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The Optimal Size of a Bank: Costs and Benefits of Diversification

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Abstract

This paper provides a theory of diversification and financial structure of banks. It shows that by diversifying the bank portfolio and financing it with debt, the bank can commit to a higher level of monitoring. By linking the benefits of diversification to the costs, the paper derives an optimal size of the bank, which is bounded. The costs of diversification lie in the growing size of the organization needed to achieve diversification, that is, the costs of hiring more managers and providing them with the incentives to monitor. The benefits of diversification lie in increasing the bank`s owner`s incentives to supervise managers and thereby increase the overall level of monitoring in the bank.

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1 Introduction

In the literature on financial intermediation there are several explanations as to why banks should be diversified and large. Firstly, in credit markets where information is asymmetrically distributed, banks evaluate projects and monitor borrowers. As a consequence, bank assets are indivisible and illiquid. Diversification enables the bank to finance illiquid assets with liquid liabilities. Hence, through diversfication the bank can provide liquidity services to investors. Secondly, diversification on the asset side reduces the variance of the returns that accrue to claimholders of the bank; this is beneficial when claimholders are risk-averse or if there are bankruptcy costs. On the other hand, because of indivisibilities of bank assets, increasing diversification implies increasing the size of the bank.

This suggests that there should be economies of scale in banking and that financial intermediation should tend to be a natural monopoly. However, although banking systems tend to be concentrated, in some developed countries they are quite fragmented. Furthermore, in the empirical literature on banking there is no sharp evidence in favour of economies of scale above a certain threshold. On the contrary, there is often evidence that large banks suffer a cost disadvantage.[1]

One explanation, as we see it, for the discrepancy between the theory of financial intermediation and the empirical evidence is that the theory has not considered the issue of a bank's internal organization. Loans are monitored not by the bank as such, but by people working for the bank. Since there is a limit to the number of projects one person can monitor, monitoring more loans entails a larger organization, and increasing the size of an organization is costly.

In this paper we provide a theory of the optimal size of a bank, the function of which is to monitor loans on behalf of small investors. We also provide a theory of the financial structure of banks. The starting-point is that the outcome of monitoring depends on the effort of the person performing the task, and therefore delegation of monitoring involves an incentive problem for a monitor protected by limited liability. We prove that diversification improves the incentive of the banker to monitor, if the bank is debt financed. If the bank is financed with equity only, diversification does not have this effect.

This result can be intuitively explained as follows. The portfolio performance depends, among other things, upon the level of monitoring by the banker. With debt, the share of profits that accrues to the banker, who in this case is the bank's sole owner, depends on the performance of the bank's portfolio; with equity, however, the share is invariant to portfolio performance. Moreover, diversification augments the impact of increased monitoring on the banker's profit share. Hence, by changing the banker's marginal incentive to monitor, diversification acts as a commitment to increase the monitoring effort in the bank. This in turn improves bank performance, which reinforces the positive effect on incentives.

Another way of looking at this is to say that diversification increases the probability that the bank will be able to repay its debt, and reduces the expected shortfalls on

[1] See for instance Clark (1988).

debt, that is, the expected loss of debtholders when the portfolio of the bank performs poorly. This means that the standard debt contract approaches the full liability ("net residual claimant") contract, which, as we know from the agency literature, provides the correct incentives.

Our results are complementary to previous research on financial intermediation in that we provide an additional reason for why banks should be diversified and debt financed. In our model, the bank does not provide any liquidity service, the claimholders of the bank are risk-neutral, and there are no bankruptcy costs, but diversification improves the incentive of inside equity holders to monitor, if the bank is debt financed.

Contrary to the banking literature that takes debt financing of banks as given and focuses on the asset substitution problem of debt, we focus on the incentive problems arising from lack of inside capital, as we believe that these are at least as important, while attracting much less attention. It follows directly from the role of the bank as delegated monitor that the bank will have very little inside capital, and we provide one explanation for why the bank is still able to operate. One important implication of the analysis is that the incentive problem arising from lack of inside capital cannot be solved through capital constraints. On the contrary, our analysis suggests that for a diversified bank, outside equity is a costly source of finance.[2]

While the *benefits of diversification* derive from improving the banker's monitoring incentives, the *costs of diversification* arise from the growing size of the organization needed to achieve diversification. The idea is that an individual's monitoring capacity is limited, that is, it is increasingly costly for one person to monitor an increasing number of projects. As a consequence, in order to diversify the bank portfolio, the banker may want to hire managers to do the monitoring. However, if the interests of the managers are not perfectly aligned to those of the banker, costs will arise from the agency relation, as the managers must be provided with incentives to monitor. In our model, where monetary incentives are not sufficient, the banker has to supervise the managers. The cost of this grows with the number of projects, since increasing the number of projects causes "overload" in terms of the number of managers the banker has to monitor. By linking the benefits of diversification to the costs, the paper derives an optimal size of the bank, which is bounded.

In the next section we relate this paper to the literature. Section 3 presents the model and the main assumptions. In sections 4 and 5 we analyze the banker's incentive problem by assuming that she does not delegate the job of monitoring to managers. In section 6 we relax this assumption and show how delegation may increase the equilibrium level of monitoring in the bank. Section 7 concludes.

[2]Thus, this suggests a trade-off between the asset substitution problem and the monitoring incentive problem, which implies that capital constraints migth be costly for banks. Boyd and Gertler (1993) observe that for the US banking industry the equity to assets ratio has been steadily declining since 1980.

2 Relation to the literature

On the one hand this paper is closely related to Diamond (1984), where financial intermediation arises as an efficient way of delegating monitoring. There, diversification of the bank portfolio is beneficial, if the bank is debt financed, because it reduces the probability that the bank will go bankrupt, and therefore the costs connected to bank failure. In our paper diversification under debt financing can be beneficial for providing incentives ex ante, even when there are no costs of bank failure.[3]

On the other hand this paper is closely related to the literature on incentives to monitor. We exploit the idea that the financial structure may affect the monitoring level in the firm.[4] This idea is not new and it has been applied to banking by Holmstrom and Tirole (1994) and Dewatripont and Tirole (1995).

Holmstrom and Tirole (1994) show that delegated monitoring is optimal for entrepreneurs with insufficient collateral to finance investments directly. Because the bank is externally financed, it needs to invest some of its own capital in the project to convince the financier that it will monitor the entrepreneur. Our vision of the main activity of banks is very similar to theirs, in that they assume that banks principally monitor entrepreneurs and that banks can do this more efficiently than credit markets. However, they focus on inside capital as an incentive mechanism, while we are more concerned with diversification of the bank portfolio.[5] Moreover, we also analyze the incentive of the banker to delegate monitoring to managers, taking into account, not only that the banker's interests are not aligned with those of external financiers, but also that the interests of managers are not fully aligned with those of the banker.

Dewatripont and Tirole (1995) focus on the conflict between the manager and the bank's claimholders and show how the financial structure of the bank can be used as an incentive mechanism for the manager. We, on the other hand, focus on how the financial structure affects the behavior of inside equity holders, in particular the incentive of the banker to monitor.

[3]Diamond (1984) compares delegated monitoring by a bank to direct monitoring. Due to duplication of effort, direct monitoring involves higher verification costs than delegated monitoring, but delegated monitoring involves a non-pecuniary penalty in case of bankruptcy of the bank. As the number of projects increases, the likelihood of bankruptcy goes to zero, and so the non-pecuniary penalty. Hence, the average cost for the bank (monitoring cost plus non-pecuniary penalty) decreases as the number of projects the bank monitors rises. Therefore a sufficiently diversified delegated monitor is more efficient than direct monitoring. Diamond assumes that project monitoring is always performed by the bank; this is a convenient arrangement as the bank will choose to diversify because of economies of scale in monitoring. We build a model where there are diseconomies of scale in monitoring, the intensity of monitoring is a choice variable for the banker and there are no costs of bankruptcy. Still we show that the banker is able to raise money from claimholders committing through diversification of the portfolio to monitor each project enough to avoid bad performances by entrepreneurs.

