills[4], which can be high or low. Unlike in Stiglitz and Weiss (1981), neither the entrepreneur nor banks know her skills. Only the distribution of skills is publicly known. If the project is successful, the entrepreneur continues her business, payoffs are realized and the game is over. If the project fails, the bank that financed the project loses its investment and the entrepreneur asks for further entrepreneurial finance in order to start a new project in the next period. The structure of the game is the same in each period. However, after each failure, banks update their belief about the probability whether the entrepreneur has high skills or not. This belief is not only dependent on the initial distribution of skills, but also on the level of risk, which has been chosen in the preceding periods: if this risk has been high (low), the belief about the probability that the entrepreneur has high skills is also relatively high (low).

Different scopes of the "stigma of failure" can occur in equilibrium only if the entrepreneur can trade off the expected return of a project against its maximal return: therefore we assume that a low-risk project has a higher expected return, while the return from the high-risk project in case of success exceeds the return from the low-risk project. We show that if the risk of failure of the high-risk project is not too high and the probability of having high skills is sufficiently close to unity, then the first-best outcome is as follows: the entrepreneur realizes high-risk projects in the first periods and then (if all these projects were unsuccessful) switches to the low-risk project. Finally, if she also fails with the low-risk project, she stops realizing projects as it becomes relatively certain that she has low skills.

We will analyze three informational settings: (I.) Under perfect information, banks can observe both the entrepreneur's past and present risk choices, i.e. there is no moral hazard. We show that any sequential equilibrium is efficient in this setting. (II.) Under private information of banks, these can only assess the riskiness of projects financed by themselves. Conservative and experimental equilibria can then simultaneously exist and be sequential equilibria. This is due to the fact that not all banks can observe the entrepreneur's decisions. A bank may then become a monopolistic supplier of finance to the entrepreneur if all of its competitors believe that the entrepreneur's skills are low. The credit market outcome might be inefficient, as the entrepreneur chooses the low-risk project too early. (III.) Finally, the same result obtains under moral hazard, where banks can neither observe the riskiness of past, nor present projects: if banks believe that the entrepreneur chooses high (low) risk, they charge a high (low) loan rate, which makes the entrepreneur choose the high (low) risk. There is, however, one exception: there may also arise a situation, in which a conservative equilibrium is more efficient than any experimental equilibrium.

[4]For example, entrepreneural skills can represent whether the ideas of an entrepreneur have a high or low probability of success.

We provide a novel explanation on why economies with identical cultural and institutional constraints can suffer from different scopes of the “stigma of failure”. Our results lead to a number of policy implications. A banks' ability to observe both past and present risk choices of entrepreneurs proves crucial in preventing credit market inefficiencies. This supports the view that an efficient system of entrepreneurial finance may be based on small banks or venture capital firms who know their clients' business well. We argue that most of the EU's envisaged policies to reduce the “stigma of failure” might not be effective, since the expectations and actions of many market participants must be changed simultaneously. Likewise, potential gains from an increase in entrepreneurial skills in the population might not fully be realized unless the risk of both past and present projects can be evaluated by investors.

Related Literature Varying levels of the “stigma of failure” have typically been attributed to either persistent cultural or institutional differences between countries. There is nevertheless still widespread dispute about which and how cultural traits might shape attitudes towards entrepreneurial failure.[5] Burchell and Hughes (2006) obtain that GDP growth is not related to failure tolerance, but positively to society's positivity towards second chancing. Yet, as respondents in the US show higher levels of failure tolerance but less willingness to grant a second chance to failed entrepreneurs than Europeans, more entrepreneurial activity in the US cannot be attributed to a more favorable cultural perception of second chancing. Institutional constraints show limited impact on agents' decision to start new firms. This suggests the experience of the EU-15, where entrepreneurial activity remained quite stable - even after firm setup costs had declined by a third between 2002 and 2007 (see EurActiv 2007).

We focus instead on capital market constraints, which we endogenize. The closest paper to ours is Landier (2006). In his model, high-skill entrepreneurs liquidate mediocre projects in the experimental equilibrium despite their positive net present values. In the conservative equilibrium, entrepreneurs maintain mediocre projects and therefore only low-skill entrepreneurs start a second-time business, which then increases the loan rate. Landier thus rather scrutinizes the liquidation decision and not, like our paper, second chancing after bankruptcy. Groom and Scharfstein (2002) study an organizational choice model with labor market rigidities as barriers to entrepreneurship. When managerial incentives depend on the career prospects, agents might prefer dependent- to self-employment. Due to asymmetric information, financing capital is then shifted to lower quality and younger firms. Our key driver, in contrast, is the interplay between the entrepreneur's skills and risk choices. Finally, the setting with private information of banks builds on Petersen and Rajan (1995), Sharpe (1990) and von Thadden (2004). They show that long-term bank-firm relationships enable banks to gather valuable costly

[5] See e.g. Licht and Siegel (2006), Hayton et al. (2002) or Giannetti and Simonov (2004).

information on their customers. That overrides bank competition for older customers, so that banks can capture some of their rents.

The paper is organized as follows. Section 4.2 introduces the model and derives the first-best outcome. In Sections 4.3 to 4.5 we analyze credit market equilibria for different informational settings: perfect information, private information of banks and imperfect information. After having studied welfare and policy implications in Section 4.5, Section 4.6 concludes. All proofs are in Appendix C.

4.2 The model

We consider an economy populated by an entrepreneur E and $N > 1$ banks B_k, $k \in \{1, ..., N\}$.[6] Time is discrete and denoted by $t \in \{1, 2, ...\}$. All players are risk-neutral.

4.2.1 The Entrepreneur

The entrepreneur is endowed with entrepreneurial skills θ_i which are either high ($i = H$) or low ($i = L$), but with no wealth on her own. The level of skills i is time-invariant and unobservable to her and banks. However, both E and banks know that the ex-ante probability of high skills is equal to $\alpha_1 \in (0, 1)$. In period 1, E has access to a project of size 1, which she can realize or not. If E does not realize the project or she does not get a loan, the game is over an the payoff is 0 for all players. Otherwise, E chooses a risk of failure p_j of either high ($j = H$) or low ($j = L$) value. The project's return structure y_{ij} is determined by E's level of skills i and choice of risk j:

$$y_{ij} = \begin{cases} y_j, \text{ with probability } (1 - p_j)\theta_i \\ 0, \text{ with probability } 1 - (1 - p_j)\theta_i \end{cases}$$

Thereby, y_j is the risk-dependent project return in case of success and $(1 - p_j)\theta_i$ the probability of success when E's skill is $i \in \{L, H\}$ and her risk choice is $j \in \{L, H\}$. In order to simplify matters, we set $p_L = 0$ and $\theta_H = 1$. If E's project with risk of failure j is successful, she exits the game and her payoff is equal to y_j minus the loan rate for this project.[7] As E has no own wealth, this payoff cannot be negative: if the loan rate is higher than the project return, her payoff is equal to 0 and the bank gets the project return. If E's project is not successful, she does not pay anything to the bank that granted the loan and moves on to the next period. The structure of the game is the

[6] The results carry over easily to a continuum of entrepreneurs.

[7] This assumption embodies that E continues her successful business (with y_j, $j \in \{L, H\}$, being the net present value of certain future payoff streams), and therefore does not need to ask for entrepreneural finance another time.

same in each period. Thus, E asks for finance in period t only if she realized $t-1$ times a project that failed. As tie-breaking rule we assume that E chooses $j = L$ whenever she is indifferent between the high- and the low-risk project.

In period 1, E has a belief $\tilde{\alpha}_1^E = \alpha_1$ about the probability that she has high skills. She updates this belief according to Bayes' rule. If she chooses the risk of failure j in period t and the project fails, then her belief is given by

$$\tilde{\alpha}_{t+1}^E(\tilde{\alpha}_t^E, j) = \frac{\tilde{\alpha}_t^E p_j}{1-(1-p_j)(\tilde{\alpha}_t^E + \theta_L - \tilde{\alpha}_t^E \theta_L)}. \tag{4.1}$$

Her expected level of skills in a period t is given by

$$\tilde{\theta}_t^E = \tilde{\alpha}_t^E + (1-\tilde{\alpha}_t^E)\theta_L. \tag{4.2}$$

4.2.2 Banks

Banks compete in a Bertrand manner by offering loan contracts to E. A contract only specifies the loan rate E has to pay in case of success. They also may decide not to offer any loans, however, we will assume that banks offer contracts as long as they can make zero-profits in expectation. We will consider three informational settings:

(I.) Perfect information (PI): banks can observe the riskiness of both E's past and present projects.

(II.) Private information of banks (PRB): each bank can only observe the riskiness of past and present projects it financed itself.

(III.) Imperfect information (IM): banks cannot observe any project's riskiness.

Each bank B_k has a belief $\tilde{\alpha}_t^{B_k}$ about the probability that E has high skills if she asks for project financing in period t. The way this belief is formed depends on the informational setting: under (PI), banks observe all of the E's past decisions, therefore they can update their belief using Bayes' rule like E does in (4.1). Under (PRB), a bank k can update its belief from $\tilde{\alpha}_t^{B_k}$ to $\tilde{\alpha}_{t+1}^{B_k}$ according to Bayes' rule only if it financed the project in period t. Otherwise, $\tilde{\alpha}_{t+1}^{B_k}$ is given exogenously. Under (IM), the belief of each bank in each period is given exogenously. Denote the expected level of skills in a period t for B_k by

$$\tilde{\theta}_t^{B_k} = \tilde{\alpha}_t^{B_k} + (1-\tilde{\alpha}_t^{B_k})\theta_L.$$

Under (PI) and (PRB), B_k can condition its loan rate r_t^k both on its belief $\tilde{\alpha}_t^{B_k}$ and on the risk of failure of the present project, i.e. there is no moral hazard. Thus, it offers two contracts with loan rates $r_t^k(\tilde{\alpha}_t^{B_k}, H)$ and $r_t^k(\tilde{\alpha}_t^{B_k}, L)$. Under (IM), a bank cannot condition on the risk of failure of the project, therefore it offers only one loan rate $r_t^k(\tilde{\alpha}_t^{B_k})$. We assume that banks cannot commit to certain loan rates in future periods.

4.2.3 Timing and Equilibrium

Altogether, if E is in the game at the beginning of period t, the sequence of events is as follows:

1. Each bank decides whether to offer loan contracts or not. If yes, it chooses the loan rate(s). If no bank offers loan contracts, the game is over and payoffs are 0 for all players.
2. E decides whether to undertake a project or not. If yes, she chooses the risk of failure $j \in \{L, H\}$ and the contract with the lowest loan rate for this risk (if more than one bank offers the lowest loan rate, E chooses each of those offers with equal probability). If not, the game is over and payoffs are 0 for all players.
3. The project is successful or not. In case of success, E receives the payoff from the project, pays the loan rate to the bank and the game is over. Otherwise, she defaults and enters the next period. The bank that financed the project incurs a loss of 1.

Our main focus lies on the sequential equilibria of the game under the different informational settings. In our model, any sequential equilibrium exhibits the following features: Firstly, beliefs are derived from Bayes' rule whenever E's actions are observable. Secondly, banks correctly anticipate E's actions whenever these are unobservable. We therefore have

$$\tilde{\alpha}_t^{B_k} = \tilde{\alpha}_t^E$$

for $k \in \{1, ..., N\}$ in each period t of an equilibrium. Finally, E's action in period t maximizes her expected payoff for given belief and the banks' decisions in subsequent periods. A bank's decisions in period t maximize its expected payoff for given belief and other banks' decisions in period t.[8] To illustrate important results, we will also refer sometimes to Nash equilibria of the game (in which beliefs do not play a role).

[8]To keep matters simple we suppress some notation here, which would be needed to define the sequential equilibrium formally. The first two points follow from the concept of "consistency" of strategies and beliefs, the last point follows from "sequential rationality". To proof "consistency" one usually has

4.2.4 Projects and the First-Best Outcome

The high-risk project has a higher return than the low-risk project, i.e. $y_H > y_L > 1$. Moreover, it holds that high skills and low risk increase the probability of success, i.e. $\theta_H > \theta_L$ and $p_H > p_L$. The projects taken by the high- (low-) skill entrepreneur always have a positive (negative) net present value (NPV):

$$(1 - p_j)y_j > 1 \text{ and } (1 - p_j)\theta_L y_j < 1 \text{ for } j \in \{L, H\}\,. \tag{4.3}$$

E can trade off the expected return of a project against the maximal return,[9] i.e. the expected return from the low-risk project is higher than from the high-risk project:

Assumption (A1): *We have* $y_L > (1 - p_H)\, y_H$.

Consider an entrepreneur with "deep pockets" who knows that she has high skills and who can finance projects by herself. Given that this entrepreneur has only one chance to realize a project, she would choose the low-risk project if (**A1**) holds. If (**A1**) does not hold, she would go for the high-risk project. Assume now that this entrepreneur can start a new project in infinitely many periods like in our model, i.e. if she succeeds, payoffs are realized and the game is over, otherwise she can start another project. Her expected payoff from always choosing the high-risk project, V_1^H, is then given by

$$V_1^H = (1 - p_H)\,(y_H - 1) + p_H \left(-1 + V_1^H\right).$$

Solving for V_1^H yields us

$$V_1^H = y_H - \frac{1}{1 - p_H}.$$

Her expected payoff from choosing the low-risk project, V_1^L, is given by

$$V_1^L = y_L - 1.$$

We will assume that $V_1^H > V_1^L$:

Assumption (A2): *We have* $y_H - \dfrac{1}{1 - p_H} > y_L - 1$.

to construct a sequence of mixed strategies and beliefs (derived for a given strategy according to Bayes' rule) which converges against the equilibrium strategy profile and equilibrium beliefs. For details we refer to Fudenberg and Tirole (1991), pages 337 - 338. As equilibria in our model have a very simple structure, we will do without this construction.

[9] Our results would be similar in a model in which E can trade-off those two variables continuously.

If (**A2**) holds, then the entrepreneur with deep pockets and high skills would choose $j = H$ in each period. If (**A2**) does not hold, she would choose the low-risk project. The assumptions in (**A1**) and (**A2**) can be fulfilled at the same time if and only if $y_L > 1$. This is ensured by the fact that both projects have a positive NPV as long as the high-skill entrepreneur runs them.

