Dipartimento Economia Politica e Aziendale
Università degli Studi di Milano

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Vittoria Cerasi - Sonja Daltung

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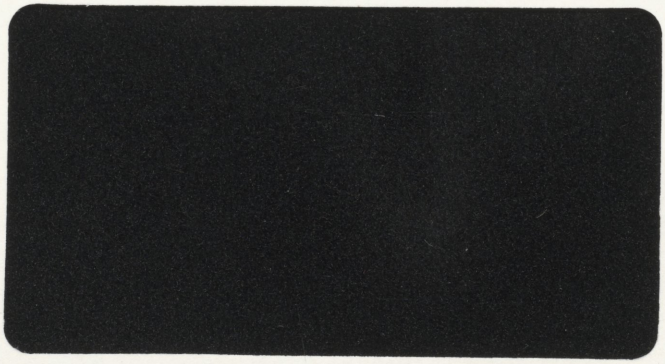

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The Optimal Size of a Bank: Costs and Benefits of Diversification [1]

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PRELIMINARY. COMMENTS WELCOME.

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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 owner can commit to a higher level of monitoring. By linking the benefits to the costs of diversification, the paper derives an optimal size of the bank, which is bounded. The costs of diversification are 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 are in increasing the incentives of the owner in supervising her managers and thereby increasing the overall level of monitoring of the bank.

1 Introduction

In the literature on financial intermediation there are several explanations for why banks should be large and diversified.

In credit markets, where information is asymmetrically distributed, banks fulfill a function as project evaluators and monitors of borrowers. As a consequence, bank assets are indivisible and illiquid. Through diversification the bank is able to transform illiquid assets into liquid liabilities. Furthermore, diversification on the asset side reduces the variance of the returns that accrue to claimholders of the bank, and this is beneficial when claimholders are risk-averse or if there are bankruptcy costs. Because of indivisibilities of bank assets, increasing diversification implies increasing the size of the bank. This suggests that there may be economies of scale in banking and that financial intermediation tends to be a natural monopoly. However, although many countries have concentrated banking systems, still many developed countries have quite fragmented systems. Furthermore, in the empirical literature on banking there is no sharp evidence in favour of economies of scale after a certain threshold. On the contrary, there is often evidence that banks of large size suffer a cost disadvantage.

One explanation, as we see it, for the discrepancy between the theory of financial intermediation and the empirical evidence is that the financial intermediation theory has not considered the issue of internal organization of banks. Loans are not monitored by the bank itself, but by people working for the bank. Since it is not possible for one person to monitor infinitely many projects, monitoring more loans entails a larger organization, and this increases the costs for the bank.

In this paper we want to provide a theory of the optimal size of a bank, taking as given the function of the bank as monitor of loans. The main idea 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 **owner** of the bank to monitor, **if the bank is debt financed**. Hence, diversification can be beneficial even though the bank does not provide any liquidity services, the claimholders of the bank are risk-neutral, and there are no bankruptcy costs. We also show that, if the bank is financed with outside equity, diversification does not improve the incentives of the bank owner to monitor.

This result can be intuitively explained as follows. Issuing debt is a way to change

the share of profits between the owner and the creditors, according to the performance of the portfolio of the bank; with equity instead this share is invariant to the performance of the portfolio. The portfolio performance depends, among other things, upon the level of monitoring of the owner. By changing the marginal incentive to monitor of the owner, diversification acts as a commitment to increase the effort of monitoring in the bank. More specifically diversification reduces the expected shortfalls on debt, that is the expected loss of depositors when the portfolio of the bank performs poorly. We show that this improves at the margin the monitoring incentive of the owner, improving the performance of the bank and reinforcing the positive effect on incentives.

On the cost side of diversification, we think it is reasonable to assume that there is limited ability to monitor, i.e. that it is increasingly costly to monitor several projects. As a consequence, in order to diversify the bank portfolio, the owner of the bank may hire managers to perform the monitoring task. If their interests are not perfectly aligned to those of the owner of the bank, there will be some cost arising from the agency relation, as the managers must be provided with incentives to monitor. In our model the monitoring effort of the owner affects positively the monitoring of the manager. However this is more costly the more projects there are, since increasing the number of projects causes "overload" in terms of the number of managers to monitor for the owner.

While the **costs of diversification** are due to the growing size of the organization needed to achieve diversification, the **benefits of diversification** derive from improving the incentives of the owner in supervising his managers.

Finally we think that no firm better than a bank can not only diversify, but also get outside financing mainly in the form of debt. Therefore this model can be used to explain why banks diversify and engage in financial intermediation.

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

2 Relation to the literature

This paper is closely related to **Diamond (1984)** where financial intermediation arises as an efficient arrangement to delegate 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 diseconomies of scale in monitoring and there are no costs of bank failure.[1]

In our paper we introduce the assumption that agents have limited ability to monitor. **Krasa-Villamil (1992)** examine the effect of limited ability to monitor the bank by depositors. Their finding is that, even if monitoring costs of depositors are increasing with respect to the size of the bank, there are increasing returns to scale in financial intermediation. In our paper this assumption allows us to explain why the optimal size of intermediaries is bounded.

Holmstrom-Tirole (1994) studies the case in which financial intermediaries monitor entrepreneurs with low collateral, who are not able to finance investments directly. Because the bank is externally financed, it needs to invest some capital of its own 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 it more efficiently than credit markets. However they exclude diversification by assuming perfect correlation between projects.[2]

There are no papers, at least that we are aware of, which focus on the agency costs inside the bank to explain the scale of activity. There are few papers on the internal organization

[1] Diamond compares delegated monitoring by a bank to direct monitoring. The cost of direct monitoring increases proportionally with the number of projects, while the cost of delegated monitoring increases less than proportionally. Delegated monitoring involves fixed cost, given by the cost of verification for each project plus a non-pecuniary penalty in case of bankruptcy of the intermediary. As the number of projects increases the likelihood of bankruptcy goes to zero, and so the non-pecuniary penalty. Therefore delegated monitoring is more efficient when there is enough diversification, as it avoids duplication of the costs of verification. Diamond assumes that the bank will always monitor the projects, however this is a convenient arrangement and creditors will accept to lend to the bank, only when there is diversification, 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 convince the claimholders that she is going to monitor each project enough to avoid bad performances of the bank by diversifying the portfolio of the bank.