[4]Therefore, the paper is also related to the corporate finance literature, but we defer the discussion of this to section 5.2.

[5]Holmstrom and Tirole (1994) exclude diversification by assuming perfect correlation between projects. The rationale is that in order to justify the need for bank capital, one has to exclude the case where banking becomes a perfectly safe business. We too exclude this case by assuming limited ability to monitor.

Aghion and Tirole (1994) and Burkart,Gromb and Panunzi (1994) analyze the incentive of the owner to monitor the manager, when monitoring by the owner is not always good as it reduces the manager's initiative. The latter show that the optimal amount of monitoring in a firm can be chosen by setting the firm's financial structure. In particular, having a mix of large and small shareholders among the firm's creditors may have advantages when the initiative of the manager is important. Aghion and Tirole (1994) suggest, among other things, the introduction of some overload in order to reduce monitoring by the owner. The idea is that agents have a limited ability to monitor, so by increasing the span of control the owner can commit to monitor less. In our paper, monitoring by the owner is always good, but there is not enough inside capital to incentivate the owner. Instead incentives are provided by diversification, so that increasing the span of control, although it increases the cost of monitoring, may induce *more* monitoring by the owner.

The assumption that agents have limited ability to monitor allows us to explain why the optimal size of intermediaries is bounded. This contrasts with the result of Krasa and Villamil (1992), who examine the effect of limited ability of depositors to monitor the bank. They find that even if monitoring costs of depositors increase with the size of the bank, there are increasing returns to scale in financial intermediation.

There are no papers, at least that we are aware of, which focus on agency costs inside the bank to explain the scale of activity. The few papers on the internal organization of the bank mainly focus on the effect of the organization on the ex-ante screening activity of projects that require financing.[6]

Our idea of the design of the bank's internal organization is influenced by Qian (1994) and more generally by Williamson's (1967) view of factors affecting the size of organizations. A firm will be limited in size because of agency costs arising from the owner's limited ability to monitor. We depart from that literature in that we relax the assumption that the owner has no incentive problem at all, always exerting the maximum monitoring effort. The different ingredient in our paper is that the owner has somehow to be given incentives to exert this effort.

3 The model

Consider an economy consisting of two types of risk-neutral agents: entrepreneurs and investors.

The *entrepreneurs* have access to investment projects with a stochastic return, and can carry out one project each. The project requires one unit of capital: if it succeeds it returns R; if it fails, it returns nothing. The entrepreneurs have no own capital and therefore have to borrow from investors in order to carry out the project. Project outcomes are observable and independent across entrepreneurs. The probability of success depends on the entrepreneur's behavior. If the entrepreneur behaves well, the probability of success is p_H ("the entrepreneur chooses the good project"). However, unless he is monitored by the creditor the entrepreneur may misbehave, which renders

[6]See for example Sah and Stiglitz (1986).

him a private benefit B but reduces the probability of the project succeeding, $p_L < p_H$ ("the entrepreneur chooses the bad project").

The *investors* have access to an alternative investment that yields a safe return y, which we assume to be lower than the project's expected return when the entrepreneur is behaving, but higher than the expected return when the entrepreneur is misbehaving. For this reason we refer to the former type as good projects and the latter as bad projects.

All agents are protected by limited liability, so no one can end up with negative consumption. This means that the entrepreneur can repay the loan only if the project succeeds, which depends on his behavior.[7] The entrepreneur prefers the good project if and only if

$$p_H(R-r) \geq p_L(R-r) + B,$$

where r is the loan rate. The higher the private benefit and the higher the loan rate, the more likely is the entrepreneur to prefer the bad project. We assume that the private benefit is sufficiently large for the entrepreneur to prefer the bad project for all loan rates which would give the lenders an expected return of at least y, if the entrepreneur was behaving. With $\Delta p = p_H - p_L$, this assumption can be stated as

Assumption 1 $p_H R - y - \frac{p_H}{\Delta p} B < 0.$

Hence, unless monitored, the entrepreneur always chooses the bad project. Another interpretation is the following: in order to be incentive compatible, the loan rate must be less than $R - B/\Delta p$, and B is so high that even if $r = R - B/\Delta p$, the expected net return earned by the lenders would be negative. The idea is that the interests of the lenders and of the entrepreneur differ so much that they cannot be aligned through a financial contract. The only way to resolve this conflict is through monitoring.

Through costly monitoring the investor can find out whether the entrepreneur is misbehaving. However, each investor is assumed to have a negligible amount of capital so that there is an incentive to free-ride on monitoring.[8] Therefore direct lending is not feasible.

Observation 1 *No direct credit from investors to entrepreneurs will take place.*

As a response, investors form intermediaries (banks) which borrow from investors and lend to entrepreneurs. For simplicity, each bank will have just one investor as

[7] We refer to the contract between the entrepreneur and the lender as a debt contract, but, because of the assumptions about the returns of the project, a debt contract is equivalent to an equity contract.

[8] This assumption simplifies the formulas, but for the results it is sufficient that each investor has a small amount of capital compared to the capital required by the project. The idea is to capture that banks collect funds from small investors, who in contrast to sufficiently large investors are not able to lend directly to entrepreneurs.

inside equity holder, named the *banker*.[9] Bankers can, by monitoring, induce the entrepreneur to behave ("choose the good project").

Instead of themselves monitoring the entrepreneurs, bankers can arrange this by hiring other investors, named *bank managers*. In order to distinguish them from bankers who themselves monitor the entrepreneurs, we sometimes refer to manager-hiring bankers as *owners*. Finally, we assume that each banker hires no more than one manager for each financed project.[10]

As for the *monitoring technology*, we assume that by choosing the level of effort ω, with $0 \leq \omega \leq 1$, a banker or a bank manager is able to discover with probability ω that the entrepreneur is misbehaving and can intervene to insure that the good project is chosen instead. Each agent has *limited ability to monitor* in the sense that the marginal cost of monitoring increases with the number of projects. More specifically we assume that monitoring m projects, that is, finding out with probability ω_i the behavior of entrepreneur i, implies the following private cost:

$$\frac{c}{2}\left(\sum_{i=1}^{m}\omega_i\right)^2, \tag{1}$$

where $c/2$ is the cost of fully monitoring only one project.

One interpretation is the following: monitoring a project takes time and each person's time is limited. The probability of finding out the behavior of the entrepreneur depends on the time spent on monitoring and on the monitoring intensity. In order to keep the quality of monitoring with respect to each project constant, increasing the number of projects requires that the monitor works harder. Therefore the disutility of effort increases with the number of projects to be monitored, which is to say that there are overload costs.

We assume that the good project is sufficiently profitable to cover the marginal cost of fully monitoring one project, that is,

Assumption 2 $p_H R - c > y > p_L R$.

To summarize, there are good projects which can be profitably financed. However, direct lending is not feasible, since the entrepreneur will always misbehave, as no investor has the incentive to monitor him. Delegation of monitoring to a banker solves the free-rider problem of investors, but because the banker does not have enough money to finance the entrepreneurs herself, she needs to raise money from outsiders. For investors to be willing to finance the banker, they need to be convinced

[9] More generally, a bank could be established by a group of investors, if the free-rider problem could be solved within this group. Although such a bank could have a non-negligible amount of inside capital, the group of inside equity holders has to be small in order to avoid free-riding so that presumely the amount of inside equity would not be sufficient to eliminate the incentive problem of the inside equity holders.

[10] We do not analyze the optimal hierarchy, but merely compare two organizational structures. For instance, it might be more efficient to hire a manager to monitor several projects at the same time. However since we are interested in finding a reason for delegation, if there are benefits of delegation in our case, which may be less efficient, they must also exist for the optimal structure.

that the banker will exert a sufficiently high effort, so that the expected return is at least as high as the alternative return.