We now derive the first-best outcome if (**A1**) and (**A2**) hold and the entrepreneur is uncertain about her skills. Again assume that E has deep pockets and can finance all projects by herself. Note that in period 1, her expected payoff from realizing the low-risk project is positive if and only if

$$\alpha_1 > \frac{1}{1-\theta_L}\left(\frac{1}{y_L} - \theta_L\right). \tag{4.4}$$

If (4.4) does not hold, then the entrepreneur does not start any projects. As $\alpha_1 < 1$, she will not finance high-risk projects in infinitely many periods, as her belief $\tilde{\alpha}_t^E \to 0$ for $t \to \infty$, according to (4.1). If she anticipates in period $\bar{t}$ that her belief $\tilde{\alpha}_{\bar{t}+1}^E$ will be below the right-hand side of (4.4) in case of failure, then she chooses $j = L$ in this period (and stops realizing projects if this project fails). Define

$$I(\theta_L, y_L) \equiv \left(\frac{1}{1-\theta_L}\left(\frac{1}{y_L} - \theta_L\right), 1\right).$$

Note that this interval is always non-empty. We then get the first-best outcome:

Proposition 1 Assume that (**A1**) and (**A2**) hold. Then for each $\alpha_1 \in I(\theta_L, y_L)$ there is a number $\bar{t}_{\alpha_1} \in \mathbb{N}$, such that the entrepreneur with deep pockets chooses $j = H$ in the periods $t \in \{1, ..., \bar{t}_{\alpha_1} - 1\}$ and $j = L$ in period $t = \bar{t}_{\alpha_1}$. For $\bar{t} \in \mathbb{N}$ there is a $\hat{\alpha}_1 < 1$, such that $\bar{t}_{\alpha_1} > \bar{t}$ whenever $\alpha_1 > \hat{\alpha}_1$.

Proof. See Appendix C.

4.3 Equilibria under perfect information (PI)

In our first informational setting, banks can evaluate the riskiness of past and present projects. As the NPV of projects run by a low-skill entrepreneur is negative, projects will only be financed in finitely many periods. Facing Bertrand competition, banks only offer loan rates, which generate zero profits in equilibrium. Hence, the expected repayment equals the investment sum. If B_k then sells a loan contract to E to finance a project of risk $j \in \{L, H\}$ in period t, the loan rate must be

$$r_t^k(\tilde{\alpha}_t^{B_k}, j) = \frac{1}{(1-p_j)\tilde{\theta}_t^{B_k}}, \tag{4.5}$$

where $\tilde{\alpha}_t^{B_k} = \tilde{\alpha}_t^E$. As $\theta_L < 1$, the loan rate decreases in $\tilde{\alpha}_t^{B_k}$.

Let banks' loan rates and E's decisions be given for all t. Denote by V_t be the expected payoff of E in the beginning of period t. If banks do not provide loans anymore (or if E does not realize a project) in period t, $V_t = 0$. If E gets a loan from B_k in period t, her expected payoff from realizing a project with risk j is

$$V_t = (1-p_j)\tilde{\theta}_t^E(y_j - r_t^k(\tilde{\alpha}_t^{B_k}, j)) + (1-(1-p_j)\tilde{\theta}_t^E)V_{t+1}. \tag{4.6}$$

This allows us to calculate recursively E's expected payoff V_1.

4.3.1 The conservative equilibrium

We first show that there is a Nash equilibrium in which E gets finance only if she never went bankrupt, i.e. in period 1 and never thereafter. If banks do not offer loans in periods $t \in \{2, 3, ...\}$, we have $V_2 = 0$. Equations (4.5) and (4.6) imply that E picks $j = L$ in period 1 if

$$\tilde{\theta}_1^E y_L \geq (1-p_H)\tilde{\theta}_1^E y_H.$$

This expression is equivalent to (**A1**). A bank B_k provides funding for a low-risk project as long as

$$\tilde{\theta}_1^{B_k} y_L - 1 \geq 0,$$

which is satisfied if $\alpha_1 \in I(\theta_L, y_L)$. It remains to show that banks do not provide loans in $t \in \{2, 3, ...\}$. Note that failure of a low-risk project reveals low skills. As all banks can observe E's decisions, it is rational for them not to finance any more projects.

Lemma 1 If and only if (**A1**) holds and $\alpha_1 \in I(\theta_L, y_L)$, then under PI there is a Nash equilibrium, in which E chooses $j = L$ in period 1. Banks finance the project in this period, but do not provide loans in periods $t \in \{2, 3, ...\}$.

This equilibrium may, however, not be a sequential equilibrium. The threat that no offers are made in period 2, even if E chooses $j = H$ in period 1, may not be credible, as all banks observe E's decisions and can update their belief via Bayes' rule. If E deviates and chooses the high-risk project, it can be profitable for a bank to finance her after failure given that α_1 is sufficiently high. This is what we are going to show now.

4.3.2 Experimental Equilibria

Assume that banks provide finance up to period $\bar{t} > 1$. As the failure of a low-risk project reveals low skills, this only happens if E picks $j = H$ in periods $t \in \{1, ..., \bar{t} - 1\}$. Provided that (**A1**) holds, E faces the same trade-off in period $\bar{t}$ as in the previous subsection. In view of a zero-payoff in case of failure and a higher expected payoff from the low-risk project, E chooses $j = L$. She might be willing to realize high-risk projects in periods $t \in \{1, ..., \bar{t} - 1\}$ if condition (**A2**) holds. With banks' beliefs being derived from Bayes' rule, (4.1) entails that for any values of p_H, θ_L and $k \in \{1, ..., N\}$:

$$\lim_{\tilde{\alpha}_{t-1}^{B_k} \to 1} \tilde{\alpha}_t^{B_k}(\tilde{\alpha}_{t-1}^{B_k}, H) = 1.$$

For any t, we get that $\tilde{\alpha}_t^{B_k} \to 1$ as $\tilde{\alpha}_1^{B_k} \to 1$. We obtain

$$\begin{aligned} \tilde{\theta}_{\bar{t}}^{B_k} y_L - 1 &\geq 0, \\ (1 - p_H)\tilde{\theta}_t^{B_k} y_H - 1 &\geq 0, \end{aligned}$$

for $t \in \{1, ..., \bar{t}-1\}$ if α_1 is sufficiently high. In these periods, projects' NPV is positive, so that banks provide loans to E. This allows us to establish the existence of experimental equilibria:

Lemma 1 Let $\bar{t} \in \mathbb{N}$ be given. If (**A1**), (**A2**) hold and α_1 is sufficiently high, then under PI there is a Nash equilibrium in which E chooses $j = H$ in periods $t \in \{1, ..., \bar{t}-1\}$ and $j = L$ in period $\bar{t}$. Banks finance all projects in periods $t \in \{1, ..., \bar{t}\}$, but not in periods $t \in \{\bar{t} + 1, \bar{t} + 2, ...\}$.

Proof. See Appendix C.

Again, not every experimental equilibrium is a sequential equilibrium: If in period $\bar{t}$, belief $\tilde{\alpha}_{\bar{t}}^{B_k}$ is sufficiently large, then banks can profitably finance projects in period $\bar{t}+1$, given that E chooses $j = H$ in period $\bar{t}$. The following result owes to the perfect observability of past and present risk choices:

Proposition 2 If **(A1)**, **(A2)** hold and $\alpha_1 \in I(\theta_L, y_L)$, then under PI in any sequential equilibrium, E chooses $j = H$ in the periods $t \in \{1, ..., \bar{t}_{\alpha_1} - 1\}$ and $j = L$ in period $\bar{t}_{\alpha_1}$. Projects are financed in periods $t \in \{0, ..., \bar{t}_{\alpha_1}\}$, but not in periods $t \in \{\bar{t}_{\alpha_1} + 1, \bar{t}_{\alpha_1} + 2, ...\}$.

Proof. See Appendix C.

Therefore, if entrepreneurial risk choices are perfectly observable, countries with similar entrepreneurial skills and similar institutional constraints should expose the same scope of the "stigma of failure".

4.4 Equilibria under private information of banks (PRB)

In this section, we relax the assumption that banks can perfectly observe the riskiness of all past projects. Instead, a bank only knows the risk of projects which it financed itself. As in Sharpe (1990) and von Thadden (2004), this enables banks to acquire private information about E. The risk of projects financed by other banks remains unknown. We thereby implicitly assume that banks cannot (or do not) infer the risk of past projects from past loan rates.[10]

4.4.1 The conservative equilibrium

As in the last chapter, we can show that there is a conservative equilibrium if (**A1**) holds and α_1 is sufficiently large. Now this is a sequential equilibrium. To see why, assume that E deviates and chooses $j = H$ in period 1 instead of $j = L$. Further assume that she gets financed by bank B_k. If her project fails, B_k updates its belief about her type to $\tilde{\alpha}_1^{B_k}$ according to Bayes' rule as in (4.1). All other banks assume that E has chosen the low-risk project in period 1. Their belief about E is $\tilde{\alpha}_2^{B_l} = 0$, $l \in \{1, ..., k-1, k+1, ..., N\}$. Thus, they will refuse to finance E's project in a period $t > 1$. This makes B_k a monopolistic supplier of finance to E. It can charge the maximal loan rates, $r_t^k(\tilde{\alpha}_t^{B_k}, j) = y_j$, in all subsequent periods $t > 1$. E's expected payoff then equals zero. Therefore, it pays off for E to pick the project with the highest expected return in period 1. We conclude:

Lemma 3 If and only if (**A1**) holds and $\alpha_1 \in I(\theta_L, y_L)$, then under PRB there is a sequential equilibrium, in which E chooses $j = L$ in period 1. Banks finance projects in this period, but do not provide loans in periods $t \in \{2, 3, ...\}$.

4.4.2 Experimental Equilibria

Experimental equilibria have the same form as in the last section: E chooses $j = H$ in the first $\bar{t} - 1$ periods and $j = L$ in $\bar{t}$. Given that E and banks (regardless of whether they financed the projects of E or not) have the same beliefs on the equilibrium path, banks charge a loan rate according to (4.5). For the same reasons as for a conservative equilibrium, these experimental equilibria must be also sequential equilibria. We therefore obtain:

[10] This assumption is not innocuous if there are detailed credit registers. If banks infer previous risk choices from the loan rates of past projects, then the results of the setting with perfect information apply.

Lemma 4 Let $\bar{t} \in \mathbb{N}$ be given. If (**A1**), (**A2**) hold and α_1 is sufficiently high, then under PRB there is a sequential equilibrium in which E chooses $j = H$ in periods $t \in \{1, ..., \bar{t} - 1\}$ and $j = L$ in period $\bar{t}$. Banks finance all projects in periods $t \in \{1, ..., \bar{t}\}$, but not in periods $t \in \{\bar{t} + 1, \bar{t} + 2, ...\}$.

Proof. See Appendix C.

Several experimental equilibria with different numbers of periods with project financing exist simultaneously if α_1 is sufficiently close to unity. Note that for a given $\alpha_1 \in I(\theta_L, y_L)$, an equilibrium with $\bar{t}_{\alpha_1}$ periods of project financing may not exist: E could probably gain by choosing $j = L$ in all periods $t \in \{1, ..., \bar{t}\}$ and switch to another bank after each failure (as all banks which financed previous projects know for sure that E has low skills). However, she will refrain from doing so as long as she feels reasonably comfortable that she has high skills (i.e. as long as α_1 and therefore $\tilde{\alpha}_t^E$, $t \in \{1, ..., \bar{t}\}$, is sufficiently high). Combining Lemmata 3 and 4 gives rise to our next result:

Proposition 3 Let $\bar{t} \in \mathbb{N}$ be given. If (**A1**), (**A2**) hold and α_1 is sufficiently high, then under PRB both a conservative equilibrium (in which banks only finance projects in period 1) and an experimental equilibrium (in which banks finance all projects in periods $t \in \{1, ..., \bar{t}\}$, but not in periods $t \in \{\bar{t} + 1, \bar{t} + 2, ...\}$) exist and are sequential equilibria.

The multiplicity of sequential equilibria implies that the "stigma of failure" may differ among countries with the same institutional environment and the same average level of entrepreneurial skills. The outcome in the credit market depends on banks' expectations and E's risk choices. If both cannot be altered simultaneously, changes in the institutional environment may not have an impact on the "stigma of failure". Before we discuss this result's welfare- and policy implications, we show that the same also obtains if banks cannot control E's current risk choice.

4.5 Equilibria under imperfect information (IM)

Finally, we also relax the assumption about banks' control of E's currently chosen risk level. Instead, banks only know the period number, i.e. how many times E previously went bankrupt. They are also aware of the fact that E can choose between a risky and a less risky business strategy. Details, however, remain hidden to banks. This creates moral hazard in the credit market: E may be inclined to choose the high risk if banks charge a loan rate, which only covers low risk. Still, both conservative and experimental equilibria can exist at the same time as sequential equilibria.

4.5.1 The conservative equilibrium

For a conservative equilibrium, in which E chooses the low-risk project, we must rule out that E can gain from picking a high-risk project. For this, we need to modify assumption (**A1**):

Assumption (A1*): *We have* $y_L - 1 > (1 - p_H)(y_H - 1)$.

Note that (**A1***) implies (**A1**). Assume that E purchases the loan contract from B^k in period 1. For a given loan rate r_1^k, E prefers the low-risk project in this period if and only if

$$\tilde{\theta}_1^E(y_L - r_1^k) \geq (1 - p_H)\tilde{\theta}_1^E(y_H - r_1^k).$$

Rearranging terms yields us the inequality

$$r_1^k \leq \frac{y_L - (1 - p_H)y_H}{p_H}. \tag{4.7}$$

Provided that E chooses $j = L$, B^k makes zero-profits if it charges the loan rate

$$r_1^k = \frac{1}{\tilde{\theta}_1^E}. \tag{4.8}$$

By combining (4.7) and (4.8), we can show the existence of a conservative equilibrium:

Lemma 5 *If* and only if (**A1***) holds and α_1 is sufficiently high, then under IM there is a sequential equilibrium, in which E chooses $j = L$ in period 1. Banks finance projects in this period, but do not provide loans in periods $t \in \{2, 3, ...\}$.

The threat of not providing further credits in the next periods is credible, as banks cannot observe the risk choice of E. Thus, a conservative equilibrium is robust under imperfect information.