[2] The rational to assume perfect correlation 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 showing that it is never optimal to have perfect diversification. Hence only up to a certain level it is optimal to finance a growing firm by debt. Afterwards debt doesn't provide any additional benefit, and one may think that equity could be efficiently used.

of the bank, and they mainly focus on the effect of the organization on the ex-ante screening activity of projects that require financing.[3]

Our idea of the design of the internal organization of the bank is inspired by **Quian (1994)**, in which agency costs arise because of limited ability to monitor by the owner. However in his paper the owner has no incentive problem at all and always exerts the maximum effort to monitor. The different ingredient in our paper is that the owner has somehow to be given incentives to exert this effort.

This paper is closely related to the literature on incentives to monitor. **Aghion-Tirole (1994)** and **Burkart-Gromb-Panunzi(1994)** relate the incentives to monitor to control rights and return rights. However both these papers are concerned with the optimal amount of monitoring by the owner, while we assume that monitoring is always good and needs to be incentivated.

In **Aghion-Tirole (1994)** there is the idea of "overload" in organizations, which constitutes the costs of diversification in our paper. In their paper monitoring by the owner has a cost since it reduces the initiative of the manager. They suggest for example to induce some "overload", by increasing the span of control of the owner in order to reduce her monitoring. In our paper increasing the span of control may induce more monitoring by the owner, although it increases the cost of monitoring.

Burkart-Gromb-Panunzi(1994) show that the optimal amount of monitoring in a firm can be choosen by setting the financial structure of the firm. In particular that there may be advantages from having a mix of large and small shareholders among the creditors of the firm in order to commit not to monitor too much when the initiative of the manager is important.

Dewatripont-Tirole (1994) explore the issue that the financial structure may be used as an incentive scheme to increase the effort of the manager of the bank. Despite sharing the same flavour, our paper is more concerned with the issue of diversification of claims.

Finally the idea that diversification of the bank portfolio reduces the incentive of the bank owner to exploit depositors, which is the driving force of the results in our paper, is in **Daltung (1994)**. However we apply it to the monitoring incentive of the bank owner and to study the effect on the internal organization of the bank.

[3]See for example **Sah-Stiglitz(1986)** and **Gehrig (1994)**.

3 The model

In our economy there are four types of agents: entrepreneurs, investors, bankers and bank managers.

The **entrepreneurs** have projects, but need to get financing. If the project succeeds it returns R; if it fails, it returns nothing. The probability of success depends on the behavior of the entrepreneur. If the entrepreneur is behaving 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 him a private benefit B. Then the project has a lower probability to succeed, $p_L < p_H$ ("the entrepreneur chooses the bad project").

The **investors** have capital, but no ability to monitor entrepreneurs. They can either finance entrepreneurs directly, or finance bankers. They have also access to an alternative investment that yields a safe return y.

The **bankers** have no capital, but they have bank charter, which means that they can raise capital from investors. Bankers can, by monitoring, induce the entrepreneur to behave ("choose the good project").

Finally the **bank managers** have access to the same technology of monitoring as the bankers, but they have no bank charter. However we assume that they have a private benefit from the job, b, which they loose if they are fired.[4]

All agents are risk-neutral. Moreover entrepreneurs, bankers and bank managers have limited liability (LL) since they are initially resourceless.

The **monitoring technology** is such that, by choosing the level of effort ω, 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 choosen instead. When $\omega \geq 1$ the agent will learn with certainty the behavior of the entrepreneur, but since monitoring a project has a cost in terms of disutility of effort, increasing in the effort level, the agent will never choose ω larger than one.

There is **limited ability to monitor** in the sense that it is increasingly costly for one person to monitor an increasing number of projects. More specifically we assume that to

[4] We start by analysing the case with private benefits, without introducing monetary incentives. Later we will see how monetary incentives change the analysis.

monitor m projects, each one with probability ω_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 one project. We will denote the monitoring effort of the banker by E and the effort of the manager by e.

We are going to make few assumptions to start with.

Assumption 1 $p_H R - y - c > 0 > p_L R - y$

Hence, the project is socially valuable, if the probability of success is high, but not if it is low. For this reason we refer to the first type as good projects and the latter as bad projects. Moreover, to make a strong case for monitoring we assume that the good project is sufficiently profitable to recover the marginal cost of monitoring one project all the time.

Assumption 2 $p_L R + B > p_H R$

The entrepreneur always prefers the bad project because he can divert a private benefit B. Since investors are not able to monitor, they cannot stop the entrepreneurs from choosing bad projects.

Observation 1 *No direct credit will take place.*

There are good projects which can be valuably financed. However without monitoring, entrepreneurs would choose bad projects. Since entrepreneurs know that investors are not able to monitor, they will always misbehave. Hence direct credit is excluded by lack of ability to monitor by investors.

On the other side bankers are able to monitor, and can possibly induce the entrepreneurs to choose the good projects. However they do not have the money to finance the entrepreneurs directly, but they need to obtain external finance from the investors. For investors to be willing to finance the banker, they must be convinced 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 comes with a private cost, the manager would like to avoid to monitor while keeping the job. A banker, by hiring a manager, can save on her own monitoring cost,

but still needs to monitor the manager to make sure that he will monitor the entrepreneur. Assume that the banker hires no more than one manager for each financed project.[5] We are going to show that delegation might be optimal, when there is need for diversification.