Bankers can alternatively hire managers to monitor the entrepreneurs. However, since monitoring involves a private cost, the banker needs to monitor the manager to make sure he will monitor the entrepreneur.

The **timing** of the game is the following:

- The loan rate (r = gross interest rate) is determined;
- the number of projects m to be financed is chosen;
- the decision whether to hire managers is taken;
- the financial structure of the bank is determined;
- the monitoring efforts for each project are determined;
- payments are made in accordance with the financial contracts.

We assume that investors observe both the loan rate and the number of projects before investing, whereas monitoring efforts are neither observable nor contractible.

We will focus on the size of a bank as an incentive mechanism and assume that the demand for loans does not place any restriction on size, as long as $r \leq R$. This assumption is reasonable when for instance the number of banks is restricted by entry regulation or when the number of entrepreneurs is very large. While the loan rate presumely differs in these two cases, in neither of them will there be strategic interaction between banks on the loan side. Moreover, we assume that there are sufficiently many investors for there not to be competition among banks for funds. Hence, we can consider the problem in terms of a representative banker.

4 The incentive problem of the banker

We want to show that there is scope for diversification in financial intermediation even though there are diseconomies of scale in monitoring. The idea is that diversification may work as a commitment device when there is moral hazard in monitoring. In this section we illustrate the moral hazard problem of a banker, which arises because monitoring is not contractible. In the next section we will show how diversification can mitigate this moral hazard problem. In both this and next section we assume that the banker monitors the projects herself. The results are then compared in section 6 to the case where the banker delegates project monitoring to managers.

In order to create a benchmark we relax the assumption that the banker has only a negligible amount of wealth and consider the case in which the banker has enough capital to finance the projects herself. This means that, even if the banker finances the investment with a loan, she can be made fully liable for the loan. Because all

agents are risk-neutral, this case is equivalent to external financing with contractible efforts.[11]

• *The benchmark: full liability* Given the loan rate, the banker first decides how many projects to finance, and then how much monitoring effort to allocate to each project. By exerting a monitoring effort E_i, the banker finances a good project with probability E_i. Hence, the expected return to the banker from financing m projects at the loan rate r is

$$\Pi = \sum_{i=1}^{m} p_i r - my - \frac{c}{2}(\sum_{i=1}^{m} E_i)^2,$$

where $p_i = p_L + E_i \Delta p$ is the probability of success of project i, and $\Delta p = p_H - p_L$ is the marginal increment in the probability of success. The opportunity cost of funds is given by the alternative return y.

Given the total number of projects to finance, m, the banker chooses the amount of monitoring for each project so as to maximize the overall profits of the bank. The first order conditions (FOCs) for the optimal effort choice are

$$\frac{\partial \Pi}{\partial E_i} = \Delta p r - c \sum_{i=1}^{m} E_i \geq 0, \qquad i = 1, ..., m. \tag{2}$$

Note that for this particular cost function the FOCs allow us to find uniquely the optimal average effort level, while there are many different individual monitoring levels that solve the system of FOCs. We will discuss the solution in terms of this average effort level, $\bar{E} = \sum E_i / m$.

The FOCs are not equalities as $\bar{E}$ is constrained to be less than or equal to one. Thus, only if $\frac{\Delta p r}{cm} \leq 1$, will the FOCs be fulfilled with equality. In this case the optimal average effort level is increasing in r and decreasing in m. A higher loan rate implies a higher return on monitoring, while a larger number of projects implies higher overload costs.

What size of bank will the banker choose? That depends on the loan rate. A higher loan rate implies a higher marginal return on a loan both directly and via a higher marginal benefit of monitoring. Therefore the higher the loan rate, the more likely it is that the optimal effort level is equal to one and that the optimal number of projects is larger than one.

Taking into account the effect of a change in m on the effort level, the optimal size of the bank is given by:

$$\frac{d\Pi}{dm} = p_L r - y + \frac{d(\sum_{i=1}^{m} E_i)}{dm} [\Delta p r - c \sum_{i=1}^{m} E_i] = 0. \tag{3}$$

First we can conclude that *the optimal size is larger than one project only if the equilibrium effort level is equal to one.* If in equilibrium $\bar{E} < 1$, the second term in

[11] When the effort is contractible, the expected return of the investor will be y for all levels of effort, not just for the equilibrium level. Thus, funding the bank costs y per unit of capital independently of the level of effort.

equation 3 is zero, and profits are decreasing in m, as $p_L r < y$. Hence, if $\bar{E} < 1$ for all m, the banker will choose to finance only one project.

Secondly, *if the bank is financing more than one project, it makes positive profits in equilibrium.* In fact, we just argued that if the bank is financing more than one project, $\bar{E} = 1$. In this case the optimal size of the bank is given by

$$p_H r - y - cm = 0, \tag{4}$$

which implies that the bank makes positive profits, because, due to the limited ability to monitor, the marginal cost of monitoring is higher than the average monitoring cost.[12] As a consequence, if the bank is making zero profits, the left-hand side of equation 4 is negative, and the bank lends to only one project.

From assumption 2 follows that the left hand side of equation 4 is strictly positive for $r = R$ and $m = 1$. Thus, imperfect competition may involve a welfare loss in form of overload costs. We will show that with external financing overload costs actually can be optimal, but first we will consider the case of a banker who finances one project alone ($m = 1$) in order to show that, due to limited liability, outside finance introduces an incentive problem for the banker.

• *The one-project bank* Since the banker has a negligible amount of capital, she has to raise one unit from investors to finance the project. For investors to be willing to invest, they must believe that the investment will return at least y. They know that this is only possible if the banker monitors the entrepreneur. Since the monitoring level is not contractible, the issue is whether the banker has the incentive to monitor the entrepreneur given the contract with investors (and the contract with the entrepreneur).

Generally, the banker's incentive to monitor will depend on whether the bank is equity or debt financed. However, this is not the case for the one-project bank, because of the simple project structure. Since the project does not return anything when it fails, the banker can only get a share of the return when the project succeeds and so can the investors. Let us consider the case of the banker issuing debt at the interest rate r_D. Although there is no liquidity in the model, we will refer to the debtholders as depositors, because these investors are small and uninformed.

The banker chooses the optimal level of her effort, given the interest rates, by maximizing profits:

$$\Pi = p(r - r_D) - \frac{c}{2}E^2,$$

where $p = p_L + E\Delta p$ is the probability that the project succeeds. The FOC with respect to effort is:

$$\Delta p r - \Delta p r_D - cE \geq 0. \tag{5}$$

Let us compare this condition to the benchmark case given by equation 2 with $m = 1$,

$$\Delta p r - cE \geq 0. \tag{6}$$

[12]Note that, for all m satisfying equation 4, the FOCs for the effort will indeed be fulfilled with strict inequality. This can be easily derived from $p_L r < y$. Substituting $p_H r$ from 4 into equation 2, we get $y - p_L r + c(m - \sum E_i) > 0$.

The incentive to exert monitoring is lower with outside finance, because the gain from increasing the effort is partly expropriated by the outsiders, who do not bear the cost of monitoring. The banker, by increasing her monitoring effort, increases the probability that depositors get r_D. By marginally increasing the effort, the probability of the project's success increases by Δp, whereas the expected repayment to depositors increases by $\Delta p r_D$. The banker is then less willing to increase her monitoring effort, since part of this investment goes to benefit depositors. Alternatively, we can say that the incentive to exert effort is weaker when the bank is debt financed because there is then an incentive to exploit depositors, shifting part of the losses due to low monitoring onto their shoulders. This incentive arises because the deposit rate does not depend on the monitoring level in the bank, which is not observable to outsiders, and thus is related to the well-known risk incentive of fixed-price deposit insurance.[13]

When will the investors be willing to finance the banker? Only when the amount of monitoring induced by the banker is large "enough" to make their investment worth at least as much as the alternative return y. Thus, r_D must fulfill the individual rationality (IR) condition for investors:

$$\hat{p}_1 r_D = y, \tag{7}$$

where $\hat{p}_1$ is the expected probability of success of the project. In the rational expectations equilibrium it must be true that

$$\hat{p}_1 = p_L + \hat{E}_1 \Delta p,$$

where $\hat{E}_1$ fulfills condition 5.