4.5.2 Experimental Equilibria

In a sequential equilibrium with $\bar{t}$ periods of project financing, banks correctly anticipate that E chooses $j = H$ in periods $t \in \{1, ..., \bar{t} - 1\}$ and $j = L$ in $t = \bar{t}$. This results in loan rates of

$$r_t^k = \frac{1}{(1 - p_H)\tilde{\theta}_t^{B_k}} \tag{4.9}$$

in $t \in \{1, ..., \bar{t}-1\}$ and

$$r_{\bar{t}}^{k} = \frac{1}{\tilde{\theta}_{\bar{t}}^{B_k}},$$

where $\tilde{\alpha}_t^{B_k} = \tilde{\alpha}_t^{E}$ in all periods $t \in \{1, ..., \bar{t}\}$ for $k \in \{1, ..., N\}$. Again, if (**A1***) holds and $\tilde{\alpha}_{\bar{t}}^{B_k}$ is sufficiently close to unity, then in period $t = \bar{t}$, E cannot gain by choosing $j = H$ instead of $j = L$. In order to show that E cannot profitably deviate in periods $t \in \{1, ..., \bar{t}-1\}$, we need to modify assumption (**A2**):

Assumption (**A2***): *We have* $(1-p_H)y_H + \dfrac{1}{1-p_H} > y_L + 1.$

(**A2***) requires that a high-risk project's expected payoff is not too small relative to a low-risk project's. Assumptions (**A1***) and (**A2***) can hold at the same time if and only if $p_H > 0$ (which is implied by the construction of the model). Note that (**A2***) may hold even if (**A2**) does not and vice versa. We now can show:

Lemma 6 Let $\bar{t} \in \mathbb{N}$ be given. If (**A1***), (**A2***) hold and α_1 is sufficiently high, then under IM there is a sequential equilibrium, in which E chooses $j = H$ in periods $t \in \{1, ..., \bar{t}-1\}$ and $j = L$ in period $\bar{t}$. Banks finance all projects in periods $t \in \{1, ..., \bar{t}\}$, but not in periods $t \in \{\bar{t}+1, \bar{t}+2, ...\}$.

Proof. See Appendix C.

Again, it may well be that for given $\alpha_1 \in I(\theta_L, y_L)$, an equilibrium with $\bar{t}_{\alpha_1}$ periods of project financing does not exist, as loan rates are inflexible to entrepreneurial decisions: E does not choose $j = L$ in periods $t \in \{1, ..., \bar{t}-1\}$ if she is relatively convinced of her high skills (and therefore will be successful with the low-risk project in period $\bar{t}$ with high probability).

Consequently, the existence of multiple equilibria remains unaffected by the introduction of imperfect information. Combining Lemmata 5 and 6 leads us to conclude:

Proposition 4 Let $\bar{t} \in \mathbb{N}$ be given. If (**A1***), (**A2***) hold and α_1 is sufficiently high, then under IM both a conservative equilibrium (in which banks only finance projects in period 1) and an experimental equilibrium (in which banks finance all projects in periods $t \in \{1, ..., \bar{t}\}$, but not in periods $t \in \{\bar{t}+1, \bar{t}+2, ...\}$) exist and are sequential equilibria.

4.6 Welfare and policy implications

The results under the different informational settings offer a new framework for the analysis of welfare and policy making.

4.6.1 Welfare

Perfect Information and Private Information of Banks As banks make zero expected profits in all periods, welfare is given by the E's expected payoff V_1 at the beginning of the first period.[11] We have shown that in the setting with perfect information, the first-best outcome with $\bar{t}_{\alpha_1}$ periods of project financing is realized in any sequential equilibrium. The tie-breaking rule for E implies that in any other Nash equilibrium with fewer periods of project financing, E's expected payoff must be smaller (as the low-risk project is realized too soon). However, in the setting with private information of banks, these equilibria can be sequential equilibria. This implies that the credit market outcome with private information may be inefficient.

Consider now two assessments with $\bar{t}^1$ and $\bar{t}^2$, $\bar{t}^1 < \bar{t}^2$, periods of project financing, where E picks $j = H$ in the periods $t \in \left\{1, ..., \bar{t}^l - 1\right\}$ and $j = L$ in period $\bar{t}^l$, $l \in \{1, 2\}$. By Lemma 4, these assessments can be equilibrium outcomes if α_1 is sufficiently high. Let $V_1^{(\bar{t}^1)}$ and $V_1^{(\bar{t}^2)}$ the expected payoffs of E in the corresponding equilibria. It must hold that $V_1^{(\bar{t}^2)} > V_1^{(\bar{t}^1)}$. If $V_1^{(\bar{t}^2)} < V_1^{(\bar{t}^1)}$, E could increase her expected payoff in period $\bar{t}^1$ of the equilibrium with $\bar{t}^2$ periods of project financing by choosing $j = L$. The loan rate for this project must be the same in both equilibria. If $V_1^{(\bar{t}^2)} = V_1^{(\bar{t}^1)}$, then the tie-breaking rule implies that E chooses $j = L$ in period $\bar{t}^1$. We conclude that welfare is higher in an equilibrium with more periods of project financing than in an equilibrium with fewer periods of project financing.

Imperfect Information Under imperfect information, things are more difficult. We saw that an experimental equilibrium exists even if (**A2**) does not hold. Then, it is against the E's interest to realize high-risk projects. The reason is that after subtracting the bank's break-even loan rate, this project's net return in case of success is lower than for the low-risk project. E would prefer to realize projects with low risk. Yet, if banks assume that E chooses the high-risk realization of the project, the high loan rate prevents E from picking the low risk. This effect is the same as in models of asymmetric information in which inefficient high-risk projects crowd out efficient low-risk projects. A conservative then dominates any experimental equilibrium. However, (**A1***) and (**A2**)

[11] If we consider a continuum of entrepreneurs of mass 1, banks make zero profits for sure and welfare is the aggregated payoff of entrepreneurs (which is equivalent to the expected payoff in our setting).

can be fulfilled at the same time if and only if $y_L > 2$. This implies that if $y_L \leq 2$ holds, any experimental equilibrium is dominated by a conservative equilibrium under imperfect information.

Provided that $y_L > 2$ and that assumptions (**A1***), (**A2**) and (**A2***) are fulfilled, an experimental equilibrium may well dominate a conservative equilibrium. We know from Lemma 6 that if α_1 is sufficiently high, there can simultaneously exist equilibria with different numbers of periods of project financing. As before, we can show that an equilibrium with more periods of project financing always dominates an equilibrium with fewer periods of project financing in terms of welfare.

Example Consider a scenario with the following values: $y_L = 2.5$, $y_H = 2.66$, $p_H = 0.1$, $\theta_L = 0.3$, $\alpha_1 = 0.9$. It is straightforward to verify that assumptions (**A1**), (**A1***), (**A2**) and (**A2***) are satisfied for these values. Let the equilibrium loan rates for $k \in \{1, ..., N\}$ be as follows:

$$\begin{aligned} r_1^k(\tilde{\alpha}_1^{B_k}) &= 1,075, \\ \tilde{r}_1^k(\tilde{\alpha}_1^{B_k}) &= 1,195, \\ \tilde{r}_2^k(\tilde{\alpha}_2^{B_k}) &= 1,457. \end{aligned}$$

The expected payoff in the conservative equilibrium (with $\tilde{\alpha}_1^{B_k} = \alpha_1$ and $r_1^k = r_1^k(\tilde{\alpha}_1^{B_k})$, $k \in \{1, ..., N\}$) is therefore $V_1^C = 1,325$. In contrast, an experimental equilibrium with two periods of project financing (with $\tilde{\alpha}_t^{B_k} = \tilde{\alpha}_t^E$ and $r_t^k = \tilde{r}_t^k(\tilde{\alpha}_t^{B_k})$, $k \in \{1, ..., N\}$, $t \in \{1, 2\}$), leads to $V_1^E = 1,363$. The loan rates are chosen such that banks make zero-profits in expectation. Both under (PI) and (IM), the experimental equilibrium dominates the conservative one.

Now stick to the same setting, but with $y_L = 1.5$ and $y_H = 1.55$. Assumption (**A2**) is violated, while the others remain fulfilled. As the underlying risk is the same as before, the loan rates remain unchanged. Under (IM), there can be both the conservative and the experimental equilibrium with two periods of project financing. Clearly, this experimental equilibrium is inefficient, because of $V_1^C = 0,395$ and $V_2^E = 0,303$. In contrast, under (PI), the experimental equilibrium does not exist.

4.6.2 Policy Implications

Banking System Design Our analysis shows that the observability of entrepreneurs' past and present risk choices is a crucial feature that prevents inefficiencies in the credit market. We think that a banking system, which is most likely to exhibit this feature, is based on small, specialized and regional banks or on venture capitalists. Such institutions keep close ties to their clients and may well observe the risk involved in past and present business decisions. Some empirical support for this result comes from a comparison of the EU and Japan to the US: by trend, a more (less) pronounced "stigma of failure" seems to go in hand with more bank finance (market finance).

Economies with a financial system in which banks are able to observe past and present risk choices should be left unchanged. As the highest equilibrium level of welfare is attained in any sequential equilibrium, there is no room for policies aimed at changing the nature of the equilibrium. In particular, a conservative equilibrium may be the result of a relatively low level of average entrepreneurial skills. Yet, De Meza (2002) and ABRP (2002) caution that most businesses failures stem from low project quality and management incompetence. Hence, enabling more entrepreneurs might simply result in more costly failures.

On the contrary, large banks may be too distant to their borrowers in order to evaluate the risk of failed projects. These creditors mainly rely on statistical data ("credit scoring"), so that the results of the settings with private information of banks or imperfect information apply. As entrepreneurs choose the low-risk project to early in some equilibria, the outcome in the credit market may be inefficient. Policies aiming at changing the nature of the equilibrium may not be effective, as many entrepreneurs' actions and banks' expectations must be changed simultaneously. Consider for example the approach adopted by the European Commission (2000, 2007) through programs initiated in the aftermath of the Lisbon Council in 2000. Among other things, it foresees reducing the stigma of failure by advising entrepreneurs to choose higher risk levels. Entrepreneurs will follow such advice only if banks change their policy at the same time. This remains impossible as long as banks do not understand better the risk involved in their clients' business.

Improving Entrepreneurial Skills Another measure of the EU to increase entrepreneurial activity is education, formation of relevant skills and early support for viable enterprises (see European Commission, 2007). In our model, such policies are reflected by an increase in α_1. If banks have perfect information, an increase in the share of skilled entrepreneurs α_1 has a direct and an indirect effect on welfare in a sequential equilibrium: the loan rate decreases in all periods, see equation (4.5), and it (weakly) increases the number $\bar{t}_{\alpha_1}$ of periods in which projects are financed in equilibrium (see Proposition 1).

However, under private information or imperfect information of banks, inflexible beliefs about entrepreneurial decisions deter policy's impact on the nature of the equilibrium. Unless banks' credit offers and agents' risk-taking behavior becomes simultaneously coordinated to another equilibrium, only the direct effect will materialize.

4.7 Conclusion

This paper presents a multi-period credit market model where the extent to which failed entrepreneurs are excluded from further start-up financing is determined endogenously. The results' key driver is the evolution of a banks belief with regard to an entrepreneur's skills and its interplay with her risk choices. If the probability of high skills is sufficiently large, multiple equilibria may obtain. We observed that under perfect information (i.e. if banks can evaluate both past and present risk choices of an entrepreneur), in any sequential equilibrium the first-best outcome is realized. Second, under private information of banks (i.e. if banks can evaluate only the risk of projects which were financed by themselves), both a conservative and experimental equilibria are sequential equilibria. The multiplicity of equilibria is robust. Finally, the same result obtains if banks cannot evaluate the risk of any projects. We concluded that the outcome in credit markets where banks do not always observe the full history of entrepreneurial risk choices can be inefficient. Policy measures aiming at lowering the "stigma of failure" might not be effective, because banks' expectations and entrepreneurs' actions must simultaneously be shifted to a new equilibrium. However, our results also leave room for regulation: a banking system with small banks that know well their clients' business should be more prone to achieving an efficient allocation than one with arms-length finance.

Altogether, our paper is a starting point that offers ample scope for future research. It allows for the incorporation of numerous additional factors that might influence credit market conditions, such as education, social security, or the tax system. More specifically, the integration of learning would result in a lower decline of financiers' beliefs about entrepreneurs' skills over time. A population's age distribution should also matter, as younger agents have a higher risk appetite and thus readiness to create new firms, see Lévesque and Minniti (2006). Related work suggests taking into account multi-tool contracts (that include risk monitoring or quality screening) or various effects of the creation of innovative firms, such as technological- or demand-spillovers. At last, more convincing empirical evidence is needed to support effective policy making.

Appendix A

Appendix to Chapter 2

Proof of Lemma 2 The incentive compatible set of $(q;x)$ is feasible if and only if the following conditions are satisfied: $\widehat{q} \leq 1$ and the lower bound on x from (2.5) for $q = 1$ cannot be higher than $1 - k_H$. This is equivalent to:

$$1 \geq \gamma \geq \max\left\{\frac{(1+\delta)\Delta k}{\Delta k(1+\delta)+(\delta-r_D)(1-k_L)}; \frac{1+\delta}{1+r_D} - \sqrt{\frac{1+\delta}{1+r_D}\left(\frac{1+\delta}{1+r_D}-1\right)}\right\}. \tag{A.1}$$

The first term is obtained by inserting $x = 1 - k_H$ and $q = 1$ into (2.5) and solving for γ. The second term is the smaller solution of the quadratic inequality implied by $\widehat{q} \leq 1$. Both terms are smaller than 1 and the second term is also bigger than 1/2.