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

- The loan rate (r = gross interest rate) is determined;
- the decision whether to hire managers is taken;
- the number of projects m to be financed is choosen;
- the financial structure of the bank is determined: debt (r_D = gross interest rate) or equity ($1-\alpha$ = amount of retained equity);
- the monitoring efforts (E_1, e_1), (E_2, e_2), ...(E_m, e_m) for each project are determined;
- payments are made in accordance with the financial contracts.

The entrepreneur obtains credit through a debt contract that requires r to be paid out when the project succeeds, with $r \leq R$.[6] In this analysis, we will take the loan rate r as given. In particular we assume that the loan rate fulfills

Assumption 3 $p_H r - y - c > 0$

whereas we leave for future work the analysis of competition among banks.

Finally we assume that investors can observe the number of projects m, but not the monitoring efforts before investing, i.e. that the efforts (E_i, e_i) are not contractible. In equilibrium however investors are rational and require the expected portfolio distribution to coincide with the true distribution of the portfolio of the bank.

[5] It could turn out that it is more efficient to hire a manager to monitor several projects at the same time. However we are interested in finding a reason for delegation. If there are benefits for delegation in this case, it must also be true for optimal delegation.

[6] Notice that we could also assume that $r = R$, i.e. that the entrepreneur gets zero profits from the project. The important assumption is that monitoring is necessary to get the good projects and that reducing r alone is not enough to induce the entrepreneur to choose the good project. It is enough to say that the private benefit is large enough, i.e. $B > \Delta p(R - r)$ where $r \geq \frac{y}{p_H}$.

4 The incentive problem of the banker

The banker does not have any initial wealth, but has to borrow from investors to finance entrepreneurs. Since the monitoring effort is not contractible, the banker is subject to moral hazard. To illustrate the incentive problem let us first consider the case in which the banker is financing the projects herself.

• *The benchmark: full liability* The banker decides how many projects to finance, and 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 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 each project 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 number of projects m to finance, the banker chooses the amount of monitoring effort for each project in order to maximize the overall profits of the bank. The first order conditions (FOCs) for the optimal effort choice are

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

The derivative of the profit function with respect to the effort must be non-negative. Whether the FOCs are fulfilled with equality or not depends upon the loan rate r and the number of projects. Note that, if the FOCs are fulfilled with inequality, $E_i = 1$ for all i. On the other hand, if the FOCs are fulfilled with equality, there are many different individual monitoring levels that solve the system of FOCs, but there is one unique total effort level. Furthermore, due to limited ability to monitor, when m increases, the monitoring level for some of the projects must eventually decrease.

The optimal size of the bank is given by

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

Note that, if the FOC for the optimal effort choice given by 2 is fulfilled with equality, the second term in 3 is equal to zero. In this case profits are decreasing in m, since $p_L r < y$

by assumption 1. This means that the banker chooses m as small as possible. However for $m = 1$, given assumptions 1 and 3, $\Delta pr - c > 0$, thus the FOC in 2 will be fulfilled with inequality and $E = 1$. This means that the derivative with respect to the total effort is equal to 1, and the optimal size of the bank is given by

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

Since $y > p_L r$, the FOC for an optimal effort choice is fulfilled with inequality, for all the m for which equation 4 is fulfilled. Hence **the optimal number of projects is given by equation 4, and $E_i = 1$ for all i.**

Whether the optimal number of projects is larger than 1 rests on the loan rate. The banker chooses $m > 1$ only if the expected return on the loan is larger than the marginal cost of the effort. Furthermore, since the marginal revenue of increasing the size is constant, while the marginal cost is increasing in m, **the optimal size of the bank is bounded.**

Now consider the case in which the banker has to rely on outside finance. Let us focus on the case of a banker who finances one project alone ($m = 1$) to show that outside finance introduces an incentive problem for the banker.

• *The one-project bank with equity* Let us analyze the case in which the banker finances one project by issuing equity. Suppose the banker retains $(1 - \alpha)$ of the future profits, while promising α to outsiders. For a given share of retained equity $(1 - \alpha)$, the optimal effort of the banker is determined by maximizing the expected profits:

$$\Pi = (1 - \alpha)pr - \frac{c}{2}E^2$$

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

$$\Delta pr - \alpha \Delta pr - cE \geq 0 \tag{5}$$

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

$$\Delta pr - cE \geq 0 \tag{6}$$

We can say that the incentive to exert monitoring is lower in the case with outside finance, because the gain from increasing the effort is partly expropriated by the outsiders, who do not bear the cost of the monitoring.

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 compared to the alternative return y. Thus, α must fulfill the individual rationality (IR) condition for investors.

$$\alpha \hat{p}_1 r = y \tag{7}$$

where $\hat{p}_1$ is the expected probability of success of the project.

Assume that investors believe that the banker will monitor the project all the time. Then

$$\alpha = \frac{y}{p_H r} \tag{8}$$

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

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

In order to focus on the incentive problem that arises from outside finance we will assume the opposite, that is

Assumption 4 $p_H r - y - \frac{p_H}{\Delta p} c < 0$

It is easy to show that given assumption 4 there is no solution to the system of equations 5 and 7. This means that there is no rational expectation equilibrium in which investors are willing to buy the equity of the bank. Hence the **one-project bank is not viable**, when equity financed.

From the agency literature we know that the incentive problem could be resolved by making the banker residual claimant of the net profits of the bank. That is, if investors receive a safe return y in all states of nature, while the residual return accrues to the banker. However, this is not possible as the banker has no initial wealth and is protected by limited liability. In fact, we will show that given our assumption about the distribution of the return of the project, the debt contract when $m = 1$ is identical to the equity contract. As a consequence also the one-project bank financed by debt is not viable.