Assume that investors believe that the banker will fully monitor the project. Then

$$r_D = \frac{y}{p_H}. \tag{8}$$

Will the banker actually choose $E = 1$? Substituting equation 8 into equation 5 shows that she will only do so if

$$\Delta p r - \frac{\Delta p}{p_H} y - c \geq 0,$$

that is

$$p_H(p_H r - y - c) - p_L(p_H r - y) \geq 0.$$

First of all, the loan rate must be sufficiently high for the good loan to cover the marginal monitoring cost. Secondly, the bad project must have a sufficiently low probability of success for the banker to have the incentive to monitor. According to assumption 2, $p_L < \frac{y}{R}$; however this may not be sufficient, even when $r = R$. In order to focus on the incentive problem that arises from outside finance, we assume that the one-project bank is not viable and show that nevertheless the bank can become viable

[13] As a matter of fact, assuming that deposits are fully insured and that the insurer charges a fair premium given his expectation about the bank's behavior, would not change the results if the insurer has the same information as investors [see Daltung (1994)].

by diversifying. We exclude the one-project bank by assuming that the difference in the probability of success is sufficiently small for the banker not to choose $E = 1$, even though the loan rate is equal to R, that is

Assumption 3 $p_H R - y - \frac{p_H}{\Delta p} c < 0$.

It is easy to show that, given assumption 3, independently of r, there is no rational expectation equilibrium in which investors are willing to deposit at the bank,[14] that is,

Observation 2 *There is no equilibrium in which externally financed banks are lending to only one project.*

5 Diversification and incentives

We have shown that the need for external finance gives rise to an incentive problem for the banker and that this incentive problem could be sufficiently severe for the bank not to be viable when financing only one project. In this section we will show that diversifying the bank portfolio by financing more than one project may mitigate the banker's incentive problem *if the bank is debt financed.*

Why would diversification of the bank portfolio improve the banker's monitoring incentive under debt financing? From the agency literature we know that the incentive problem could be resolved by making the banker the residual claimant of the bank's net profits, that is, if investors were to receive a return y in all states of nature, while the residual return accrues to the banker. This is not possible when the banker is financing only one project, since, having no initial wealth, the banker cannot pay y when the project fails.[15]

However, if the banker is financing many projects, according to the Law of Large Numbers the return on the loan portfolio will be almost certain, so that, if the expected return is sufficiently high, the banker will almost always be able to repay depositors. Therefore the deposit rate will be approximately equal to y, and virtually all the marginal benefit of monitoring accrues to the banker. In other words, the debt contract will be close to the full liability contract. This is not true for the equity contract. Independently of the size of the bank, outside equity holders always get a share of the benefit from increased monitoring.

The banker's incentive to monitor, however, depends also on the marginal cost of monitoring, which increases with the number of projects. As a matter of fact, if monitoring costs are high, a bank with a perfectly diversified portfolio will *never* be able to pay the deposit rate, as this will be higher than the expected return, since the high monitoring costs spoil the incentive to monitor. In this section we want to

[14]There is no intersection for any value of r, between equation 5 and 8 when assumption 3 holds true.

[15]Furthermore, the banker is protected by limited liability and cannot be punished for not being able to repay the debt; in other words, there are no private bankruptcy costs here.

show that diversification can resolve the banker's incentive problem *when monitoring costs increase sufficiently slowly with the number of projects to be monitored.* Then in the next section we study how monitoring costs may be reduced if the monitoring task is delegated to managers.

5.1 Debt and diversification: how to reduce the incentives to exploit depositors

The debt contract could be described as a promise by the debtor to pay r_D in every state of the world; however, the contracting parties are aware that in some states this promise will not be kept. Thus, the expected return per unit of debt can be written as:

$$r_D - \frac{1}{m} S_m,$$

where S_m is the expected shortfalls on the total debt, that is the difference between the promised amount mr_D and the amount recovered by the creditors in expected terms. For instance, when $m = 1$, the expected shortfall is

$$S_1 = (1 - p)r_D. \tag{9}$$

Thus, what distinguishes the risky debt contract from the full liability contract is the expected shortfalls on debt.

The expected shortfalls are given by the portfolio distribution and the promised debt repayments, since the banker can pay mr_D only when solvent, that is, when:

$$\sum_{i=1}^{m} z_i \geq mr_D,$$

where z_i is the repayment by entrepreneur i. Otherwise the bank is declared bankrupt and depositors recover whatever there is, which is less than was promised.

The distribution of the portfolio return depends in turn on the loan rate, the number of projects, and the degree of monitoring by the banker. Somehow a higher loan rate, or monitoring level, shifts the distribution to the right, while an increase in the number of projects reduces the variance of the average portfolio return.

The banker's expected returns on financing m projects by issuing deposits at the interest rate r_D are:

$$\Pi = \sum_{i=1}^{m} p_i r - (mr_D - S_m) - \frac{c}{2}(\sum_{i=1}^{m} E_i)^2, \tag{10}$$

where again $p_i = p_L + E_i \Delta p$ is the probability of success of project i. For each project, the banker chooses the effort so as to maximize profits:

$$\Delta p r + \frac{\partial S_m}{\partial E_i} - c \sum_{i=1}^{m} E_i \geq 0, \qquad i = 1, ..., m. \tag{11}$$

Notice again that the FOCs might be fulfilled with inequality, since E_i is constrained to be less than one. However, in contrast to the full liability case, here there is only

a symmetric solution to the system of FOCs, even when each FOC is fulfilled with equality. We will denote the symmetric effort level at equilibrium by $\hat{E}_m$.

Comparing the FOCs in 11 with the FOCs for a fully liable bank given by 2, we see that the difference arises from the effect of a change in the monitoring level on the expected shortfalls. This term is negative, as increased monitoring shifts the distribution of the portfolio return to the right. When the banker exerts more monitoring effort, she increases the probability of her being able to repay the debt and reduces the expected shortfalls on debt. Since depositors cannot observe the effort provided by the banker, higher effort does not lead to a lower deposit rate. Consequently a part of the benefit from increased monitoring would accrue to depositors, which reduces the banker's incentive to monitor.

Since the expected shortfalls depend on the deposit rate, so do the FOCs. In the absence of interbank competition for funds, the banker sets the lowest deposit rate at which investors are willing to deposit at the bank. Investors cannot observe the banker's effort choice but have rational expectations about her behavior. The banker takes into account that the deposit rate has to fulfill the IR condition for the investors given by

$$r_D - \frac{1}{m} S_m = y. \tag{12}$$

We will show that, given that monitoring costs rise slowly with the number of projects to be monitored, there is a bank size for which a solution exists to conditions 11 and 12. We do this in two steps. First we show that, as the size of the bank increases, the debt contract approaches the full liability contract, given a monitoring level that is sufficiently high. Then we show that, given the full liability contract, the monitoring level will indeed be sufficiently high.

Lemma 1 *If the expected return on the bank portfolio is higher than the deposit rate, the derivative of the expected shortfalls with respect to E_i and the average expected shortfalls approach zero, as m goes to infinity.*

PROOF See the Appendix.