Proof of Lemma 3 (2.6) can be ignored if $\widehat{q}$ is not higher than q for which (2.5) is equal to $1 - k_H$. This is equivalent to

$$1 \geq \gamma \geq \frac{(1+\delta)(1-k_H)}{(1+\delta)(1-k_H)+\Delta k(1+\delta)+(\delta-r_D)(1-k_L)}.^{1} \tag{A.2}$$

Now I compare three lower bounds from (A.1) and (A.2) in order to determine the range of parameters for which the supervisor is not constrained in choosing q. If $r_H \geq 1 + 2r_L - b$, the first lower bound from (A.1) is the biggest. This case is however ruled out by (2.8), because $2r_L - r_D < 1 + 2r_L - b$. If $r_H < 2r_L - r_D$, these three bounds cross at $\delta = \frac{(\Delta k)^2 + r_D(1-k_L)^2}{(1-k_H)(1+k_H-2k_L)} \equiv \widetilde{\delta}$. $\widetilde{\delta}$ is higher than r_D because it holds that $(1-k_L)^2 > (1-k_H)(1+k_H-2k_L)$. However, $\widetilde{\delta}$ is not always smaller than r_L. It is smaller iff

$$r_H < r_L + (1 + r_L - b)\sqrt{\frac{r_L}{1+r_L}}. \tag{A.3}$$

If $\widetilde{\delta} \geq r_L$, what may occur if (2.8) is weaker than (A.3), the first bound from (A.1) is again the biggest. If $\widetilde{\delta} < r_L$, the first of these lower bounds is again the biggest for $r_D \leq \delta < \widetilde{\delta}$. If $\widetilde{\delta} < \delta < r_L$, the lower bound from (A.2) is the biggest. The supervisor is not constrained by (2.6), iff $r_H \geq r_L + (1 + r_L - b)\sqrt{\frac{r_L}{1+r_L}}$ and (2.8) is weaker than (A.3) or (A.3) and (A.2) hold. The first condition, $r_H \geq r_L + (1 + r_L - b)\sqrt{\frac{r_L}{1+r_L}}$, may hold iff its right hand side is not higher

[1] The lower bound lies between $\frac{1}{2}$ and 1.

than $b + r_D$ due to (2.1). This implies a quadratic inequality in b with a solution

$$b \geq (1 + r_D)\sqrt{r_L(1 + r_L)} - r_D(1 + r_L) > r_L - r_D.$$

Hence the first condition in Lemma 3 holds for b sufficiently high.

Proof of Lemma 5 I start the proof with the case, which is the closest to the case of recapitalization.

(i) $s_A \in [k_H; s_{MH}(p_H)]$. After inserting $V_H(s)$ and $V_L(s)$ into (2.9) and (2.10) and rearranging them, they become

$$s \geq 1 - \frac{\Delta k}{q(1-\gamma)} \text{ and } s \leq 1 - \frac{\Delta k}{\delta - r_D + r_L - r_H}\left(\frac{1+\delta}{q\gamma} - (1 + r_D)\right). \tag{A.4}$$

The procedure to find out for which parameters the incentive compatible set of $(q; s_A)$ is feasible is not empty is the same as in the case of recapitalization. Using again the notation for $q = \widehat{q} = \frac{1}{\gamma}\frac{1+\delta}{1+r_D} - \frac{1}{1-\gamma}\frac{\delta - r_D + r_L - r_H}{1+r_D}$ in which both constraints intersect, this region is not empty if s for which the constraints intersect is not higher than $s_{MH}(p_H)$ and it holds that $\widehat{q} \leq 1$. The first condition is equivalent to $1 \geq \gamma \geq \frac{1}{1+\frac{b}{1+\delta}} > 1/2$ (this is guaranteed by the fact that $1 > b > r_H - r_D$) and the second to

$$1 \geq \gamma \geq \frac{2(1+\delta) + r_L - r_H - \sqrt{(2(1+\delta) + r_L - r_H)^2 - 4(1 + r_D)(1+\delta)}}{2(1 + r_D)} > 1/2.$$[2]

The region in which s_A and q make the banks report truthfully is not empty for

$$1 \geq \gamma \geq \max\left[\frac{2(1+\delta) + r_L - r_H - \sqrt{(2(1+\delta) + r_L - r_H)^2 - 4(1 + r_D)(1+\delta)}}{2(1 + r_D)}; \frac{1}{1 + \frac{b}{1+\delta}}\right].$$

(ii) $s \in (s_{MH}(p_L); 1]$. The constraint for the bank H remains like the one in the case above. For the bank L after inserting $V_L(s_A)$ into the IC constraint, it gets $s \leq 1 - \frac{\Delta k(1+\delta)}{bq\gamma}$. This time the IC constraints for both types do not cross, hence the region in which the equilibrium may exist is not empty when the IC constraint for L is above of the one for H. This requires that $1 \geq \gamma \geq \frac{1}{1+\frac{b}{1+\delta}}$. Moreover, combinations of $(s_A; q)$ which are incentive compatible for both types are feasible iff the IC constraint for the bank L lies above of $s_{MH}(p_H)$ for $q = 1$. This requires that

$$1 \geq \gamma \geq \max\left[\frac{1+\delta}{1+r_D}\frac{b - (\delta - r_D) + r_H - r_L}{b}; \frac{1}{2}\right].$$

The last condition holds iff the first term in the square brackets is not higher than 1. This holds iff $\min\left[(1+\delta)\left(1 - \frac{r_H - r_L}{\delta - r_D}\right); 1\right] > b > r_H - r_D$. However this interval is not empty if (2.7) is strengthened to

$$\delta - r_D - r_H + r_L \geq \frac{\delta - r_D}{1+\delta}(r_H - r_D).$$

Hence the incentive compatible $(s_A; q)$ are feasible iff

$$\delta - r_D - r_H + r_L \geq \frac{\delta - r_D}{1+\delta}(r_H - r_D) \text{ and } 1 \geq \gamma \geq \max\left[\frac{1+\delta}{1+r_D}\frac{b - (\delta - r_D) + r_H - r_L}{b}; \frac{1}{1 + \frac{b}{1+\delta}}\right].$$

[2]This is guaranteed by (2.7).

(iii) $s_A \in [0; k_H]$. This case differs from the previous ones due to the full equity financing. First, the bank H is indifferent between selling or not. Second, the selling is profitable for the bank L when it reports H and does not constitute penalty any more. The IC constraints become

$$q \leq \max\left[\frac{\Delta k}{(1-k_H)(1-\gamma)}; 1\right] \text{ and } s \geq \frac{1+\delta}{(1+r_D)q\gamma} - \frac{(\delta - r_D)(1-k_H)}{r_H - r_L}.$$

The combinations of q and s_A are incentive compatible for both banks if the IC condition for the bank L is below of k_H for $q = \max\left[\frac{\Delta k}{(1-k_H)(1-\gamma)}; 1\right]$. This is equivalent to

$$k_H \geq \frac{1+\delta}{(1+r_D)q\gamma} - \frac{(\delta - r_D)(1-k_H)}{r_H - r_L} \text{ and } q = \max\left[\frac{\Delta k}{(1-k_H)(1-\gamma)}; 1\right].$$

If $\gamma \geq \frac{1-k_L}{1-k_H}$, the incentive compatible $(s_A; q)$ are feasible iff

$$1 \geq \gamma \geq \max\left[\frac{1-k_L}{1-k_H}; \frac{(1+\delta)\Delta k}{(\delta - r_D)(1-k_H) + k_H(r_H - r_L)}\right].$$

If $\gamma < \frac{1-k_L}{1-k_H}$, the incentive compatible $(s_A; q)$ are feasible iff

$$\gamma \in \left[\frac{(1+\delta)(1-k_H)}{(1+2\delta - r_D)(1-k_H) + k_H(r_H - r_L)}; \frac{1-k_L}{1-k_H}\right]. \tag{A.5}$$

If the last interval is not empty, it holds that

$$\frac{(1+\delta)(1-k_H)}{(1+2\delta - r_D)(1-k_H) + k_H(r_H - r_L)} \geq \frac{(1+\delta)\Delta k}{(\delta - r_D)(1-k_H) + k_H(r_H - r_L)}$$

and the incentive compatible $(s_A; q)$ are feasible iff

$$1 \geq \gamma \geq \frac{(1+\delta)(1-k_H)}{(1+2\delta - r_D)(1-k_H) + k_H(r_H - r_L)}.$$

However, if the interval in (A.5), it holds that

$$\frac{1-k_L}{1-k_H} \leq \frac{(1+\delta)(1-k_H)}{(1+2\delta - r_D)(1-k_H) + k_H(r_H - r_L)} \leq \frac{(1+\delta)\Delta k}{(\delta - r_D)(1-k_H) + k_H(r_H - r_L)}.$$

and the incentive compatible $(s_A; q)$ are feasible iff

$$1 \geq \gamma \geq \frac{(1+\delta)\Delta k}{(\delta - r_D)(1-k_H) + k_H(r_H - r_L)}.$$

Hence, the incentive compatible $(s_A; q)$ are feasible iff

$$1 \geq \gamma \geq \max\left[\frac{(1+\delta)\Delta k}{(\delta - r_D)(1-k_H) + k_H(r_H - r_L)}; \frac{(1+\delta)(1-k_H)}{(1+2\delta - r_D)(1-k_H) + k_H(r_H - r_L)}\right].$$

Summarizing, the truth-telling equilibria exist iff

$$\begin{cases} 1 \geq \gamma \geq \max\left[\frac{(1+\delta)\Delta k}{(\delta - r_D)(1-k_H) + k_H(r_H - r_L)}; \frac{(1+\delta)(1-k_H)}{(1+2\delta - r_D)(1-k_H) + k_H(r_H - r_L)}; \frac{1}{2}\right] & \text{for } s_A \in [0; k_H] \\ 1 \geq \gamma \geq \max\left[\frac{2(1+\delta) + r_L - r_H - \sqrt{(2(1+\delta) + r_L - r_H)^2 - 4(1+r_D)(1+\delta)}}{2(1+r_D)}; \frac{1}{1+\frac{b}{1+\delta}}\right] & \text{for } s_A \in [k_H; s_{MH}(p_H)] \\ 1 \geq \gamma \geq \max\left[\frac{1+\delta}{1+r_D}\frac{b - (\delta - r_D) + r_H - r_L}{b}; \frac{1}{1+\frac{b}{1+\delta}}\right] & \text{for } s_A \in [s_{MH}(p_H); 1] \text{ and} \\ \delta - r_D - r_H + r_L \geq \frac{\delta - r_D}{1+\delta}(r_H - r_D) & \end{cases}$$

Proof of the Lemma 6 The constraint on q is relevant only for $s_A \in [k_H; s_{MH}(p_H)]$. $\widehat{q}$ is irrelevant for the supervisor if s, for which the IC constraints intersect, is below or at k_H. This is equivalent to

$$1 \geq \gamma \geq \max\left[\frac{(1+\delta)(1-k_H)}{(1+2\delta-r_D)(1-k_H)+k_H(r_H-r_L)}; \frac{1}{2}\right].$$

The first term in the square brackets is higher than 1/2 iff

$$r_H - r_D < b < \min\left[\frac{(1+r_D)^2}{1+r_D+r_H-r_L} + r_H - r_D; 1\right].$$

Proof of Lemma 7 Again I have to deal with three cases.

(i) $s_A \in [k_H; s_{MH}(p_L)]$. Conditions for the pooling equilibrium, i.e. such that both banks report L, are

$$V_H - (\delta - r_D)\Delta k \geq [1-q(1-\gamma)]\, V_H + q(1-\gamma)\left[s(r_H - r_D - p_L(1+\delta)) + p_L(1+\delta) - (\delta - r_D)k_H\right]$$

for the bank H and

$$V_L \geq (1-q\gamma)(b-(1+\delta)k_H) + q\gamma\left[s(r_L - r_D - p_L(1+\delta)) + p_L(1+\delta) - (\delta - r_D)k_H\right]$$

for the bank L, where $p_L = \frac{r_L - \delta}{1+\delta}$. The pooling equilibrium exists iff q and s_A satisfying the above conditions are feasible, which is equivalent to

$$k_H \leq s \leq \min\left[1 - \frac{\Delta k}{r_H - r_D - r_L + \delta}\frac{\delta - r_D}{q(1-\gamma)}; 1 - \frac{\Delta k}{\delta - r_D}\left(\frac{1+\delta}{q\gamma} - (1+r_D)\right); s_{MH}(p_L)\right].$$

The region is not empty if the first two conditions for $q = 1$ are not below k_H. This holds iff

$$\gamma \in \left[\frac{(1+\delta)\Delta k}{(1-k_H)(\delta - r_D) + (1+r_D)\Delta k}; \frac{(1-k_H)(r_H - r_D - r_L + \delta) - (\delta - r_D)\Delta k}{(1-k_H)(r_H - r_D - r_L + \delta)}\right].$$

After some manipulations, the last interval is not empty under (2.8) iff

$$\delta \geq r_D - (r_H - r_L)\left(1 + \frac{\Delta k k_H}{(1-k_H)(1+k_H-2k_L)}\right).$$

(ii) $s \in (s_{MH}(p_L); 1]$. The condition guaranteeing that the bank L reports truthfully is

$$V_L \geq (1-q\gamma)(b-(1+\delta)k_H) + q\gamma\left[sb - (\delta - r_D)k_H\right].$$

As for the case (ii) in the proof of Lemma 5 the conditions for which the banks report L do not cross. The region in which the pooling equilibrium exists is given by the following constraint

$$s_{MH}(p_L) \leq s \leq \min\left[1 - \frac{\Delta k}{r_H - r_D - p_L(1+\delta)}\frac{\delta - r_D}{q(1-\gamma)}; 1 - \frac{(1+\delta)\Delta k}{b\gamma q}\right].$$

Proceeding as above one can show that the region in which the pooling equilibrium exists is not empty iff $r_H < 1 - b + 2r_L$, which is weaker than (2.8). Hence, the pooling equilibrium always exists for $s \in [k_H; 1]$. Analogous proceeding yields the result that for $s \in [0; k_H)$ there is no pooling equilibrium.

Proof of Lemma 8 If $s_A \in [0; k_H]$, then after inserting the IC constraint W_2 is strictly decreasing in q, hence the optimal solution is too set $s_A = k_H$ and

$$q(k_H) = \frac{1}{\gamma} \frac{\Delta k(1+\delta)}{(\delta - r_D) - k_H(\delta - r_D + r_L - r_H)}.$$

One has to note that in this case as the bank L finds it profitable to be downsized, the penalty is to set the highest possible s_A.