• *The one-project bank with debt* The banker receives external financing promising the interest rate r_D. Given limited liability by the banker, the creditor will receive r_D only when the project succeeds, i.e. delivers r to the bank, and 0 otherwise. Hence the expected return of the debt contract is:

$$p r_D = r_D - S_1$$

where $S_1 = (1-p)r_D$ is the shortfall on the debt contract and p the probability that the project succeeds. In other words we can describe the debt contract as a promise to pay r_D in every state of the world, however in some states we know ex-ante that the promise will not be kept. The savings for the debtor is what we call "shortfall" on the debt contract. In our case, when $m = 1$, this shortfall S_1 is the difference between the amount promised r_D and the amount recovered when the project fails, that is nothing, in expected terms.

The banker decides the optimal level of her effort, given the interest rate r_D, by maximizing profits:

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

where again $p = p_L + E\Delta p$ is the probability that the project succeeds. Notice that the banker takes as given the interest rate r_D to be repaid to the creditor, however is aware that her action is going to affect the shortfall on the debt contract. In other words she knows that if she monitors less, the probability that the loan succeeds decreases and the shortfall increases.

The FOC now is:

$$\Delta pr - \Delta p r_D - cE \geq 0 \tag{9}$$

From this equation we see that the FOC is more likely to be fulfilled with equality than in the case of full liability, given by equation 6. The intuition rests on the second term of the FOC. The banker, by increasing her monitoring effort, increases the probability that the depositor gets r_D. By marginally increasing the monitoring, the probability of success of the project increases by Δp. Hence $\Delta p r_D$ is the increase in the expected repayment to depositors. The banker is then less willing to increase her monitoring effort, since part of this investment is going to benefit depositors. Alternatively, we can say that the incentive to exert effort is lower when the bank is debt financed with respect to the benchmark case, because there is an incentive to exploit depositors by shifting part of the losses due to low monitoring on their shoulders. This effect comes from the assumption of limited liability for the banker.

Result 1 *The incentive problem of a banker, who finances only one project, is the same whether the bank is debt or equity financed. In either case the one-project bank is not viable.*

PROOF At equilibrium the interest rate is determined by the IR condition for investors

$$r_D - S_1 = y \tag{10}$$

where $S_1 = (1 - \hat{p}_1)r_D$ and $\hat{p}_1$ is the expected probability of success of the project. In the rational expectations equilibrium it must be true that

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

and since expectations of rational investors are not affected by the financial contract, i.e. $\alpha r = r_D$, it follows that there is no solution to the system of equations 9 and 10. □

5 Diversification and incentives

We have shown that the need for external finance introduces an incentive problem for the banker and that this incentive problem could be sufficiently severe for the bank not to be viable if only one project is financed. In this section we examine whether the incentive problem could be alleviated by increasing the size of the bank, i.e. by financing more than one project.

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

In this section we will show that diversification of the bank portfolio can mitigate the incentive problem of the banker, when the bank is debt financed. However, it requires monitoring costs to increase sufficiently slowly with respect to the number of projects to be monitored. In the next section, we consider delegation of the monitoring task to managers as a way to reduce monitoring costs.

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

$$\Pi = \sum_{i=1}^{m} p_i r - (m r_D - S_m) - \frac{c}{2}(\sum_{i=1}^{m} E_i)^2 \qquad (11)$$

where $p_i = p_L + E_i \Delta p$ is the probability of success of project i, while S_m is the expected shortfalls on the contract signed with depositors. Let us define the shortfall on debt in this case.

• *Digression: "shortfalls" on debt contract* The shortfalls on debt are the savings of the banker on the repayment to depositors. The bank promises to its depositors the rate r_D when the bank is solvent, i.e. whenever:

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

where z_i is the realization of project i. Otherwise the bank is declared bankrupt and depositors loose on the promised amount mr_D. The amount of this loss in expected terms is what we call "shortfalls". The shortfall depends on the degree of monitoring by the banker. As will be discussed below, in equilibrium the banker will monitor all projects with the same intensity, which implies that every project will have the same probability of success p. This in turn implies that, in equilibrium, the total returns on loans, $z = \sum_{i=1}^{m} z_i$, is r times a binomial random variable with parameters (m, p), and has the following distribution:

$$z = \begin{cases} 0 & r & 2r & \cdots & mr \\ (1-p)^m & mp(1-p)^{m-1} & \frac{m}{2}(m-1)p^2(1-p)^{m-2} & \cdots & p^m \end{cases}$$

The shortfall on total debt is given by the expected loss when the total returns are lower than mr_D. Let's assume that mr_D is somewhere between $(n-1)r$ and nr, where $1 < n < m$. To compute the expected loss for depositors we can start from the event that the total returns happen to be 0. In this case the loss on the promised amount will be mr_D and the probability that this happens is $(1-p)^m$. However the total returns from the projects can be slightly better, i.e. r. Still the depositors will not get back the amount promised, hence the loss is now $mr_D - r$ with probability $mp(1-p)^{m-1}$. And we can go on up to the realization where the loss is null. The shortfall is the expected loss:

$$S_m = mr_D(1-p)^m + (mr_D - r)mp(1-p)^{m-1} + (mr_D - 2r)\frac{m}{2}(m-1)p^2(1-p)^{m-2} + \cdots$$

So in general we can say that for any m the shortfall is the above sum, which entails more and more terms depending upon the amount of total interests mr_D. □

For each project i, the banker chooses her effort so as to maximize profits, that is

$$\Delta pr + \frac{\partial S_m}{\partial E_i} - c\sum_{i=1}^{m} E_i \geq 0 \tag{12}$$

Notice that again the FOC for the effort choice migth be fulfilled with inequality, because the banker never chooses E_i larger than one. However, in contrast to the full liability case, 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 $\hat{E}_m$.