The intuition is that, as m increases, the distribution of the average return on the loans, $\frac{1}{m}\sum_{i=1}^{m} z_i$, becomes more and more concentrated around its mean, so that if the mean is higher than the deposit rate, there will be fewer states in which the banker is unable to pay the promised amount to depositors. This means that the incentives to exploit depositors decrease with the size of the bank as the debt contract approaches the full liability contract (for which the bank always repays its debt).

The expected return, however, is higher than the deposit rate only if the banker monitors the projects, which in turn depends on the marginal monitoring costs. Whether there is a bank size for which an equilibrium exists in which the bank is active will depend on the speed at which monitoring costs increase with m. We will show that there exists such an equilibrium for the cost function given in equation 1. [16]

[16] For this cost function monitoring costs increase proportionally with m, where the proportion is

Proposition 1 *There is a marginal cost of fully monitoring one project, c, for which a sufficiently diversified bank can raise debt although a one-project bank cannot.*

PROOF If the expected shortfalls and its derivative with respect to E_i are approaching zero, the FOCs for the optimal effort approach

$$\Delta pr - c\sum_{i=1}^{m} E_i \geq 0, \qquad i = 1, ..., m. \tag{13}$$

and the IR condition for investors approaches

$$r_D = y. \tag{14}$$

Hence, if for instance $r = R$, $c = \frac{\Delta pR}{m}$, $y > p_H R(1 - \frac{1}{m})$, then assumptions 1 - 3 hold and there is an m for which $\hat{E}_m$ will be large enough for pr to be larger than r_D. □

The gains from an increase in effort accrue to the banker, provided the bank does not fail. Lower expected shortfalls imply that a larger share of the gain from monitoring goes to the banker, and this increases her incentive to monitor. This is the virtuous circle through which diversification improves the incentive to monitor.

Diversification does not have this effect if the bank is equity financed, because equity financing implies splitting returns uniformly across all the possible states of the world.

What bank size will the banker choose? The banker will take into account that investors are rational and demand an expected return equal to y, and that the size of the bank affects the rational expectation equilibrium. In order to be active the banker must choose m sufficiently large to convince investors that she will do enough monitoring. If investors are willing to deposit at the bank, we can substitute the IR condition of investors into the profit function of the banker given by equation 10. Then the FOC for the optimal size becomes

$$\frac{d\Pi}{dm} = p_L r - y + \frac{d(\sum_{i=1}^{m} E_i)}{dm}[\Delta pr - c\sum_{i=1}^{m} E_i] = 0. \tag{15}$$

This condition looks exactly like the FOC in the benchmark case, namely equation 3. In fact, if $\hat{E}_m = 1$, the optimal size coincides with the benchmark case given by equation 4. Or in other words, if the optimal size of the fully liable bank, denoted by s, is sufficiently large (and the marginal monitoring cost is sufficiently low) for the externally financed banker to choose $E_s = 1$, she will choose exactly the size s. This is to say that the loan rate is sufficiently high for the incentive problem of external financing not to constrain the banker's choice. It also implies that there is a welfare loss from unecessarily high overload costs, although the loss is lower than in the benchmark case because diversification is necessary here.

given by c. Thus, the only way we can reduce the speed is to reduce c. Then, in order not to violate assumptions 2 and 3 we have to increase y. Obviously, it is possible to prove a similar result for cost funtions for which monitoring costs increase less than proportionally with m.

Consider now the case when the incentive problem actually restricts the choice of the banker, that is either that the bank is not viable at s, which certainly would be the case if $s = 1$, or that the bank is viable, but $\hat{E}_s < 1$. In this case the FOCs for the optimal effort choice given by 11 are fulfilled with equality in equilibrium, and we can substitute them into the FOC for the optimal number of projects given by 15, which gives

$$\frac{d\Pi}{dm} = p_L r - y - \frac{d(\sum_{i=1}^{m} E_i)}{dm} \frac{\partial S_m}{\partial E_i} = 0, \tag{16}$$

Since $p_L r < y$ and $\frac{\partial S_m}{\partial E_i}$ is negative, the banker will not increase the size of the bank unless that would raise the monitoring level. In this sense there are no unecessary overload costs.

What can we say about the equilibrium for different loan rates? First we can conclude that, if the bank makes zero profits, it will not be perfectly diversified and the banker will not fully monitor the projects. It follows from the benchmark equilibrium that, if the bank were perfectly diversified, the banker financing more than one project would fully monitor the projects; but if the bank is fully monitoring more than one project it makes strictly positive profits in equilibrium, which leads to a contradiction. Secondly, as in the benchmark case, for a given bank size, a higher loan rate implies a higher level of effort. However, contrary to the benchmark case, a higher loan rate might imply a smaller size of the bank. In equation 16 the absolute value of $\frac{\partial S_m}{\partial E_i}$ decreases with r. Hence, restricting competition might be beneficial, as an increase in the loan rate might reduce overload costs and/or raise the monitoring level.

5.2 The cost of equity

As in Jensen and Meckling (1976), outside equity financing involves agency costs. In our case, independently of its size, the bank is not able to finance its lending with outside equity only. Moreover, it is not possible to avoid the agency problem by selling the firm to the inside equity holder. Even if she bought the outside equity claims by issuing debt, risky debt involves the same type of agency costs as equity. As a matter of fact, in our model, because of the simple project structure, when financing only one project, debt financing involves exactly the same agency cost as outside equity financing. With a different project structure, the agency problem could be smaller with debt financing than with equity, but the monitoring incentive could still be too low for the one-project bank to be viable. This would for instance be the case if the project returned something in the bad state, say R_L, sufficiently lower than R. Only when the debt is risk-free does debt financing not introduce any distortion of incentives. This is related to the result of Myers and Majluf (1984), that is, the firm prefers to issue risk-free debt, while risky debt is preferable to outside equity. In their case, the firm might even refrain from profitable investment opportunities when it has to finance the investment by issuing equity.

While risk-free debt does not involve any agency costs, there is no benefit in making the debt secure by splitting cash flows, since agency costs would then arise

instead from outside equity financing. For instance, in the example where the project returned something in the bad state, full debt financing would be better than full equity financing. If the bank is debt financed, introducing a small amount of outside equity has no effect at all on the banker's monitoring incentive, while introducing an amount of equity which is so large that the debt becomes secure reduces the monitoring incentive. The intuition is the following: while the incentive problem with equity is worse than with debt, issuing equity reduces the incentive problem of debt, but only when debt is not already secure. This suggests that a capital requirement can be costly as it might reduce the monitoring level in the bank.

Of course, if debt can be made secure by injection of inside capital, the incentive problem could be alleviated, and this could be a cheaper alternative to diversification.

To conclude, our analysis suggests that small banks should be closely held firms, while ownership of more diversified banks could be more dispersed. Moreover, the capital requirement is most likely to be binding in large banks with dispersed ownership.

6 Incentives to delegate

In the previous section we have shown that a sufficiently diversified bank may be able to raise debt. However, we required that costs do not increase too rapidly with the size of the bank. In this section we investigate whether delegating monitoring to managers can be a way to keep costs down, when the banker is the bank's sole owner. Since each manager is monitoring only one project, managers will not face any overload costs. Thus, if the interests of the managers were totally aligned to those of the bank's owner, delegation would result in increasing returns to scale in financial intermediation. However, since monitoring involves a private cost, the interests will not be aligned. The owner wants the manager to monitor the entrepreneur fully, while the manager wants to avoid monitoring. Thus, the owner has to supervise the manager, implying agency costs, which, given the overload faced by the owner, increase with the size of the bank. It is therefore not obvious that the banker prefers to delegate monitoring to managers.

We first analyze the case in which managers do not care about monetary incentives, but derive a private benefit from retaining their job. Then we briefly discuss the case where managers care about monetary incentives.