If $s_A \in [s_{MH}(p_H); 1]$, after inserting the IC constraint for the bank L into W_2 and rearranging it, it is again strictly decreasing in q. Hence, the solution is again the lowest q and $s_A = s_{MH}(p_H)$. This time the bank L suffers from downsizing, hence the penalty is the lowest possible s_A. The optimal q is

$$q(s_{MH}(p_H)) = \frac{1+\delta}{\gamma(1+r_D)} \frac{b + r_D + r_H - r_L - \delta}{b}.$$

If $s_A \in [k_H; s_{MH}(p_H)]$, after inserting the IC constraint for the bank L into W_2, rearranging it and eliminating terms independent of q W_2 becomes $q\left(\overline{\overline{m}} - m\right)$, where $\overline{\overline{m}} \equiv \frac{\delta - r_D}{\delta - r_D + r_L - r_H}(r_H - r_L)(1-\gamma) > \overline{m}$. Then if $m > \overline{\overline{m}}$, then the supervisor chooses the lowest $q = q(k_H)$ and $s = k_H$. If $m < \overline{\overline{m}}$, the supervisor chooses the highest possible $q = q(s_{MH}(p_H))$ and $s = s_{MH}(p_H)$. Given that for the two extremes cases the solution is the same as for the two cases arising under $s_A \in [k_H; s_{MH}(p_H)]$ and W_2 is continuous at the boundaries $s_A = k_H$ and $s_A = s_{MH}(p_H)$, I obtain the optimal solution stated in Lemma 8.

Proof of Proposition 1 Here I compare the implementation cost of both regimes. These implementation costs amount to the monitoring cost incurred by the supervisor and the cost of penalty imposed in the bank H. The implementation costs of both regimes are

$$C_r = \begin{cases} \frac{1}{\gamma} \frac{\Delta k(1+\delta)}{\Delta k(1+\delta) + (\delta - r_D)(1-k_L)} \left[m + (1-\gamma)(1-k_H)(\delta - r_D)\right] & \text{if } m \geq \overline{m} \\ m + (1-\gamma)\Delta k \left(\frac{1+\delta}{\gamma} - (1+r_D)\right) & \text{if } m < \overline{m} \end{cases}$$

for recapitalization and for downsizing

$$C_s = \begin{cases} \frac{1}{\gamma} \frac{\Delta k(1+\delta)}{(\delta - r_D) - k_H(\delta - r_D + r_L - r_H)} \left[m + (1-\gamma)(1-k_H)(\delta - r_D)\right] & \text{if } m \geq \overline{\overline{m}} \\ \frac{1+\delta}{\gamma(1+r_D)} \frac{b + r_D + r_H - r_L - \delta}{b} \left[m + (1-\gamma)\frac{r_H - r_L}{b + r_D + r_H - r_L - \delta}(\delta - r_D)\right] & \text{if } m < \overline{\overline{m}}. \end{cases}$$

The comparison of C_r and C_s has to be done for three intervals. The first one is for $m \geq \overline{\overline{m}}$. Here it is sufficient to compare the optimal probabilities of inspection. It turns out that $q_s > q_r \Leftrightarrow 1 > k_H$, hence recapitalization is better. Now I turn to the third interval, $m \in [0; \overline{m})$. Downsizing yields higher welfare for

$$m > \overline{m} \frac{b(\gamma(1+r_D) - (1+\delta)) + (\delta - r_D)(1+\delta)}{b(\gamma(1+r_D) - (1+\delta)) + (\delta - r_D)(1+\delta) - (r_H - r_L)(1+\delta)} > \overline{m}.$$

Hence, recapitalization delivers higher welfare in this interval too. Now the second interval $m \in [\overline{m}; \overline{\overline{m}})$. I rewrite C_r and C_s as functions of m:

$$C_r(m) = \frac{(1+\delta)\Delta k(1-\gamma)}{\gamma} + q\left(m - \overline{m}\right)$$

and

$$C_s(m) = \frac{(1+\delta)\Delta k(1-\gamma)}{\gamma} \frac{\delta - r_D}{\delta - r_D + r_L - r_H} + q\left(m - \overline{\overline{m}}\right).$$

First, it holds that in both cases these functions are continuous at $m = \overline{m}$ and $m = \overline{\overline{m}}$. Second, it holds for the optimal q that

$$1 > q(s_{MH}(p_H)) > q(k_H) > \frac{1}{\gamma} \frac{\Delta k(1+\delta)}{\Delta k(1+\delta) + (\delta - r_D)(1-k_L)},$$

meaning that the slope of $C_s(m)$ is higher than of $C_r(m)$ for $m > \overline{m}$. These two facts together with the fact that in the first and third interval recapitalization has lower cost, leads to the conclusion that recapitalization always delivers higher welfare.

Proof of Proposition 2 When $m > \overline{m}$, rearranging $\Delta W_1 \geq 0$ after plugging q_1 and x_1 yields

$$\gamma \geq \frac{(1+\delta)\left((\delta - r_D)(1-k_H) + m\right)}{(\delta - r_D)[(1+\delta)(1-k_H) + \Delta k(1+\delta) + (\delta - r_D)(1-k_L)]}. \tag{A.6}$$

The term on the right hand side builds the upper part of the function separating the dominance regions, $\gamma_1(\delta)$. Deriving this term with respect to δ delivers

$$-\frac{\left[\begin{array}{c} m\left[(1+r_D)(\Delta k + (1+2\delta)(1-k_H) - r_D(1-k_L) + 2(1+\delta)(\delta - r_D)(1-k_H)\right] + \\ (\delta - r_D)^2(1+r_D)(1-k_L)(1-k_H) \end{array}\right]}{\left[(\delta - r_D)[(1+\delta)(1-k_H) + \Delta k(1+\delta) + (\delta - r_D)(1-k_L)]\right]^2} < 0,$$

proving that the upper part of $\gamma_1(\delta)$ is decreasing in δ. For sufficiently low m the function implied by (A.6) may intersect with the first lower bound from (A.1), meaning that this bound becomes a part of $\gamma_1(\delta)$. This bound is also strictly decreasing in δ, as its derivative with respect to δ is

$$-(1+r_D)\Delta k(1-k_L)\left[\Delta k(1+\delta) + (\delta - r_D)(1-k_L)\right]^{-2} < 0.$$

If $m < \overline{m}$, the condition for $\Delta W_1 \geq 0$ is

$$\delta \geq \frac{\gamma^2(1+r_D)}{2\gamma - 1} - 1 + \frac{\gamma}{2\gamma - 1}\frac{m}{\Delta k}. \tag{A.7}$$

The last expression defines implicitly the lower part of $\gamma_1(\delta)$. The derivative of the right hand side term of the last expression with respect to γ is negative for $\gamma \in (1/2; 1)$:

$$\frac{\partial \delta}{\partial \gamma} = -\left(2\gamma - 1\right)^{-2}\left[6\left(1-\gamma\right)\gamma + \frac{2m}{\Delta k} + 2\gamma(1-\gamma)r_D\right] < 0.$$

Because the right hand side term is invertible for positive δ and $\gamma \in (1/2; 1)$, the lower part of $\gamma_1(\delta)$ is also decreasing. The function implied by (A.7) lies above of the second lower bound from (A.1) (rearranging the latter delivers $\delta \geq \frac{\gamma^2(1+r_D)}{2\gamma-1} - 1$). One has to keep in mind that for $m < \overline{m}$ the function implied by (A.2) has no bite, because for $m < \overline{m}$ the optimal q_1 is 1.

Rearranging (A.6) and (A.7) for $\gamma = 1 - \frac{m}{r_H - r_L}$ shows that they both intersect exactly at $\gamma = 1 - \frac{m}{r_H - r_L}$ (the line $\gamma(\overline{m})$). The function $\gamma_1(\delta)$ after solving for (A.7) is

$$\gamma_1(\delta) = \begin{cases} \max\left[\frac{\Delta k(1+\delta)}{\Delta k(1+\delta)+(\delta-r_D)(1-k_L)}; \frac{(1+\delta)((\delta-r_D)(1-k_H)+m)}{(\delta-r_D)[(1+\delta)(1-k_H)+\Delta k(1+\delta)+(\delta-r_D)(1-k_L)]}\right] & \text{for } m > \overline{m} \\ \frac{1+\delta}{1+r_D} - \frac{m}{2(1+r_D)\Delta k} - \sqrt{\frac{1+\delta}{1+r_D}\left(\frac{1+\delta}{1+r_D} - 1\right) - \frac{\frac{m}{\Delta k}\left(\frac{m}{\Delta k} - 4(1+\delta)\right)}{4(1+r_D)^2}} & \text{for } m \leq \overline{m}, \end{cases}$$

where the last expression is the smaller solution of the quadratic inequality implied by (A.7). The other solution of this inequality is always higher than 1 for $m < \overline{m}$.

Proof of Proposition 3 After inserting q_3 in ΔW_3 the condition for ΔW_3 to be not bigger than 0 is as follows:

$$\gamma \geq \frac{[m+S+\Delta k(\delta-r_D)](1+\delta)}{(r_H-r_D-(\delta-r_D)k_H)(\delta-r_D)+[S+\Delta k(\delta-r_D)](1+\delta)} \equiv \gamma_2(\delta).$$

The derivative of $\gamma_2(\delta)$ has ambiguous sign and reads

$$\begin{aligned}\frac{\partial\gamma_2(\delta)}{\partial\delta} &= \left[(r_H-r_D-(\delta-r_D)k_H)(\delta-r_D)+[S+\Delta k(\delta-r_D)](1+\delta)\right]^{-2}(1+r_D) \\ &\left[\begin{array}{c} b(r_H-r_L)(\delta-r_D)^2 \\ -S\left[(r_H-r_D)(1+\delta)^2-b(\delta-r_D)(2+\delta-r_D)\right] \\ -m\left[(2r_H-r_D-r_L)(1+\delta)^2-b(\delta-r_D)(2+\delta-r_D)\right]\end{array}\right].\end{aligned}$$

The nominator of this derivative defines a second order polynom of δ. For δ close to r_D the nominator is negative implying that for small δ the function $\gamma_2(\delta)$ is strictly decreasing for $S>0$ and $m>0$. It is possible that if S and m are sufficiently small, then the sign of the derivative will turn to positive, implying that $\gamma_2(\delta)$ starts to increase for some δ sufficiently far away from r_D. Moreover, as in the case of recapitalization the part or even the whole $\gamma_2(\delta)$ can be given by (2.11). This could happen if m and S are sufficiently low, meaning that the expected cost of inspection and closure is negligible, which in the light of $q_3 \leq 1$ means the that insensitive capital requirements deliver lower welfare. In such a case only (2.11) is the relevant condition.

Proof of Proposition 4 For $m > \overline{m}$ the derivative of $\overline{S}(\delta)$ with respect to δ is quite a complicated object. However it can be shown that it has following properties. Its nominator is a quadratic function of δ with a negative term at δ^2. Its maximum is a linear and decreasing function in the parameter m and evaluated at $m=\overline{m}$ it is 0. Then because for any $m>\overline{m}$ the maximum is negative the sign of the nominator is always negative, hence $\overline{S}(\delta)$ is decreasing in δ. For $m \in (0;\overline{m}]$ the matters are more complicated. Again one can analyze the sign of the nominator of the derivative. It turns out that its maximum (-1) is lower than $\delta = r_D$. Hence one can look at the sing of the derivative at this point. It turns out that for m close to $\overline{m}$ it is negative, so $\overline{S}(\delta)$ is decreasing in δ. However, at $m=0$ the nominator is equal to

$$-\Delta k(1+r_D)\left[b(1-\gamma)-(r_L-r_D)\right],$$

whose sign is not clear cut. This means that $\overline{S}(\delta)$ may have an inverted U-shape.

Proof of Proposition 5 There are several observations to make in order to simplify the problem. First, the moral hazard constraint for the bank L binds, because then the truthtelling constraint for this bank is relaxed and the credit supply is maximized. In what follows I use $\overline{I_i} \equiv \frac{A}{b-r_i}$. Second, the balance sheet constraints bind yielding $D_i = I_i - A$. Third, the worst case is when the capital requirements are insensitive, what imposes a lower bound on the size of the bank H, i.e. $I_H \geq \overline{I_L}$. Fourth, there is no moral hazard after equity injection r, once the truthtelling constraint for the bank L holds. This is the same result as at the beginning of Section 2.3. The bank L engages in moral hazard after equity injection when

$$(1+r_L)I_H - D_H + r < bI_H \text{ or } r < (b-r_L)(I_H - I_L).$$

Then the truthtelling constraint for such a bank reads

$$r \geq \frac{b(I_H - I_L)}{q\gamma(1+\delta)}.$$

It is easy to show that under $\delta < r_L$ the RHS of the last expression is always higher than the RHS of the previous one for any q. Fifth, the truthtelling constraint for the bank L binds at optimum as any increase in I_H, r and q that makes it slack leads to a decrease in social welfare.[3] Moreover, I will assume that γ is so high that the truthtelling constraint for the bank H can be ignored.

After using the above observations and ignoring constants in the objective functions, the program becomes:

$$\max_{I_H,r,q}\left(r_H-\frac{1-\gamma}{\gamma}b\right)I_H+q\left[(1-\gamma)(b-r_L)(I_H-\overline{I_L})-m\right]$$

s.t.

$$\overline{I_H}\geq I_H\geq\overline{I_L},\ \frac{1}{\gamma}\frac{b(I_H-\overline{I_L})}{\delta d+(b-r_L)(I_H-\overline{I_L})}\leq q\leq 1,$$

where the second constraint emerges after inserting the truthtelling constraint for the bank L into the constraint for the upper bound on r .

There are two cases to analyze.

First, if $d\geq\left[\frac{b}{\gamma}-(b-r_L)\right]\frac{r_H-r_L}{(b-r_L)(b-r_H)}\frac{A}{\delta}$, then for $I_H=\overline{I_H}$ it holds that

$$\frac{1}{\gamma}\frac{b(I_H-\overline{I_L})}{\delta d+(b-r_L)(I_H-\overline{I_L})}\leq 1$$

for every I_H. It is easy to show that for this case there are only three solutions possible from which one has to choose the one that yields the highest social welfare. There are two solutions for $I_H=\overline{I_H}$ depending on the sign $\left[(1-\gamma)(b-r_L)(\overline{I_H}-\overline{I_L})-m\right]$. If the sign is positive (negative) it holds that $q=1$ ($q=\frac{1}{\gamma}\frac{b(\overline{I_H}-\overline{I_L})}{\delta d+(b-r_L)(\overline{I_H}-\overline{I_L})}=q^*$). The third solution is $I_H=\overline{I_L}$ and $q=0$.