If we compare the FOC in equation 12 with the FOC for a fully liable bank given by equation 2, we see that the difference stems from the derivative with respect to the expected shortfalls. As increased monitoring shifts the distribution of z to the rigth, this term is negative and

therefore tends to reduce the amount of monitoring by the banker. The intuition is the following: a higher effort level would reduce the expected shortfalls on the debt payments, but since depositors cannot observe the effort of the banker it would not lead to a lower deposit rate. Therefore part of the benefit accrued by monitoring would go to depositors, and this reduces the incentive to monitor of the banker.

The FOC depends on the deposit rate, since the expected shortfalls do so. The banker sets the lowest deposit rate for which investors are willing to deposit at the bank. Investors cannot observe the effort choice of the banker, but they have rational expectations about the behavior of the banker. The banker takes into account that the deposit rate has to fulfill the IR condition for the investors given by

$$r_D - \frac{1}{m} S_m = y \tag{13}$$

From the IR condition we see that the deposit rate will be closer to y, the lower is the expected shortfalls per unit of debt.

Proposition 1 *Given that monitoring costs are increasing sufficiently slowly in m, there is a size of the bank for which there exists a rational expectation equilibrium in which the banker chooses a sufficiently high effort level such that investors are willing to deposit at the bank.*

PROOF We will show 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 the marginal monitoring cost is sufficiently small. The motivation is that, as m increases, the distribution of the average return on the loans, $\bar{z} = \frac{1}{m}\sum_{i=1}^{m} z_i$, becomes more and more concentrated around its mean, pr; and pr will be larger than y, if c is sufficiently small.

If the expected shortfalls and its derivative with respect to E_i is approaching zero, the FOC conditions for the optimal effort choices for each i approaches

$$\Delta pr - c\sum_{i=1}^{m} E_i \geq 0 \tag{14}$$

and the IR condition for investors approaches

$$r_D = y \tag{15}$$

Hence, if c is sufficiently small, $\hat{E}_m$ will be large enough for $pr > r_D$.

According to the Central Limit Theorem, the distribution of $z = m\bar{z}$, the overall returns on the bank portfolio, converges to a normal distribution with mean $\sum_{i=1}^{m} p_i r$ and variance $\sum_{i=1}^{m} p_i(1-p_i)r^2$ 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

$$\tilde{z}(z) = \frac{z - \sum p_i r}{\sqrt{\sigma^2}}$$

with $\sigma^2 = \sum_{i=1}^{m} p_i(1-p_i)r^2$, and $\phi(.)$ being the density function of a standard normal variable.

By solving the integral, as in Daltung (1994), the expected shortfalls can be rewritten as

$$S_m = \sqrt{\sigma^2}\phi[\tilde{z}(mr_D)] - (\sum_{i=1}^{m} p_i r - mr_D)\Phi[\tilde{z}(mr_D)] \tag{16}$$

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

$$\frac{\partial S_m}{\partial E_i} = \frac{1}{2\sqrt{\sigma^2}}(1-2p_i)\Delta p r^2 \phi[\tilde{z}(r_D)] - \Delta p r \Phi[\tilde{z}(r_D)] \tag{17}$$

From these equations follow that, when E_i is sufficiently large for pr to be larger than the deposit rate, as m goes to infinity, the average expected shortfalls and the derivative of the shortfalls with respect to E_i approach zero. Since the expected shortfalls and the derivatives of the shortfalls are continuous in m, for sufficiently large m, there is a rational expectation equilibrium in which $\hat{E}_m$ is sufficiently large for investors to be willing to deposit at the bank, given that c is sufficiently small. □

The incentives to monitor of the banker improve with the size of the bank. The intuition is that, as the number of projects increases, the bank becomes more diversified and is less likely to fail. This means that the debt contract approaches the full liability contract in which the bank always repays its debt. If costs are increasing sufficiently slowly in m for the increased expected return on the loan, due to intensified monitoring, to outweigh the increased costs at a high monitoring level, there is a size for which a *m-projects bank* becomes viable. However, **because marginal costs are increasing in m, this size is always bounded.**

What size of the bank 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 exert enough monitoring. In this case we can substitute the IR condition of investors into the profit function of the banker given by equation 11, and so the FOC for an optimal size becomes

$$\frac{d\Pi}{dm} = p_L r - y + \frac{\partial(\sum_{i=1}^{m} E_i)}{\partial m}[\Delta p r - c\sum_{i=1}^{m} E_i] = 0 \tag{18}$$

This condition looks exactly the same as the FOC for the optimal size in the benchmark case given by equation 3. In fact, if $\hat{E}_m = 1$, the optimal size is the same as in the benchmark case. Or in other words, if the optimal size of the fully liable bank is sufficiently large for the externally financed banker to choose $E = 1$, she will choose this size of the bank. Denote this size by s.

Assume now that $\hat{E}_s < 1$, so that the FOC of an optimal effort choice given by 12 is fulfilled with equality. We know that in this case the bank cannot be perfectly diversified at s, since then $\hat{E}_s = 1$. Hence the term within in the square brackets in 18 is positive, and it is possible that the banker would like to increase the size of the bank above s in order to increase the monitoring level, but **the bank will not be perfectly diversified.**

Finally, it is possible that the bank is not even viable at s, and then the banker must choose a larger size than in the benchmark case, but again the bank will not be perfectly diversified.

5.2 Why diversification does not help with equity?

Let us see why diversification does not help in case the bank is financed by equity.

The banker chooses the monitoring effort for each project i, by maximising the expected profits:

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

For each i, the FOC is:

$$(1-\alpha)\Delta p r - c\sum_{i=1}^{m} E_i \geq 0 \tag{19}$$

Comparing this condition to the one-project case, given by equation 5, we can say that for a given α, the level of monitoring in a *m-projects bank*, financed with equity, is lower than in a *one-project bank*.