6.1 Private benefits

Assume that the manager gets a private benefit b from retaining the job. Since the manager is reluctant to lose the benefit, the owner can induce him to monitor by threatening to fire him if he shirks. Hence, in order to induce maximum monitoring by the manager, his contract with the owner states that he will be fired if the owner learns that the project is bad. We assume that depositors know about this contract, and that, on finding a bad project, the owner can intervene directly and induce the

entrepreneur to choose the good project, so that enforcing the contract with the manager is not costly for the owner.[17]

To examine the cost of the agency relation between owner and manager, we will first consider the case in which the owner has enough capital to finance one project by herself. This will be used as a benchmark when considering external financing.

• *The benchmark: Fully liable one-project bank with manager* The owner of the bank hires a manager to monitor the entrpreneur's project. Since the manager incurs a private cost from monitoring, he is going to shirk unless the owner monitors him. Let us assume that the manager and the owner decide simultaneously how much effort to put into monitoring: E is the effort of the owner in monitoring the manager, and e is the effort of the manager in monitoring the entrepreneur. As a result, they discover whether the project is good with probabilities (E, e).

The manager chooses the effort level that maximizes his utility:

$$U = [1 - (1 - e)E]b - \frac{c}{2}e^2.$$

With probability $(1 - e)E$ the owner detects that the manager is shirking and the manager loses his private benefit, b. The FOC for the manager is given by:

$$Eb - ce \geq 0. \tag{17}$$

The project monitoring effort of the manager rises with the monitoring level of the owner. If the owner does not monitor at all, the manager will shirk for sure. On the other hand, if the owner fully monitors the manager, the manager's effort is determined by b. We assume that the benefit is smaller than the marginal cost of fully monitoring one project, that is

Assumption 4 $b \leq c$.

This assumption implies that the FOC for the manager is always fulfilled with equality.

The owner decides the optimal level of her effort by maximizing profits:

$$\Pi = p^d r - y - \frac{c}{2}E^2$$

where $p^d = p_H - (1 - E)(1 - e)\Delta p$ is the overall probability that the project succeeds.

The FOC for the owner is given by:

$$(1 - e)\Delta p r - cE \geq 0. \tag{18}$$

Notice that if $e = 0$ the condition is the same as in the non-delegation case. Furthermore, if the probability of the manager shirking is very high (e is low), and the loan rate is sufficiently high for the expected return on the loan to cover the owner's monitoring cost, the owner will fully monitor the entrepreneur. For higher values

[17] We assume that the manager cannot share his private benefit with the owner.

of e the owner will not fully monitor the entrepreneur, but substitute some of her monitoring with the manager's monitoring.

Whether the FOC of the owner is fulfilled with equality or inequality depends on the value of b, since for given E, e is determined by b. For sufficiently high b the FOC of the owner is fulfilled with equality, and the optimal levels of effort are given by[18]

$$\hat{e} = \frac{\Delta pr}{\Delta pr + c^2/b}; \tag{19}$$

$$\hat{E}^d = \frac{c}{b}\left[\frac{\Delta pr}{\Delta pr + c^2/b}\right], \tag{20}$$

In this case the entrepreneur will not be fully monitored. The reason is that delegating monitoring to the manager introduces a new commitment problem for the owner. If the manager monitors all the time, the owner has no incentive to monitor, since monitoring is costly. On the other hand, the manager is induced to monitor by the threath of losing the private benefit when the owner finds out he is shirking. Thus, if the owner is not monitoring, the manager will shirk.

The magnitude of the commitment problem increases with b. Knowing that the manager has a strong incentive to monitor, the owner has little incentive to supervise him. Therefore an increase in b may reduce the *overall* monitoring level in the bank. Since $\hat{e} = \frac{b}{c}\hat{E}^d$, the derivative of the equilibrium probability of success, $\hat{p}^d = p_L + [\hat{E}^d + \hat{e}(1-\hat{E}^d)]\Delta p$, with respect to b is given by

$$\left[\frac{1}{c}\hat{E}^d(1-\hat{E}^d) + [1 + \frac{b}{c}(1-2\hat{E}^d)]\frac{dE}{db}\right]\Delta p. \tag{21}$$

From the equilibrium solution to E^d given by 19 it follows that $\frac{dE}{db} = -\frac{1}{c}E^2$. Substituting this into 21, one finds that the sign of 21 is determined by the sign of

$$(1-\hat{e})(1-2\hat{E}^d).$$

Hence, for $\hat{E}^d > \frac{1}{2}$, the equilibrium probability of success, $\hat{p}^d$, decreases with b.

Whether $\hat{E}^d > \frac{1}{2}$ depends on b and the loan rate. $\hat{E}^d$ decreases with b and takes its lowest value for $b = c$. This value is larger than $\frac{1}{2}$ for $r = R$, according to assumption 2. Thus, for $r = R$, $\hat{E}^d > \frac{1}{2}$ for all $b \leq c$. Hence, for $r = R$, $\hat{p}^d$ decreases with b, takes its smallest value for $b = c$, and this value is larger than $\frac{3}{4}p_H + \frac{1}{4}p_L$. In order to guarantee the existence of a benchmark equilibrium we assume

Assumption 5 $(\frac{3}{4}p_H + \frac{1}{4}p_L)R > y$.

One should note that although the delegation of monitoring to a manager lowers the expected return on the loan, due to the commitment problem, the banker may still have an incentive to delegate monitoring. Delegation confers savings on the owner's monitoring costs, since she can partly substitute her own monitoring with monitoring

[18] We have $E < 1$, when $b > c(1 - \frac{c}{\Delta pr})$.

by the manager, for which she does not bear any cost. In other words the owner can indirectly appropriate a part of the manager's private benefit. However, this is not the reason for delegation that we want to focus on. Instead we want to show that, when the bank is externally financed, delegation may actually increase the overall monitoring level in the bank. Let us therefore consider external financing.

• *One-project bank with manager* The owner decides the optimal level of her effort, given the interest rates, by maximizing profits:

$$\Pi = p^d r - (r_D - S_1^d) - \frac{c}{2}E^2,$$

where $S_1^d = (1 - p^d)r_D$ is the expected shortfall on the debt contract.

The FOC for the owner is given by:

$$(1 - e)\Delta p(r - r_D) - cE = 0. \tag{22}$$

It follows from assumption 3 that the owner will not fully monitor the entrepreneur, hence the FOC of an active bank will be fulfilled with equality. The optimal levels of effort can be derived from equations 17 and 22 :

$$\hat{e} = \frac{\Delta p\rho}{\Delta p\rho + c^2/b}; \tag{23}$$

$$\hat{E}^d = \frac{c}{b}\left[\frac{\Delta p\rho}{\Delta p\rho + c^2/b}\right], \tag{24}$$

where $\rho = (r - r_D)$ is the return to the banker, net of debt repayment. Because of the incentive problem of external financing, the owner never fully monitors the manager, and therefore the manager never fully monitors the entrepreneur. Hence, if the one-project bank is viable, it entails a solution where both manager and owner monitor, but neither of them fully monitors the entrepreneur.

On the other hand, delegation does alleviate the incentive problem of external financing. This is seen from a comparison of the FOC for the owner with the equivalent condition in section 4, that is, when the banker does not delegate monitoring to the manager. In that case the level of monitoring was given by:

$$\Delta p(r - r_D) - cE = 0.$$

The comparison shows that the banker's incentives to exploit depositors are lower in the delegation case, since $(1 - e)\Delta p r_D < \Delta p r_D$; the effect on the expected shortfall of a change in the owner's monitoring level is reduced by the manager's monitoring.

The reason for the bank not being viable in the non-delegation case is that even when $r_D = \frac{y}{p_H}$, the banker does not have the incentive to monitor the entrepreneur fully, and increasing the deposit rate to compensate for this increases the expected shortfall and thereby the incentive to exploit depositors.