It remains to show that there is no interior solution for I_H. Assume that such a solution exists. It can only exist when $q=\frac{1}{\gamma}\frac{b(I_H-\overline{I_L})}{\delta d+(b-r_L)(I_H-\overline{I_L})}$. If $q=1$ it would be better to increase I_H to $\overline{I_H}$. An interior solution for q does not exist either as the objective function is linear in q. However, if one explores the function which emerges after inserting $q=\frac{1}{\gamma}\frac{b(I_H-\overline{I_L})}{\delta d+(b-r_L)(I_H-\overline{I_L})}$ into the objective function, it turns out that it is a parabola of the following form

$$r_H\gamma(b-r_L)I_H^2+\left[-bm-A(b(1-\gamma)+r_H\gamma)+\delta d(-b(1-\gamma)+r_H\gamma)\right]I_H+bI_L\left[m+A(1-\gamma)\right].$$

Given that this function has a positive parameter at I_H^2 it means that its maxima are at corners of the interval $\left[\overline{I_L};\overline{I_H}\right]$. Hence, there is no interior solution for I_H .

The comparison of the objective function at these three solutions delivers the following outcome. For

$$m>\frac{r_H-r_L}{(b-r_L)(b-r_H)}\frac{A}{\delta}\left((1-\gamma)(b-r_L)+\max\left[\frac{r_H-\frac{1-\gamma}{\gamma}b}{q^*};r_H-\frac{1-\gamma}{\gamma}b\right]\right)$$

the insensitive capital requirements deliver the highest social welfare. The precise solution depends on the sign of the term $r_H-\frac{1-\gamma}{\gamma}b$. If this term is negative, i.e. $\gamma<\frac{b}{b+r_H}$, then the solution with $I_H=\overline{I_L}$ and $q=q^*$ always yields lower social welfare than the other two solutions.

[3] The truthtelling constraint for the bank L becomes

$$r\geq\frac{I_H-\overline{I_L}}{\gamma\delta}\left(\frac{b}{q}-\gamma(b-r_L)\right).$$

Second, if $d < \left[\frac{b}{\gamma} - (b - r_L)\right] \frac{r_H - r_L}{(b-r_L)(b-r_H)} \frac{A}{\delta}$, there are only two solutions. $I_H = \overline{I_H}$ cannot be achieved any more. Hence, it is either $I_H = \overline{I_L}$ and $q = 0$, or $q = 1$ and I_H is given by $\frac{1}{\gamma} \frac{b(I_H - \overline{I_L})}{\delta d + (b-r_L)(I_H - \overline{I_L})} = 1$. The comparison of these two solutions delivers that the insensitive capital requirements are better in welfare terms for

$$m > \left(\frac{\gamma r_H}{b(1-\gamma) + \gamma r_L} - (1-\gamma) \right) \delta d.$$

Model with outside investors from Section 2.7.4 The basic model is modified as follows: In addition to the capital that the bank has, A, it is allowed issue uninsured outside financing, D, to boost the amount of lending.[4] The outside investors do not have the possibility to recognize the type of the bank and have to rely on the supervisor in using his power to inspect, recognize the type and punish the undercapitalized bank. There are two types of banks as in the previous case. L is more riskier than H with the following return structure:

$$\begin{cases} R, & \text{with prob. } p_i \\ 0, & \text{with prob. } 1 - p_i \end{cases} \quad \text{and } p_H > p_L.$$

If the supervisor is able to make the banks reveal the true risk, the solution to the model, i.e. the rate of return and the amount of outside financing, is such as if the investors knew the type of the bank (moral hazard is still present). The solution is as follows. Moral hazard puts a upper level on the bank's balance sheet

$$p_i(RI - R_D D) \geq bI \text{ and } L = A + D$$

and is value-destroying leaving nothing for the outside investors once the bank takes private benefits

$$p_i R > 1 > b.$$

The outside investors are competitive and require rate of return equal to 0. They provide funding only if the bank does not take private benefits. The bank maximizing its payoff will take so much outside financing that the moral hazard and participation constraint of the outside investors bind at optimum. The solution yields that

$$R_{D,i} = \frac{1}{p_i},\ D_i = \frac{p_i R - b}{1 - (p_i R - b)} A \text{ and } I_i = \frac{1}{1 - (p_i R - b)} A.$$

Hence the capital requirements imposed by the market are interesting, if $p_H R - b < 1$. It holds that $D_H > D_L$, which means that when the investors recognize the types they will provide more financing for the good types.

Now, I analyze the decision of the supervisor to enforce the truthtelling. For simplicity I assume that the supervisor closes the undercapitalized bank and commits to the supervisory scheme, where q is the probability of inspection. The bank L report true risk if the expected payoff from misreporting is lower than truthtelling. Hence, the incentive compatibility constraint is

$$p_L(RI_L - R_{D,L} D_L) \geq (1 - q\gamma) b I_H$$

or

$$q \geq \frac{1}{\gamma} \frac{R \Delta p}{1 - (p_L R - b)}$$

[4] For simplicity insured deposits are disregarded.

If $\gamma = 1$, the right hand side is always lower than 1, which means that with the sufficiently high probability of inspection the supervisor will always be able to enforce the risk-sensitive capital requirements.

However, if the right hand side is higher than 1 the bank L always finds profitable to misreport. In such a case the investors disregard information provided by the banks and provide the funding to both types of banks that corresponds to the highest risk:

$$R_{D,H} = R_{D,L} = \frac{1}{p_L}, D_H = D_L = \frac{p_L R - b}{1-(p_L R - b)} A.$$

The right hand side of the previous expression may be higher than 1 for sufficiently low γ, b and p_L, as well as for sufficiently high p_H and R. Hence if γ is low, meaning that the quality of supervisor inspection is low, the investors disregard information from the banks and will require high rate of return and provide low amount of financing from all banks. Such a behavior results in a low credit expansion.

i can be treated as a point-in-time ranking, i.e. the current risk of loan portfolio. If the supervisor allows that banks to average out the risk of loans across the cycle in order to boost the credit supply, the bank L could report more favorable information (if its loans had lower risk in a previous period). In a model with continuous types of risks, the outside investors worried about the probability of default will not accept such a modified information and will judge the banks by the worst current i, as they will not be able to distinguish between the banks on their own. Hence, an attempt to boost credit supply by making capital requirements less sensitive to i will fail.

Proof of Lemma 10 The program can be rewritten as

$$\min_{(q,x,f)} qm + q(1-\gamma)((\delta - r_D)x + \delta f)$$

s.t.:

$$IC_{ML}\colon\ x \geq \Delta k$$
$$IC_{TT}\colon\ q\gamma\left[(\delta - r_D)x + (1+\delta)f + (1+r_D)\Delta k\right] \geq \Delta k(1+\delta)$$
$$IR\colon\ (\delta - r_D)x + (1+\delta)f \leq r_L - r_D - (\delta - r_D)k_H$$
$$0 \leq q \leq 1$$

The truth-telling constraint, IC_{TT}, is binding, because otherwise any decrease in q, x or f is still incentive compatible and increases the implementation cost. Hence, I can solve IC_{TT} for f and plug it into objective function and the participation constraint. Then the program becomes:

$$\min_{(q,x)} q\left[m + (1-\gamma)\left(\frac{\delta - r_D}{1+\delta}x - \frac{\delta(1+r_D)}{1+\delta}\Delta k\right)\right] + \frac{\delta \Delta k(1-\gamma)}{\gamma}$$

s.t.:

$$x \geq \Delta k \text{ and } \frac{1}{\gamma}\frac{\Delta k(1+\delta)}{r_H - r_D - (\delta - r_D)k_H} \leq q \leq 1.$$

At an optimum, q and the term in the square brackets in the objective function are the smallest. There are two solutions, because the term in the square brackets can be negative or positive for $x = \Delta k$. If it is positive, q has to be the smallest and the solution is $x = \Delta k$, $q = \frac{1}{\gamma}\frac{\Delta k(1+\delta)}{r_H - r_D - (\delta - r_D)k_H}$ and f such that IC for truth-telling holds with equality for these x and q. If it is negative, the optimal solution delivers $q = 1$, $x = \Delta k$ and f such that IC for truth-telling holds with equality for these x and q. The former solution occurs for $m \geq (1-\gamma)r_D \Delta k$.

Appendix B

Appendix to Chapter 3

Proof of Proposition 1 Let $\Delta(l,d,\theta) = U_r(l,d,\theta) - U_n(\theta)$ denote the difference in utility from repaying the loan or not:

$$\Delta(l,d,\theta) = \begin{cases} u(\alpha - l - s) + \delta u(\theta + s(1+d)) - u(1+\alpha) - \delta u(\theta) \text{ for } \theta \in [\underline{\theta}, \theta_s] \\ \\ u(\alpha - l) - u(1+\alpha) \text{ for } \theta \in (\theta_s, \overline{\theta}]. \end{cases}$$

where $s = s(l,d,\theta)$ are the optimal savings of individuals. Observe that Δ is continuous in θ, by the continuity of $u(c)$.

Moreover $\Delta(l,d,\theta)$ is strictly decreasing for all $\theta \in [\underline{\theta}, \theta_s)$. Differentiating $\Delta(l,d,\theta)$ and using the envelope theorem, together with the fact that optimal savings in the range $[\underline{\theta}, \theta_s)$ are positive and $u''(c) < 0$, we obtain

$$\frac{\partial \Delta(l,d,\theta)}{\partial \theta} = \delta \left[u'(\theta + s(1+d)) - u'(\theta)\right] < 0.$$

Finally, $\Delta(l,d,\theta)$ is positive for θ near $\underline{\theta}$ as $\lim_{\theta \to \underline{\theta}} \Delta(l,d,\theta) = +\infty$ by $u(\underline{\theta}) = -\infty$, and it is clearly negative for $\theta \in (\theta_s, \overline{\theta}]$. From the monotonicity of $\Delta(l,d,\theta)$ and its values on $\underline{\theta}$ and θ_s, we conclude that there exists a threshold $\widehat{\theta}(l,d)$, such that $\Delta(l,d,\theta) > 0$ when $\theta < \widehat{\theta}(l,d)$, which means that borrowers with $\theta < \widehat{\theta}(l,d)$ repay the loan. On the other hand, for individuals with $\theta > \widehat{\theta}(l,d)$ it is satisfied that $\Delta(l,d,\theta) < 0$, which means that borrowers with $\theta > \widehat{\theta}(l,d)$ default on their loan.

The second result follows from the above proof as if $\Delta(l,d,\theta)$ is strictly decreasing on $[\underline{\theta}, \theta_s)$ and $\Delta(l,d,\theta)$ is negative for θ_s then it must be that $\widehat{\theta}(l,d) < \theta_s$.

Proof of Lemma 1 The threshold $\widehat{\theta}(l,d)$ is implicitly defined by the equation

$$u(\alpha - l - s) + \delta u(\widehat{\theta} + s(1+d)) = u(1+\alpha) + \delta u(\widehat{\theta}).$$

Decreasing (increasing) the loan (deposit) rate increases the left hand side of the equation without any effect on the right hand side. Hence the previously indifferent individual is now better off by not defaulting on the loan.

Proof of Proposition 4 Those individuals for whom their θ comes from F_1 have worse outside options on average than those whose θ comes from F_2. Using Proposition 1, we can show that for a given l and d the repayment rate is higher for individuals under F_1 than for those under F_2, i.e. $F_1(\widehat{\theta}(l,d)) > F_2(\widehat{\theta}(l,d))$.

Definitions of Variables

Default: is a dummy variable that takes the value 1 if the loan is not repaid 3 months after its due date

Female: is a dummy variable that takes the value 1 when the borrower is a woman.

Income: is the income of the borrower which he obtained in the last 12 months. Income is the sum of income from all the sources given in the data (self employment, dependent employment, obtained financial help and pensions).

Income others: is the sum of the income obtained by the other people in the borrower's household.

Savings: are the savings the borrower reported.

Average wage (female/male): is the average wage in non agricultural activities in the village of the borrower by gender.

Dependency ratio: is the ratio of the number of individuals not obtaining any income to those obtaining in the household.

Age: is the borrower's age when he was granted the loan.

Education: is a dummy variable taking the value 1 when the borrower reports positive number of years of attending the school or taking part in educational activities offered by e.g. NGOs. We use the dummy because these other education activities cannot be coded as a concrete number of education years.

Microfinance group: is a dummy variable taking value 1 if the loan comes from one of the microfinance institutions reported in the sample.

NGO group: is a dummy variable taking value 1 if the loan comes from one of the non governmental organizations reported in the sample.

Relatives group: is a dummy variable taking value 1 if the loan comes from one of the relatives.

Banks: *is a* dummy variable taking value 1 if the loan comes from one of the commercial banks reported in the sample.

Bank availability: is a dummy variable taking the value 1 if someone in the village accessed commercial banking services

Model with competing alternative savings

This section analyses the individuals decision in a context in which the individual has the opportunity of accessing a savings technology different for that of the monopolistic bank of our main section.

In this section the individual has the opportunity of accessing a savings technology different from that of the monopolistic bank. With this savings technology the individual receives $1 + r$ for every unit of savings. We assume that the realization of this opportunity of savings is not observable by the original bank. If not the original bank would offer different deposit and loan rates to those individuals which have the opportunity to save.

Hence the decision of defaulting on the loan granted by the original bank, following the same intuition as in the main section, can be characterized as

$$u(\alpha - l - s_o) + u(\theta + s_o(1 + d)) - [u(1 + \alpha - s_z) + u(\theta + s_z(1 + r))] < 0$$

wheres_o are the optimal savings of the individual in the monopolistic bank ands_z are the savings under the new alternative.

The threshold for the individual that defaults is defined as$\tilde{\theta}$. Where$\tilde{\theta}$ is such that

$$u(\alpha - l - s_o) + u(\theta + s_o(1 + d)) = u(1 + \alpha - s_z) + u(\theta + s_z(1 + r)).$$

Hence, in a model with alternative savings technologies the fraction of individuals that do not default will be$F(\tilde{\theta})$.