Proposition 2 *Independently of the size of the bank, there is no rational expectation equilibrium in which the banker chooses a sufficiently high effort level for investors to be willing to subscribe the equity claims of the bank.*

PROOF The rational expectation equilibrium is given by the FOC in equation 19 and the IR condition for the investors

$$\alpha mpr = my$$

For a given promised share to outsiders α, the left hand side of the FOC is strictly decreasing in m. The expected return on bank loans increases at a constant rate with m, while the monitoring cost is increasing at an increasing rate. The IR condition for investors, on the other hand, is independent of the size of the bank. Thus given that there is no rational expectation equilibrium in which investors are willing to invest in the *one-project bank*, there is no such equilibrium for any larger size either. □

Diversification of the bank portfolio does not improve the incentive to monitor of the banker, if the bank is equity financed. Thus, there is no gain that outweighs the increased monitoring costs.

We can conclude that, if for a *one-project bank*, the expected effort level were too low to convince the investors to finance the bank, this is still true for the *m-projects bank* with equity. Hence diversification does not help if the bank is equity financed.

5.3 Discussion of the results

Outside finance gives rise to an incentive problem for the banker, because the monitoring level is not observable to outsiders. By assuming that $c > \Delta pr - \frac{\Delta p}{p_H} y$, we have assumed that the incentive problem is sufficiently severe for the one-project bank not to be viable. Depositors know that any positive expectations about the monitoring level in the bank would not be fulfilled. Thus, they perceive that the monitoring level will be too low for the investment to return at least y. Now let's see why a diversified bank can obtain funds in the credit market. If the bank finances m projects, the FOC is given by equation 12

$$\Delta pr + \frac{\partial S_m}{\partial E_i} - c \sum_{i=1}^{m} E_i \geq 0$$

The incentive problem arises from the second term. If the banker increases her monitoring, part of the benefits will accrue to depositors in the form of reduced shortfalls. Assume

now that depositors believe that the monitoring level in the bank is high. Will then the banker actually choose a high monitoring level? It depends on the size of the bank, because the larger the bank, the smaller is the effect on the expected shortfall of a change in the monitoring level.

The gains from an increase in the effort of the owner accrue to the owner if the bank does not fail. A lower shortfall implies that a larger share of the gain from monitoring goes to the owner, which increases her incentive to monitor. This is the virtuous circle through which diversification helps.

This result cannot be achieved through equity, because it involves a way to split returns uniformly across all the possible states of the world. As m increases, there is no way to change the distribution of the gains from monitoring between creditors and owner for each state of the world.

Debt is a mechanism through which it is possible to commit to exploit less depositors, so that they will be more willing to lend money to the bank.

6 Incentives to delegate

In the previous section we have shown that a debt financed bank may be able to exploit the advantages of diversification. However, we required costs to increase not too rapidly in the size of the bank. In this section we examine whether delegating monitoring to managers can be a way to keep costs down. If each manager is monitoring only one project, he does not face any overload costs. Thus if the interests of the managers were totally aligned to those of the owner of bank, delegation would result in increasing returns to scale in financial intermediation. However, because monitoring efforts are not contractible, there will be some costs arising from the agency relation between owner and managers. Since these agency costs are increasing in the size of the bank, it is not obvious that the owner prefers to delegate monitoring to managers.

We first analyze the case in which managers derive only private benefits from the job, and then discuss monetary incentives.

6.1 Private benefits

The way the owner can induce the manager to monitor is by threatening to fire him if he is shirking, since the manager fears to lose his private benefit. Hence the manager will be

fired every time the owner finds out that the project is bad. Moreover, when finding a bad project, the owner by directly intervening can induce the entrepreneur to choose the good project.

Let us start with the case of a bank that finances one project with debt.

• *The one-project bank with manager* The owner of the bank hires a manager to monitor the project of the entrepreneur. Since the manager has some private cost from monitoring, he is going to shirk with some positive probability, unless the owner is monitoring him all the time. 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 to monitor the manager, and e is the effort of the manager to monitor 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 finds out that the manager is shirking, and the manager loses b.

The FOC for the manager is given by:

$$Eb - ce = 0 \tag{20}$$

The manager exerts more effort in monitoring the project if the owner increases the level of her effort. If the owner is not monitoring at all, the manager will shirk for sure.

The owner decides the optimal level of her effort, given the interest rate r_D, by maximizing profits:

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

where $p^d = p_H - (1 - E)(1 - e)\Delta p$ is the overall probability that the project succeeds, $\Delta p = p_H - p_L$ is the difference in the probabilities of success and $S_1^d = (1 - p^d)r_D$ is the shortfall on the debt contract.

The FOC for the owner is given by:

$$(1 - e)\Delta p(r - r_D) - cE = 0 \tag{21}$$

Notice that if the manager increases his monitoring effort, the optimal level of monitoring of the owner could be reduced.

Let us compare the FOC condition for the owner to the equivalent condition in section 4, i.e. when the banker does not delegate the job of monitoring to the manager. In that case the level of monitoring was given by:

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

Notice that the level of effort in the non-delegation case corresponds to the case where $e = 0$. When delegating monitoring to the manager, the owner reduces her own monitoring. This does not necessarily mean, however, that the overall level of monitoring in the bank will be lower, since now the owner can substitute her monitoring with the monitoring of the manager. The probability of success of the project is given by $p_L + [e + E(1 - e)]\Delta p$. Hence when e is close to one, the owner can reduce her own monitoring without affecting too much the overall probability of success.

Notice also that the incentives to exploit depositors are lower in the delegation case, since $(1 - e)\Delta p r_D < \Delta p r_D$.

The optimal levels of effort can be derived from equations 20 and 21 :

$$\hat{e} = \frac{\Delta p \rho}{\Delta p \rho + c^2/b} \tag{22}$$

$$\hat{E}^d = \frac{c}{b}\left[\frac{\Delta p \rho}{\Delta p \rho + c^2/b}\right] \tag{23}$$

where $\rho = (r - r_D)$ is the return to the banker, net of debt repayment. Notice that from assumption 4 it follows that both levels are strictly less than 1. Hence, if the one-project bank is viable, it entails a solution where both manager and owner monitor, but not all the time.