In the delegation case the owner has less incentive to exploit depositors, because the impact of her monitoring on the expected shortfalls is reduced by the manager's

monitoring. It is even possible that the one-project bank with manager is viable, although the one-project bank without manager is not. If the owner could find a manager who very much wants the job for reasons of prestige, for example, the one-project bank would be viable, since hiring this manager would convince investors that there will be enough monitoring in the bank. Since we want to focus on *diversification as an incentive mechanism*, assume that *b is small enough for the one-project bank with manager not to be viable*, and consider the general case of a bank that finances m projects.

• *The m-projects bank with managers* Assume that the owner hires m managers to monitor m borrowers. The bank finances the lending with deposits. The expected return of the owner is:

$$\pi = \sum_{i=1}^{m} p_i^d r - (m r_D - S_m^d) - \frac{c}{2}(\sum_{i=1}^{m} E_i)^2, \tag{25}$$

where both the probability of success of project i, $p_i^d = p_H - (1 - E_i)(1 - e_i)\Delta p$, and the expected shortfalls on debt, S_m^d, depend on the monitoring efforts of the manager as well as of the owner.

For each project, the owner chooses the effort in order to maximize profits, that is

$$(1 - e_i)\Delta p r + \frac{\partial S_m^d}{\partial E_i} - c\sum_{i=1}^{m} E_i = 0, \qquad i = 1, ..., m, \tag{26}$$

while the optimal effort choice of manager i is given by

$$bE_i - ce_i = 0. \tag{27}$$

Substituting the FOCs of the managers into the FOCs of the owner gives

$$(1 - \frac{b}{c}E_i)\Delta p r + \frac{\partial S_m^d}{\partial E_i} - c\sum_{i=1}^{m} E_i = 0, \qquad i = 1, ..., m. \tag{28}$$

The solution to this system is symmetric and we denote the equilibrium effort level by $\hat{E}_m^d$.

The rational expectation equilibrium is given by the solution to the system of equations 26, 27, and the IR condition for investors:

$$r_D - \frac{1}{m} S_m^d = y. \tag{29}$$

We have ruled out the one project bank by assuming that the manager's private benefit is so low that there is a need for more supervision than the owner is willing to provide, as part of the benefits of monitoring accrues to depositors. However, as in the non-delegation case, diversification of the bank portfolio increases the owner's monitoring incentive, and we have the following result:

Proposition 2 *There is a marginal cost of fully monitoring one project for which a sufficiently diversified bank with managers can raise debt, although a one-project bank with manager cannot.*

PROOF It follows directly from the proof of Lemma 1 that as the number of projects increases, the derivative of the expected shortfalls with respect to E_i and the average expected shortfalls approach zero, if $[p_H - (1-\hat{E}_m^d)(1-\hat{e}_m)\Delta p]r > \hat{r}_D$. Then, as m increases, the FOCs for the effort choice of the owner approach for each i

$$(1-e_i)\Delta pr - c\sum_{i=1}^{m} E_i \geq 0. \tag{30}$$

If b is close to zero, $\hat{e}_i$ will be close to zero for all i. This means that the owner monitors the projects by herself, and it follows directly from the proof of Proposition 1 that there is a value of c and m for which there is a rational expectation equilibrium in this case.

For larger b, the owner substitutes her monitoring with monitoring by the manager, and the commitment problem reduces the overall monitoring level. However, we will show that for $b \leq c$ there is a bank size for which there is an equilibrium in which the bank is active.

Consider the case when $b = c = \frac{\Delta pr}{m}$. The owner's monitoring effort then approaches $\frac{1}{2}$ for each project and so does the monitoring effort of each manager as m goes to infinity. This implies that the success probability for each project in the bank approaches $\hat{p}_m^d = (\frac{3}{4}p_H + \frac{1}{4}p_L)$. Hence, if $r = R$, $y > p_H R(1-\frac{1}{m})$, and $\Delta p < \frac{4p_H}{m}$, assumptions $1-5$ hold and there is a bank size for which there is a rational expectation equilibirum. □

As in the non-delegation case, diversification reduces the owner's incentive to exploit depositors. Moreover, if costs rise sufficiently slowly in m for $\Delta pr \geq cm$ for an m for which the expected shortfalls are approximately zero, the owner's incentive problem could be resolved. However, even if there is no incentive problem connected to external financing, projects will not be fully monitored in the bank with managers due to the problem of the owner to commit to supervising her managers. Hence, if monitoring costs increase slowly with m, for a sufficiently large m, the monitoring level will be higher in the m-projects bank without managers.[19]

Assume instead that monitoring costs rise somewhat more rapidly with m so that $\Delta pr < cm$ for an m sufficiently large for the expected shortfalls to be approximately zero. In this case it is not possible fully to solve the owner's incentive problem and the projects will not be fully monitored in the bank without managers either. On the contrary, the monitoring level might now be higher in the bank with managers, because the monitoring intensities decrease less with c in the delegation case than in the non-delegation case. This is easy to see when $b = c$. Then the overall monitoring level in the delegation case is higher than in the non-delegation case, when $\frac{\Delta pr}{cm} < \frac{\sqrt{5}-1}{2}$. In this particular example $\hat{E}_m^d < 1/2$. This means that the overall monitoring level in the bank with managers increase with b so that for $b < c$ the monitoring level will be lower than in this example. On the other hand, since the monitoring level decreases

[19] As already discussed, this does not neccessarily imply that the owner would not like to hire managers, since her monitoring costs are lower when she delegates.

less with c when the owner delegates monitoring, *for larger c the owner may still prefer to delegate monitoring of the entrepreneurs to managers.*

Consider now a smaller bank. For a given cost structure, the incentive to delegate is stronger in a small bank than in a large and diversified bank, as the incentive problem of external financing is more troublesome in a small bank and this incentive problem is smaller in the bank with managers. This follows because for a given probability of success of the projects, $S_m^d = (1-e)S_m$. Hence, if monitoring costs rise rather rapidly with the number of projects, the banker is more likely to delegate.

6.2 Comment on monetary incentives

In the previous section we argued that the banker may prefer to delegate monitoring to managers, given that the manager derives a private benefit from the job. Assume now that the manager has no private benefit, but his incentive to monitor is determined by the wage he is paid by the owner. Why would the owner choose to delegate monitoring in this case? Consider first a bank that finances one project alone.

When the manager has no private benefit, the owner of a one-project bank cannot save on monitoring costs by delegating monitoring to the manager, since the expected wage payments have to cover the marginal cost of monitoring by the manager. On the contrary, delegation is more costly, because sometimes there is duplication of monitoring without any extra benefit. Hence, the only reason to delegate in this case is to increase the monitoring level in the bank.

Since the owner has no wealth of her own, the salary to the manager must be paid from the return on the loan. Thus, assume that the owner pays the manager w with $w \leq r - r_D$ when the project succeeds and the owner does not detect that the manager is shirking. The expected utility of the manager is then

$$U = [ep_H + (1-e)(1-E)p_L]w - \frac{c}{2}e^2,$$

and the FOC is

$$\Delta p w + Ep_L w - ce = 0.$$

The fact that the manager gets the salary only if the project succeeds implies that he has an incentive to monitor even if the owner does not monitor him at all. However, since w cannot be larger than $(r - r_D)$, it follows from assumptions 2 and 3 that it is not possible for the owner to induce the manager fully to monitor the entrepreneur unless she in turn monitors the manager.

For given interest rates the profits of the owner are:

$$\Pi = p^d(r - r_D) - [ep_H + (1-e)(1-E)p_L]w - \frac{c}{2}E^2,$$

and the FOC is

$$(1-e)\Delta p(r - r_D) + (1-e)p_L w - cE = 0.$$

The monitoring incentive of the owner is larger now than in the private benefit case, because the owner can save on the wage payments by detecting when the manager is

shirking. Furthermore, the incentive of the owner, as well as of the manager, increases with w. However, since w must be less or equal to $r - r_D$, the one-project bank might not be viable.