Recall that$\hat{\theta}$ is the threshold of default for those individuals that do not have an alternative savings technology. It can be proved that$F(\tilde{\theta}) \leq F(\hat{\theta})$, so when a profitable source of savings is included the default rate of the monopolistic bank increases. This is because individuals can default on the monopolistic bank and deposit their savings in the other savings technology.

Lemma When an alternative savings technology is introduced the default rate of the monopolistic bank (weakly) increases.

Proof When $r \geq d$, or in other words, when the alternative technology offers the same or higher deposit rate as the monopolistic bank, then the default rate of the economy increases. More precisely in our setup the default rate goes to 1, which would in equilibrium mean that no bank would grant loans to the individuals in the first period.

It is direct to show that, when $r \geq d$, then

$$u(\alpha - l - s_o) + u(\theta + s_o(1 + d)) < u(1 + \alpha - s_z) + u(\theta + s_z(1 + r)).$$

When$s_z = s_o$ then$u(\theta + s_o(1+d)) \leq u(\theta + s_z(1+r))$ and$u(\alpha - l - s_o) < u(1+\alpha - s_z)$. Therefore the above inequality holds. The individual can always have the same income when old and increase his income when young by defaulting. Hence, the individual is better off defaulting on the loan of the monopolistic bank and saving in the alternative technology independently of its outside optionθ.

When$r < d$ the default rate of the economy may not increase. But it will never decrease as the individuals can always choose not to save through the new savings mechanism and then he would in fact react as if the new savings mechanism was not present. The default rate increases if the individual previously indifferent in defaulting now prefers to default. This happens when the following condition holds

$$u(\alpha - l - s_o) + u(\hat{\theta} + s_o(1 + d)) < u(1 + \alpha - s_z) + u(\hat{\theta} + s_z(1 + r)) \tag{B.1}$$

When $r < d$ this condition (B.1) may not hold. If the alternative strategy offers a low savings rate then individuals with$\hat{\theta}$ may continue to find it profitable to repay and save with better deposit rates than to default and use the new savings mechanism. Condition (B.1) holds whenever$s_z(l, r, \hat{\theta}) = 0$, that is when individuals with$\hat{\theta}$ do not find it profitable so save under the alternative technology. When$s_z(l, r, \hat{\theta}) = 0$ then by definition it is satisfied that$u(1 + \alpha - s_z) + u(\hat{\theta} + s_z(1 + r)) = u(1 + \alpha) + u(\hat{\theta})$, which recall defined$\hat{\theta}$ in the first place. On the other hand if$s_z(l, r, \hat{\theta}) > 0$ then it is satisfied that$u(1 + \alpha - s_z) + u(\hat{\theta} + s_z(1 + r)) > u(1 + \alpha) + u(\hat{\theta})$. In this case the individual with$\hat{\theta}$ is better off by defaulting and therefore the default rate of the economy increases. In such case the indifferent individual will be defined by$\tilde{\theta}$ such that

$$u(\alpha - l - s_o) + u(\tilde{\theta} + s_o(1 + d)) = u(1 + \alpha - s_z) + u(\tilde{\theta} + s_z(1 + r)),$$

where $\tilde{\theta} < \hat{\theta}$.

Table 1. Descriptive statistics of the variables

This table shows the descriptive statistics of the variables that are going to be used in our future analysis. The descriptive statistics are shown for those observations in which a loan was taken. It must be taken into account that for some of our analysis some variables are constructed using information of observations in which no loan was taken. Examples of this are the average wage of female and male individuals.

Variable	Mean	Std deviation	Min	Max	Observations
Default	0.120	0.325	0	1	6385
Female	0.748	0.434	0	1	6385
Dowry	0.161	0.391	0	5	5421
Average wage female	27.652	10.470	6	60	2188
Average wage male	76.464	26.454	35	150	1484
Age	37.766	11.151	5	85	6385
Education	0.349	0.476	0	1	6385
Income	0.086	0.268	-0.278	3.995	6385
Income others	0.411	0.633	-0.317	14.103	6385
Dependency ratio	2.482	1.779	0	12	6285
Microfinance group	0.521	0.499	0	1	6385
NGO group	0.077	0.268	0	1	6385
Relatives group	0.357	0.479	0	1	6385
Commercial lender group	0.038	0.192	0	1	6385
Cooperatives of credit	0.004	0.063	0	1	6385
Bank availability	0.488	0.499	0	1	21643
Savings	0.027	0.045	0	0.855	6385

Table 2. Logit regressions of default

This table presents logit regressions with robust standard errors of the dichotomic variable Default on the reported variables. For an explanation of the construction of the variables please refer to Appendix A. For those regressions in which controls other than Female and Age are included the sample is restricted to those loans that were undertook from 1997 onwards as the control variables were not available for previous dates. We report robust standard errors in parentheses with *** ,**, * representing coefficients significant at the 1%, 5% and 10% level, respectively.

Variable	(1)	(2)	(3)	(4)
Female	-1.543***	-1.555***	-0.704*	-0.973*
	(0.0797)	(0.132)	(0.377)	(0.568)
Average female wage			0.0110*	0.0304***
			(0.00564)	(0.00910)
Average male wage			0.0157***	0.0215***
			(0.00420)	(0.00617)
Age		0.0244***		0.0247***
		(0.00440)		(0.00733)
Income		-0.119		-0.198
		(0.165)		(0.240)
Income others		-0.100		0.0332
		(0.121)		(0.162)
Dependency ratio		0.110***		0.120***
		(0.0295)		(0.0390)
Number of children		-0.00541		-0.0769**
		(0.0220)		(0.0313)
Education		0.185*		-0.0463
		(0.108)		(0.174)
Constant	-1.020***	-2.398***	-2.103***	-3.698***
	(0.0565)	(0.262)	(0.332)	(0.571)
Observations	6385	3790	2828	1654
Pseudo R^2	0.0792	0.125	0.0903	0.164

Table 3. Regressions using dowry as a proxy of the outside option

This table presents logit regressions with robust standard errors of the dichotomic variable Default on the reported variables. This table shows the positive correlation between the variable Dowry and Default. For an explanation of the construction of the variables please refer to Appendix A. For those regressions in which controls other than Female and Age are included the sample is restricted to those loans that were undertook from 1997 onwards as the control variables were not available for previous dates. Column (3) reports the estimates of an instrumental probit regression where Income is instrumented by Dowry. We report robust standard errors in parentheses with *** ,**, * representing coefficients significant at the 1%, 5% and 10% level, respectively.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Female	-1.565***	-1.617***	-0.064	-1.837***	-1.618***	-0.970
	(0.0900)	(0.156)	(0.383)	(0.280)	(0.156)	(0.605)
Dowry	0.345***	0.367***		0.425***	0.317**	0.223
	(0.0915)	(0.118)		(0.146)	(0.130)	(0.151)
Average male wage						0.0294***
						(0.0105)
Average female wage						0.0222***
						(0.00647)
Age		0.0124	-0.0038	0.00845	0.0131	-0.00291
		(0.00879)	(0.00523)	(0.0169)	(0.00887)	(0.0144)
Income		-0.129	1.949***	-1.303***	-0.135	-0.107
		(0.187)	(0.760)	(0.322)	(0.188)	(0.239)
Income others		-0.292*		-1.146***	-0.287	-0.344
		(0.174)		(0.406)	(0.175)	(0.261)
Dependency ratio		0.0144	0.036	0.0118	0.0164	-0.0116
		(0.0356)	(0.0171)	(0.0656)	(0.0356)	(0.0577)
Number of children		0.0837**	0.0521***	0.143**	0.0843***	0.0359
		(0.0327)	(0.0163)	(0.0694)	(0.0326)	(0.0460)
Education		0.238**	0.0141	0.280	0.251**	0.0190
		(0.117)	(0.0603)	(0.196)	(0.118)	(0.189)
Dummy Dowry					0.114	
					(0.144)	
Constant	-1.160***	-2.057***	-1.431***	-1.519***	-2.135***	-2.769***
	(0.0670)	(0.348)	(0.190)	(0.586)	(0.364)	(0.702)
Observations	5421	3221	3790	1186	3221	1401
Pseudo R^2	0.0859	0.120	0.125	0.142	0.121	0.138

Table 4. Means of the variables depending on the lender type

This table presents the means of Default Female Dowry Average wage female (awagef) and average wage male (awagem) depending on the source of the loan. We report the ttest of the difference in means when the source of the loan is a microfinance institution or not.

Group	Default	Female	Dowry	Awagef	Awagem
Non microfinance	0.25	0.48	0.22	27.65	73.54
Microfinance institution	0.07	0.83	0.14	27.64	79.01
t-statistic	15.16	-25.75	5.57	0.03	-4.46

Table 5. Regressions controlling for different sources of credit

This table presents logit regressions with robust standard errors of the dichotomic variable Default on the reported variables. For an explanation of the construction of the variables refer to Appendix A. We report robust standard errors in parentheses with *** ,**, * representing coefficients significant at the 1%, 5% and 10% level, respectively.

Variable	(1)	(2)	(3)	(4)
Female	-0.218	-0.492**	-0.0281	-0.404
	(0.181)	(0.204)	(0.679)	(0.687)
Dowry		0.297**		0.248
		(0.141)		(0.177)
Average wage female			0.0304***	0.0308***
			(0.00941)	(0.0108)
Average wage male			0.0196***	0.0190***
			(0.00715)	(0.00695)
Age	0.0139***	-0.000291	0.00871	-0.0247
	(0.00467)	(0.00945)	(0.00873)	(0.0163)
Income	0.00445	-0.0394	-0.295	-0.271
	(0.160)	(0.178)	(0.225)	(0.236)
Income others	-0.0465	-0.210	0.0964	-0.107
	(0.0960)	(0.163)	(0.133)	(0.240)
Dependency ratio	0.0917***	-0.000474	0.0479	-0.0824
	(0.0296)	(0.0377)	(0.0421)	(0.0590)
Number of children	-0.00180	0.0913**	-0.0549	0.0836
	(0.0228)	(0.0368)	(0.0352)	(0.0530)
Education	-0.0227	0.0405	-0.256	-0.142
	(0.118)	(0.129)	(0.189)	(0.207)
microfinance	-2.004***	-1.211**	-1.941***	-1.379
	(0.375)	(0.515)	(0.540)	(0.869)
NGO	-2.291***	-1.615***	-2.297***	-1.720*
	(0.434)	(0.567)	(0.635)	(0.947)
Relatives	0.537	1.057**	0.619	1.021
	(0.367)	(0.511)	(0.500)	(0.844)
Banks	0.0649	0.612	0.0737	0.569
	(0.377)	(0.521)	(0.510)	(0.852)
Constant	-1.435***	-1.582**	-2.109***	-1.439
	(0.451)	(0.616)	(0.801)	(1.100)
Observations	3790	3221	1654	1401
PseudoR^2	0.228	0.204	0.259	0.228

Table 6. Logit regressions of default for Grameen Bank borrowers

This table presents logit regressions with robust standard errors of the dichotomic variable Default on the reported variables only for borrowers of the Grameen Bank. For an explanation of the construction of the variables please refer to Appendix A. For those regressions in which controls other than Female and Age are included the sample is restricted to those loans that were undertook from 1997 onwards as the control variables were not available for previous dates. We report robust standard errors in parentheses with *** ,**, * representing coefficients significant at the 1%, 5% and 10% level, respectively.

Variable	(1)	(2)	(3)
Female	-0.554*	-1.016***	-1.074***
	(0.289)	(0.320)	(0.316)
Dowry		0.663**	0.625**
		(0.303)	(0.303)
Loan amount			-0.192***
			(0.0594)
Age	-0.0102	-0.0288	-0.0126
	(0.0109)	(0.0186)	(0.0181)
Income	-0.358	-0.710*	-0.655
	(0.315)	(0.398)	(0.422)
Income others	-1.216**	-0.995**	-0.476
	(0.502)	(0.482)	(0.408)
Dependency ratio	-0.00466	-0.0101	0.0539
	(0.0610)	(0.0677)	(0.0682)
Number of children	0.0580	0.137**	0.0895
	(0.0471)	(0.0617)	(0.0598)
Education	-0.146	-0.119	-0.0737
	(0.213)	(0.224)	(0.227)
Constant	-1.734***	-1.213*	-0.794
	(0.519)	(0.728)	(0.729)
Observations	1966	1683	1683
Pseudo R^2	0.0289	0.0418	0.0717

Table 7. Regressions controlling for availability of banks

This table presents a logit regression with robust standard errors of the dichotomic variable Default on the reported variables. For an explanation of the construction of the variables please refer to Appendix A. For those regressions in which controls other than Female and Age are included the sample is restricted to those loans that were undertook from 1997 onwards as the control variables were not available for previous dates. This table shows the positive correlation between bank availability and Default. We report robust standard errors in parentheses with *** ,**, * representing coefficients significant at the 1%, 5% and 10% level respectively.

Variable	(1)
Female	-1.522***
	(0.162)
Dowry	0.340***
	(0.119)
Bank availability	0.815***
	(0.137)
Age	0.0122
	(0.00888)
Income	-0.0967
	(0.191)
Income others	-0.355*
	(0.193)
Dependency ratio	0.0203
	(0.0356)
Number of children	0.0627*
	(0.0337)
Education	0.150
	(0.119)
Constant	-2.500***
	(0.358)
Observations	3221
Pseudo R^2	0.138

Table 8. Further tests of the model

This table presents the results of doing difference in means tests of the reported variables. We denote as 1 those individuals for which the described condition is satisfied.