The reason for both monitoring intensities to be less than one is that delegating monitoring to the manager introduces a new commitment problem for the owner, which has nothing to do with the incentive to exploit depositors. 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 that he is shirking. Thus, if the owner is not monitoring, the manager will shirk.[7]

[7]The condition for this equilibrium to be stable, is

$$\frac{b\Delta p \rho}{c^2} < 1$$

Hence, there are no stable equilibria for b very large. This can be interpreted as the commitment problem being worse for large b. The owner, knowing that the manager has very strong incentive to monitor has very small incentive to monitor herself.

Why would the owner like to delegate monitoring? First, delegation allows to save on monitoring costs by the owner, since she can partly substitute her own monitoring with the monitoring of the manager, for which she does not bear any cost when there are private benefits. In other words, a given probability of success of the project is cheaper in terms of disutility of effort for the owner when she can delegate.

Second, for a given deposit rate, delegation might increase the overall monitoring level in the bank. It is even possible that the one-project bank with manager is viable, although the one-project bank without manager is not viable.

The reason for the bank not to be 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 all the time, and increasing the deposit rate to compensate for this, increases the expected shortfall and thereby the incentive to exploit depositors.

In the delegation case, however, the incentive of the owner to exploit depositors is smaller, because the impact of her monitoring on the expected shortfalls is reduced by the monitoring of the manager. Given the monitoring of the owner, the level of monitoring of the manager is determined by b.

Thus, if the owner could find a manager, who likes very much to be a bank manager for reasons of prestige for example, the one-project bank could 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**, we will assume that **b is small enough for the one-project bank with a manager not to be viable.** In particular we assume that $b \leq c$.

Let us now 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:

$$\pi = \sum_{i=1}^{m} p_i^d r - (mr_D - S_m^d) - \frac{c}{2}(\sum_{i=1}^{m} E_i)^2 \tag{24}$$

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

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

$$(1 - e_i)\Delta pr + \frac{\partial S_m^d}{\partial E_i} - c\sum_{i=1}^{m} E_i = 0 \tag{25}$$

while the optimal effort choice of each manager i is given by

$$bE_i - ce_i = 0 \tag{26}$$

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

$$(1 - \frac{b}{c}E_i)\Delta pr + \frac{\partial S_m^d}{\partial E_i} - c\sum_{i=1}^{m} E_i = 0 \qquad i = 1, ..., m \tag{27}$$

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 27 and the IR condition for investors:

$$r_D - \frac{1}{m}S_m^d = y \tag{28}$$

We rule out the *one project bank*. It is not viable, because the owner has to monitor the manager to induce him to monitor, but the owner's incentive to monitor is too weak because part of the benefits of monitoring accrues to depositors. However, as in the non-delegation case, diversification of the bank portfolio increases the monitoring incentive of the owner and we have the following result:

Proposition 3 *Given that the good project is sufficiently profitable and monitoring costs are increasing sufficiently slowly in m, there is a size of the bank for which the overall level of monitoring in the bank is high enough to convince investors to deposit at the bank.*

PROOF We will show 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.

The argument is similar to that given in the proof of proposition 1. The distribution of the total returns on the loans converges to a normal distribution with mean $\sum_{i=1}^{m} p_i^d r$ and variance $\sum_{i=1}^{m} p_i^d(1 - p_i^d)r^2$ as m goes to infinity, and the shortfalls and its derivative go to zero, given that the probability of success is sufficiently large for the average expected return on the loans to be larger than y.

Assume that $[p_H - (1 - \hat{E}_m^d)(1 - \hat{e}_m)\Delta p]r > y$. Then, as m increases, the FOCs for the effort choice of the owner approach

$$(1 - e_i)\Delta pr - c\sum_{i=1}^{m} E_i \geq 0 \qquad i = 1, ..., m \tag{29}$$

Assume that monitoring costs are increasing sufficiently slowly, so that $\Delta pr > cm$. Then, for very small b, $\hat{E}_m^d = 1$ and $\hat{p}_m^d = p_H$, independently of $\hat{e}_m$. For larger b, the owner substitutes her monitoring with the monitoring of the manager, and the optimal effort levels are given by

$$\hat{e}_m = \frac{\Delta pr}{\Delta pr + c^2 m/b} \tag{30}$$

$$\hat{E}_m^d = \frac{c}{b}\left[\frac{\Delta pr}{\Delta pr + c^2 m/b}\right] \tag{31}$$

and $\hat{p}_m^d = p_L + [\hat{E}_m^d + \hat{e}_m(1 - \hat{E}_m^d)]\Delta p$.

Since $\hat{e}_m = \frac{b}{c}\hat{E}_m^d$ the derivative of $\hat{p}_m^d$ with respect to b is given by

$$\left[\frac{1}{c}\hat{E}_m^d(1 - \hat{E}_m^d) + [1 + \frac{b}{c}(1 - 2\hat{E}_m^d)]\frac{dE}{db}\right]\Delta p \tag{32}$$

Given that $\frac{dE}{db} = -\frac{1}{c}E^2$, the sign of the derivative in equation 32 is determined by the sign of

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

Hence, for $\hat{E}_m^d > \frac{1}{2}$, $\hat{p}_m^d$ is decreasing in b. The intuition is that for large b there is no incentive problem of outside finance, and the commitment problem is worse.