As in the private benefit case, diversification of the bank portfolio increases the owner's incentive to monitor the managers, and if monitoring costs increase sufficiently slowly with m, there should be a size at which the bank is viable. Furthermore, there should be cases in which the overall monitoring level is higher than in the bank without managers. Moreover, delegation may be cost-reducing even though there is some duplication of monitoring, since the owner with high monitoring costs can reduce her monitoring, while each manager is operating at the lowest possible monitoring cost.

In the delegation case, each unit of monitoring by the *manager* gives $\Delta pr(1-E)$ in extra return and costs c. In both the non-delegation and the delegation case, instead, each unit of effort by the *owner* gives Δpr in return but costs cm in an m-projects bank. For a large m and a low c, the equilibrium value of E is high in both the delegation and the non-delegation case, and there is no gain from delegation. However, for larger c there might be a benefit from delegating, since a larger c implies a lower equilibrium value of E, and therefore less wasteful duplication of monitoring.

Note that also when delegation is preferable, the optimal size of the bank is bounded. Increasing the size of the bank is costly because it increases the agency costs. In order to keep the same expected return on the loans when increasing the bank's size, the owner must either keep her own monitoring of each project constant, which due to overload is increasingly costly, or raise the salary of the managers. Hence, *given that intermediation is viable, there is an optimal bounded size of the bank.*

7 Conclusions

In credit markets with asymmetric information, monitoring may be crucial to finance profitable projects. Banks may arise as a response to the free-riding problem of small investors. However, when the outcome of monitoring depends on the monitor's effort, delegating the task of monitoring to a bank gives rise to an incentive problem for the agent performing the monitoring task. Consider a banker, who collects funds from investors to lend to entrepreneurs. This banker may have too low an incentive to monitor as she has to share the gains from monitoring with the investors, while bearing all the costs of monitoring herself.

We show that, if the banker is the bank's sole owner, financing the bank's lending with debt, then diversification of the bank portfolio increases the banker's incentive to monitor. Intuitively, when the bank is debt financed, the gains from monitoring accrue to the banker as long as the bank does not fail, and diversification reduces the probability of bank failure.

Increasing the size of the bank, however, is costly. For the banker, monitoring an increasing number of projects is increasingly costly as time becomes more and more scarce. Delegating the monitoring task to bank managers, on the other hand,

introduces an incentive problem for the manager. To reduce shirking by managers, the banker must exert effort in supervising them. Thus, further delegation of monitoring of borrowers to managers sometimes implies duplication of monitoring costs.

There will be less need for supervision, and therefore less duplication of monitoring, if the manager gets a higher return on effort than he would in alternative occupations. Furthermore, increasing the owner's monitoring incentive through diversification is less costly when the owner has to spend little time supervising each manager. This also implies that it is less costly to increase the bank's overall monitoring level, since sharing monitoring costs with the managers reduces diseconomies of scale in monitoring by reducing the "overload" of the banker. As long as there is some need for supervision, however, total monitoring costs will increase with bank size, and the optimal size of the bank will be bounded. We therefore consider that this model offers one explanation for why banking industries sometimes are quite fragmented.

Our results are complementary to previous research on financial intermediation in that we provide an additional reason for why banks should be diversified and mainly debt financed. To put it differently, we offer an explanation for why large and diversified banks can function with very little inside capital. A large shareholder is believed to be an important device for controlling managers, but the view also is that this would be a very costly way of controlling managers of large firms.[20] We show that a very small stake of the large shareholder is sufficient to provide her with the incentive to control managers in the interest of all claimholders, if the other investors hold debt and the bank is well diversified.

There is no role for capital requirements in our model, as inside equity is limited and the incentive problem is worse with outside equity than with debt. In practice, one motive for capital regulation is the well-known incentive of shareholders to exploit debtholders by taking on more risk. The incentive problem in this paper is closely related to this risk incentive; reduced monitoring is a form of increased risk-taking as it increases the probability that the bank will fail. Outside equity involves higher agency costs than debt in our model, because monitoring involves a private cost. If the agency cost instead was in the form of lower expected return only, the interests of inside equityholders would be totally aligned with the interests of outside equityholders, and the risk incentive would arise only from debt. Thus, our result that debt financing of the bank is next best to inside equity depends on the assumption that the bank only invests in assets that require monitoring. Of course banks also have the opportunity to invest in assets which do not require any monitoring effort, which then might motivate capital constraints, but equity's negative effect on the monitoring incentive must be traded off against the risk incentive of debt. Moreover, it is shown in Daltung (1994) that the risk incentive of debt is reduced by diversification. This means that our conclusion that capital constraints are more likely to bind in large banks with dispersed ownership would still hold true when the asset substitution problem is taken into account.

The paper also gives some insights into corporate finance. It provides an explana-

[20]See for instance Shleifer-Vishny (1995).

tion for why shareholders usually do not want their firm to diversify. In the model, if the bank is equity financed, diversification does not improve incentives to monitor, but it does increase monitoring costs. Thus, this suggests that if a firm is able to find a few large investors who are willing to finance the firm's projects, project financing is better than a conglomerate. What distinguishes the bank from the firm is that the bank collects funds from small investors, in which case project financing is not possible.

In this paper we have not addressed the issue of interbank competition for lending, but analyzed the monitoring decision for a given loan rate. One interesting issue for future research is whether competition worsens the banker's incentive problem. In this model, it is true that the incentive to monitor decreases with the loan rate. However, the question is to what extent bankers are able to internalize this effect and, related to this question, what is the effect of competition on the optimal size of the bank.

8 Appendix

Proof of Lemma 1 We have to show that $\frac{1}{m}S_m$ and $\frac{\partial S_m}{\partial E_i}$ approch zero as the number of projects increases, whenever the expected portfolio return is higher than r_D.

According to the Central Limit Theorem, the distribution of $z = \sum_{i=1}^{m} z_i$, the overall return on the bank portfolio, converges to a normal distribution with mean $\bar{z} = \sum_{i=1}^{m} p_i r$ and variance $\sigma^2 = \sum_{i=1}^{m} p_i(1-p_i)r^2$ as m goes to infinity. Thus, the expected shortfalls converge to

$$\int_{-\infty}^{mr_D} (mr_D - z)\frac{1}{\sqrt{\sigma^2}}\phi[\tilde{z}(z)]dz,$$

where

$$\tilde{z}(z) = \frac{z-\bar{z}}{\sqrt{\sigma^2}},$$

and $\phi(.)$ is the density function of a standard normal variable. The integral can be rewritten as

$$mr_D\Phi[\tilde{z}(mr_D)] - \int_{-\infty}^{mr_D} \tilde{z}(z)\phi[\tilde{z}(z)]dz + \int_{-\infty}^{mr_D} \frac{\bar{z}}{\sqrt{\sigma^2}}\phi[\tilde{z}(z)]dz.$$

From $\frac{d}{dx}\phi[x] = -x\phi[x]$, we get

$$S_m = \sqrt{\sigma^2}\phi[\tilde{z}(mr_D)] - (\bar{z} - mr_D)\Phi[\tilde{z}(mr_D)], \tag{31}$$

where Φ is the c.d.f. of a standard normal variable. The derivative of the shortfalls with respect to E_i is given by

$$\frac{\partial S_m}{\partial E_i} = \frac{1}{2\sqrt{\sigma^2}}(1-2p_i)\Delta p r^2 \phi[\tilde{z}(mr_D)] - \Delta p r \Phi[\tilde{z}(r_D)]. \tag{32}$$

Since $\tilde{z}(mr_D)$ goes to $-\infty$ as m goes to ∞, whenever $\bar{z} > mr_D$, the average expected shortfalls and the derivative of the shortfalls with respect to E_i approach zero as m goes to ∞, whenever $\bar{z} > mr_D$. □

9 References

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