Description	0	1	p-value
Level of savings if the individual defaulted	0.029	0.017	1
Level of income if the individual defaulted	0.073	0.179	0
Level of income if the individual defaulted on a loan expected prior to 1998	0.061	0.11	0.002
Level of income when the individual committed early default by bank presence	0.065	0.15	0
Level of income when the individual did not default by bank presence	0.072	0.075	0.35
Savings when individual committed early default on a loan by bank presence	0.008	0.012	0.03
Savings when no default was committed on a loan by bank presence	0.034	0.036	0.13
Income when early default was committed on loan by bank presence	0.049	0.107	0
Income when no default was committed on a loan by bank presence	0.076	0.03	1
Savings if the individual has a loan from the Grameen Bank	0.02	0.033	0

Appendix C

Appendix to Chapter 4

Proof of Proposition 1 If E chooses $j = L$ and the project fails, E knows about her low skills. She then does not realize any further projects. Therefore, consider the sequence $t^* = 1, 2, ...$ and the set of assessments in which E chooses $j = H$ in periods $t \in \{1, ..., t^* - 1\}$, $j = L$ in period t^*, and no more projects thereafter. Denote by $V_t^{(t^*)}$ the expected payoff of E at the beginning of period $t \in \{1, ..., t^*\}$ under the assessment with t^* periods of project realizations. We have

$$V_{t^*}^{(t^*)} = \tilde{\theta}_{t^*}^E y_L - 1, \tag{C.1}$$

and for $t \in \{1, ..., t^* - 1\}$

$$V_t^{(t^*)} = (1 - p_H)\tilde{\theta}_t^E y_H - 1 + (1 - (1 - p_H)\tilde{\theta}_t^E)V_{t+1}^{(t^*)}. \tag{C.2}$$

For given $\alpha_1 < 1$, there is a finite period $\hat{t}$, such that $\tilde{\theta}_t^E y_L - 1 < 0$ and $(1 - p_H)\tilde{\theta}_t^E y_H - 1 < 0$ for all $t \geq \hat{t}$, regardless of the assessment. That is why $V_1^{(t^*)}$ is only positive for a finite number of assessments with periods of project realizations $t^* \in \{1, ..., t^{**}\}$. Pick two numbers $g_1, g_2 \in \{1, ..., t^{**}\}$ with $g_1 < g_2$. If $V_1^{(g_1)} \geq V_1^{(g_2)}$, then we have $V_t^{(g_1)} \geq V_t^{(g_2)}$ for $t \in \{1, ..., g_1\}$. Otherwise, we would have

$$\tilde{\theta}_{g_1}^E y_L - 1 < (1 - p_H)\tilde{\theta}_{g_1}^E y_H - 1 + (1 - (1 - p_H)\tilde{\theta}_{g_1}^E)V_{g_1+1}^{(g_2)},$$

which contradicts $V_1^{(g_1)} \geq V_1^{(g_2)}$. Hence, E never can gain by switching from one assessment to another after period 0. Because of the tie-breaking rule, we have

$$\bar{t}_{\alpha_1} = \min\left\{g \in \{1, ..., t^{**}\} \mid V_1^{(g)} \geq V_1^{(t^*)}, t^* \in \{1, ..., t^{**}\}\right\}.$$

To prove the second claim, consider two assessments with $g_1, g_2 \in \mathbb{N}$, $g_1 < g_2$, periods of project realizations. We can then calculate that

$$\lim_{\alpha_1 \to 1} V_1^{(g_l)} = \left(1 - p_H^{g_l - 1}\right)\left(y_H - \frac{1}{1 - p_H}\right) + p_H^{g_l - 1}(y_L - 1)$$

for $l \in \{1, 2\}$. If $(A2)$ holds, then

$$\lim_{\alpha_1 \to 1} V_1^{(g_2)} > \lim_{\alpha_1 \to 1} V_1^{(g_1)}.$$

Note that $V_1^{(t^*)}$ is continuous in α_1 for all $t^* \in \mathbb{N}$. Thus, there is a $\hat{\alpha}_1 < 1$, such that $V_1^{(g_2)} > V_1^{(g_1)}$ whenever $\alpha_1 > \hat{\alpha}_1$ and therefore $\bar{t}_{\alpha_1} > g_1$.

Proof of Lemma 2 Assume that the equilibrium is as stated in the claim. As banks make zero profits in equilibrium, we get

$$V_{\bar{t}} = \tilde{\theta}^E_{\bar{t}} \left(y_L - \frac{1}{\tilde{\theta}^E_{\bar{t}}} \right), \tag{C.3}$$

and for $t < \bar{t}$,

$$V_t = (1 - p_H)\tilde{\theta}^E_t \left(y_H - \frac{1}{(1 - p_H)\tilde{\theta}^E_t} \right) + (1 - (1 - p_H)\tilde{\theta}^E_t)V_{t+1}. \tag{C.4}$$

First, consider the last period $\bar{t}$: as in Lemma 1, $(A1)$ ensures that E chooses $j = L$ in period $\bar{t}$, given that banks do not finance projects in future periods. Next, focus on a period $t < \bar{t}$. If E chooses $j = L$ in this period, her expected payoff is equal to $\tilde{\theta}^E_t \left(y_L - \frac{1}{\tilde{\theta}^E_t} \right)$, since no loans will be provided to her in future periods. E therefore chooses $j = H$ if

$$V_t \geq \tilde{\theta}^E_t \left(y_L - \frac{1}{\tilde{\theta}^E_t} \right). \tag{C.5}$$

It follows from (4.1) and (4.2) that

$$\lim_{\alpha_1 \to 1} \tilde{\theta}^E_t = 1.$$

With $(A2)$, we can then estimate

$$\lim_{\alpha_1 \to 1} V_t = \left(1 - p_H^{\bar{t}-t} \right) \left(y_H - \frac{1}{1 - p_H} \right) + p_H^{\bar{t}-t} (y_L - 1) > y_L - 1.$$

Note that V_t is continuous in α_1. Thus, (C.5) holds if α_1 is sufficiently close to unity.

Proof of Proposition 2 In any sequential equilibrium, we have $\tilde{\theta}^E_t = \tilde{\theta}^{B_k}_t$ for all $k \in \{1, ..., N\}$ and all periods t. From assumption $(A1)$ if follows that in the last period of an equilibrium, in which projects are financed by banks, E chooses $j = L$. It is also clear that in the periods before this last period, E chooses $j = H$. Otherwise, banks would not finance projects any longer. Consider therefore the sequence $t^* = 1, 2, ...$ and the set of assessments in which E chooses $j = H$ in periods $t \in \{1, ..., t^* - 1\}$, $j = L$ in period t^* and banks finance all projects in periods $t \in \{1, ..., t^*\}$, but not in periods $t \in \{t^* + 1, t^* + 2, ...\}$. Denote by $V^{(t^*)}_t$ the expected payoff of E in period $t \in \{1, ..., t^*\}$ under the assessment with t^* periods of project financing. As banks make expected zero profits in each period of a sequential equilibrium, we have

$$V^{(t^*)}_{t^*} = \tilde{\theta}^E_{t^*} \left(y_L - \frac{1}{\tilde{\theta}^E_{t^*}} \right), \tag{C.6}$$

and for $t \in \{1, ..., t^* - 1\}$

$$V^{(t^*)}_t = (1 - p_H)\tilde{\theta}^E_t \left(y_H - \frac{1}{(1 - p_H)\tilde{\theta}^E_t} \right) + (1 - (1 - p_H)\tilde{\theta}^E_t)V^{(t^*)}_{t+1}. \tag{C.7}$$

Note that (C.6) equals (C.1) and (C.7) equals (C.2) from the proof of Proposition 1. Thus, $V^{(t^*)}_t$ is the same as in the proof of Proposition 1 for all $t \in \{1, ..., t^*\}$ and for all t^* .

As $\tilde{\theta}^E_{t^*} \to 0$ for $t^* \to \infty$, at least one of the following statements must be true for each assessment with t^* periods of project financing: (1.) There exists a $\tau \in \{1, ..., t^* - 1\}$, such that

$$\tilde{\theta}^E_\tau \left(y_L - \frac{1}{\tilde{\theta}^E_\tau} \right) \geq (1 - p_H)\tilde{\theta}^E_\tau \left(y_H - \frac{1}{(1 - p_H)\tilde{\theta}^E_\tau} \right) + \left(1 - (1 - p_H)\tilde{\theta}^E_\tau \right) V^{(t^*)}_{\tau+1}.$$

This assessment cannot be a Nash equilibrium as E would choose $j = L$ in period τ. It also cannot be the first-best. (2.) It holds that

$$y_L - \frac{1}{\tilde{\theta}^E_{t^*}} < 0.$$

This assessment cannot be a Nash equilibrium as banks would not any finance projects in period t^*. It also cannot be the first-best. (3.) There exists a $\tau \in \{1, ..., t^* - 1\}$, such that

$$y_H - \frac{1}{(1-p_H)\tilde{\theta}^E_{\tau}} < 0.$$

This assessment cannot be a Nash equilibrium as banks would not finance projects with high risk in period τ. It also cannot be the first-best. (4.) The assessment is a Nash equilibrium. Denote by $t^*_{\max}$ the maximal number of periods in which projects are financed and the corresponding assessment is an equilibrium. Note that $t^*_{\max}$ is well-defined as $\alpha_1 \in I(\theta_L, y_L)$. Then, this assessment must be the only sequential equilibrium outcome. To see why, consider an alternative Nash equilibrium with $t^* < t^*_{\max}$ periods of project-financing. E can gain by choosing $j = H$ in the periods $t \in \{t^*, ..., t^*_{\max} - 1\}$, $j = L$ in period $t^*_{\max}$. As beliefs must be given by Bayes' rule and E's decisions are observable, banks cannot credibly threat to stop financing projects (by offering loan contracts with expected zero-profits) in these periods. Otherwise, the assessment with $t^*_{\max}$ periods of project financing would not be an equilibrium, as statement (1.) and/or (2.) and/or (3.) would be true. It remains to show that $t^*_{\max} = \bar{t}_{\alpha_1}$: $t^*_{\max} \geq \bar{t}_{\alpha_1}$ follows from the equivalence of expected payoffs (as stated above) and the fact that statements (1.) to (3.) are not true for any period $t \in \{1, ..., \bar{t}_{\alpha_1} - 1\}$ of an assessment with less than $\bar{t}_{\alpha_1}$ periods of project financing. $t^*_{\max} \leq \bar{t}_{\alpha_1}$ follows from the equivalence of expected payoffs (as stated above) and the fact that any assessment with more than $\bar{t}_{\alpha_1}$ periods of project financing violates statement (1.). Thus, we have $t^*_{\max} = \bar{t}_{\alpha_1}$.

Proof of Lemma 4 We must have $\tilde{\theta}^E_t = \tilde{\theta}^{B_k}_t$ for $k \in \{1, ..., N\}$ and all periods t of a sequential equilibrium. If E sticks to the proposed strategy, her expected payoffs are as in the proof of Lemma 2, i.e. equations (C.3) and (C.4). First, consider the last period $t = \bar{t}$. As in Lemma 3, $(A1)$ ensures that E chooses $j = L$, as $V_{\bar{t}+1} = 0$. Next, focus on period $\bar{t} - 1$. If E chooses $j = L$ in period $\bar{t} - 1$ and she fails, then she and her bank, say B_l, know that she has low skills, i.e. $\tilde{\alpha}^E_{\bar{t}} = \tilde{\alpha}^{B_l}_{\bar{t}} = 0$. Yet, she may get credit from another bank, for example B_k, $k \neq l$, in period $\bar{t}$. Thus, if she chooses $j = L$ in period $\bar{t} - 1$, her expected payoff $\tilde{V}_{\bar{t}-1}$ is

$$\tilde{V}_{\bar{t}-1} = \tilde{\theta}^E_{\bar{t}-1}\left(y_L - \frac{1}{\tilde{\theta}^E_{\bar{t}-1}}\right) + (1 - \tilde{\theta}^E_{\bar{t}-1})\theta_L\left(y_L - \frac{1}{\tilde{\theta}^{B_k}_{\bar{t}}}\right),$$

where $\tilde{\theta}^{B_k}_{\bar{t}}$ is the equilibrium value. As in the proof of Lemma 2, we then can calculate that

$$\lim_{\alpha_1 \to 1} V_{\bar{t}-1} > \lim_{\alpha_1 \to 1} \tilde{V}_{\bar{t}-1}$$

if $(A2)$ holds. Thus, if α_1 is sufficiently large, then E chooses $j = H$ in period $\bar{t} - 1$. By going through the same steps, one can show that E chooses $j = H$ in all periods $t < \bar{t}$ if α_1 is sufficiently large.

Proof of Lemma 6 We must have $\tilde{\theta}^E_t = \tilde{\theta}^{B_k}_t$ for $k \in \{1, ..., N\}$ and all periods t of a sequential equilibrium. Assume that E acts as stated in the claim. Banks charge loan rates r^k_t, $k \in \{1, ..., N\}$, $t \in \{1, ..., \bar{t}\}$, such that they make zero-profits in expectation. Denote by V_t the corresponding expected payoff of E at the beginning of period $t \in \{1, ..., \bar{t}\}$. For period $\bar{t}$, the proof proceeds as for Lemma 5. Next, focus on a period $t < \bar{t}$. Note that E has private information about her probability of success whenever she deviates from the equilibrium path in these periods: if she chooses $j = L$, and this project fails, then she knows that she has low skills. However, as banks do not observe E's decisions, the loan rates in the next periods are not affected by E's risk choice. Denote by $\tilde{V}_t$ the expected payoff of E at the beginning of period $t \in \{2, ..., \bar{t}\}$ if she knows for sure that she has low skills but follows the equilibrium path of play. Trivially, it holds that $V_t > \tilde{V}_t$. E chooses $j = H$ in period t if

$$\tilde{\theta}_t^E (y_L - r_t^k) + \left(1 - \tilde{\theta}_t^E\right) \tilde{V}_{t+1} \leq (1 - p_H) \tilde{\theta}_t^E (y_H - r_t^k) + \left(1 - (1 - p_H)\, \tilde{\theta}_t^E\right) V_{t+1}.$$

If α_1 is sufficiently large, then this inequality is implied by

$$(y_L - r_t^k) < (1 - p_H)(y_H - r_t^k).$$

Rearranging terms gives

$$r_t^k > \frac{y_L - (1 - p_H) y_H}{p_H}. \tag{C.8}$$

Recall the loan rate in period t is given by (4.9). Assumption $(A2^*)$ ensures that inequality (C.8) holds if α_1 is sufficiently large. Thus, if $(A1^*)$ and $(A2^*)$ hold and α_1 is sufficiently high, then E chooses $j = H$ in periods $t \in \{1, ..., \bar{t} - 1\}$ and $j = L$ in period $\bar{t}$.

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Eidesstattliche Erklärung

Hiermit erkläre ich, die vorliegende Dissertation selbständig angefertigt und mich keiner anderen als der in ihr angegebenen Hilfsmittel bedient zu haben. Insbesondere sind sämtliche Zitate aus anderen Quellen als solche gekennzeichnet und mit Quellenangaben versehen.

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