Consider now $b = \frac{c^2 m}{\Delta pr}$, which for $\Delta pr \geq cm$ is smaller or equal to c. Substituting this value of b into the expressions for the optimal effort levels, we get $\hat{e}_m = \frac{1}{2}$, $\hat{E}_m^d = \frac{\Delta pr}{cm}\frac{1}{2}$, and $\hat{p}_m^d = p_L + (\frac{1}{2} + \frac{\Delta pr}{cm}\frac{1}{4})\Delta p$. Note that $\hat{E}_m^d \geq \frac{1}{2}$ for $\Delta pr \geq cm$. Since, $\hat{E}_m^d$ decreases with b, lowering b increases the probability of success in equilibrium.[8] Hence, for $b < \frac{c^2 m}{\Delta pr}$ we have that

$$\hat{p}_m^d > p_L + (\frac{1}{2} + \frac{\Delta pr}{cm}\frac{1}{4})\Delta p \tag{33}$$

and, for a sufficiently small c and a sufficiently profitable good project, $\hat{p}_m^d r$ will be larger than y. □

Diversification increases the incentive of the owner to monitor the manager. If costs are increasing slowly in m, so that $\Delta pr \geq cm$ for a m for which the expected shortfalls is

[8] Note that the stability condition is now $b < \frac{c^2 m}{\Delta pr}$.

approximately zero, the incentive of the owner to exploit depositors could be resolved. On the other hand, the monitoring of the owner is restricted by the commitment problem. Hence, for a sufficiently large m the monitoring level will be higher in the *m-projects bank* without managers. This does not imply, however, that the owner would not like to hire managers, since the monitoring costs of the owner are lower when she delegates.

Perhaps a more interesting case is when $\Delta pr < cm$, for a m sufficiently large for the expected shortfalls to be approximately zero, so that it is not possible to fully solve the incentive problem of the owner. The benefits of delegation are larger in this case, because the monitoring intensities decrease with c less in the delegation case than in the non-delegation case. To illustrate this assume that $b = c$. Then it is easy to show that if the bank is diversified enough, so that the expected shortfalls are zero, the overall monitoring level in the delegation case is higher than the monitoring level of the banker in the non-delegation case, when $\frac{\Delta pr}{cm} < \frac{\sqrt{5}-1}{2}$. Furthermore, the incentive to exploit depositors is lower in the bank with managers, since for a given probability of success of the projects, $S_m^d = (1-e)S_m$. Hence, the monitoring level in the bank with managers is even higher compared to the monitoring level in the bank without managers when the bank is not perfectly safe.

In this example $\hat{E}_m^d \leq 1/2$ in the perfectly diversified case. This means that the overall monitoring level in the bank with managers is increasing in b so that for $b < c$ the monitoring level in this bank will be lower than in this example. However, since the monitoring level decreases less with c when the owner is delegating monitoring, **for larger c the owner may still prefer to delegate the monitoring of the entrepreneurs to managers.**

What can we say about the optimal size of the bank when there is delegation? There are two effects of delegation:

(1) the incentive to exploit depositors is smaller in the delegation case. As we have seen in the previous section, it is this incentive that pushes towards diversification. Hence, we may have less need for diversification in the delegation case;

(2) delegation allows to save on monitoring costs by the owner, hence it helps the marginal cost to grow slower with m, which increases the possibilities to exploit the benefits of diversification.

We can conclude, saying that depending on which effect is stronger, the optimal size of the bank will be larger or smaller than in the case without delegation.

6.2 Comment on monetary incentives

In the previous section we argued that the banker may prefer to delegate the monitoring of entrepreneurs 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 that he is paid by the owner. Why would the owner like 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 match the marginal cost of monitoring of 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 on her own, the manager's salary must be paid out from the return on the loan. Thus, assume that the owner pays the manager w if the project succeeds and if the owner is not detecting 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 incentive to monitor even if the owner is not monitoring him at all. However, since, w cannot be larger than $(r - r_D)$, it follows from assumptions 1 and 3 that it is not possible for the owner to induce the manager to monitor all the time, unless she is monitoring the manager herself.

For a given deposit rate 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 finding out when the manager is shirking.

Furthermore, the incentive of the owner, as well as the manager, is increasing in w. However, since w must be less or equal to $r - r_D$ the *one project bank* may not be viable.

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

In the delegation case, each unit of monitoring of the *manager* gives $\Delta pr(1-E)$ in extra return and costs c. Both in the non-delegation and the delegation case instead, each unit of effort by the *owner* gives Δpr in extra-return but costs cm in a m-projects bank. Thus, if monitoring costs are increasing very slowly in m so that the equilibrium value of E is high in both the delegation and the non-delegation case there is probably 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 waistful 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 size of the bank, the owner must either keep her own monitoring of each project constant, which due to overload is increasingly costly, or she has to 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 valuable projects. However when the outcome of monitoring depends on the effort exerted by the monitor, delegating the task of monitoring borrowers to a bank, gives rise to an incentive problem for the banker. The banker has to share the gains from monitoring with the financiers, while bearing the costs of monitoring. Hence the banker may have too low incentive to monitor.

We show that, if the bank's lending is financed through debt, diversification of the bank

portfolio increases the incentive to monitor. The intuition is that when the bank is debt financed, the gains from monitoring accrues 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 owner of the bank 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, creates an incentive problem for the manager. To reduce shirking by the managers, the banker must exert effort in supervising them. Thus, delegation sometimes implies duplication of monitoring costs.

There will be less need for supervision, and therefore less duplication of monitoring, if the manager is paid a wage, or if the manager has a private benefit from the job. Furthermore, increasing the monitoring incentive of the owner 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 overall monitoring level in the bank, 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 are increasing in bank size, and the optimal size of the bank will be bounded.

We therefore think that this model may explain why banking industries could be fragmented, besides providing an additional reason for why banks should be diversified and debt financed.

In this paper we have not addressed the issue of competition among banks for lending, but analyzed the monitoring decision for a given loan rate. One interesting issue for future research is whether competition worsen the incentive problem of the banker. 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.

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