Bank Capital Structure Relevance: is Bank Equity more Expensive than Deposits?

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Abstract

We propose a model of optimal bank capital structure. There are two types of potential investors with different monitoring skills. The skilled can monitor a project and increase its productivity, whereas the unskilled cannot. Also, the skilled can divert a part of the project's return without being detected by the unskilled. Banks emerge endogenously and bank capital structure is relevant. The skilled become the bank's equity-holders whereas the unskilled become depositors. Also, our model explains why bank equity is more expensive than deposits and has implications for the optimal bank size, the impact of bank capital on social welfare and several testable implications.

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1 Introduction

A common assumption in banking literature is that bank equity is costlier than deposits. The assumption drives many results but it lacks sound theoretical foundations (Admati, et. al., 2011). Furthermore, outside U.S., the overwhelming majority of individuals hold bank deposits but not equity (Guiso, Haliasos and Jappelli, 2002). We propose a simple model which provides an explanation for why the return on bank equity is higher than that on deposits (although there is universal risk neutrality) and why deposits and equity are held by different groups of individuals.

More specifically, we consider a model in which potential investors have different monitoring skills. There are two types of investors: Skilled and Unskilled, and the type is public knowledge. The skilled can monitor a project and increase its productivity, whereas the unskilled cannot. Monitoring the project is costly, but irrespective of the scale of the project, the cost is fixed. Due to economies of scale in monitoring, investors can gain from coalescing to form a bank. In a coalition, the skilled may divert a fraction of the funds from the unskilled and this diversion cannot be detected by the unskilled.

Banks emerge endogenously and the bank manager is always a skilled financier. If diversion is large enough, bank capital structure is relevant and the optimal arrangement entails that the unskilled investors become depositors and the skilled equity-holders. An unskilled financier does not participate in an all-equity bank as if they own a security of the same seniority as the skilled, the payoff (after diversion) does not meet their outside option (so, they prefer to invest on their own than have equity in a bank). To attract funds from the unskilled, the banker offers them a deposit contract and retains the equity claim for himself and the other skilled investors. The result arises endogenously in our setting as the seniority of debt (relative to the equity held by the skilled investors) ensures that the unskilled investor's participation constraint is satisfied.

If not monitored, a skilled investor diverts from the other skilled investors in the bank. Therefore, all skilled investors in the coalition monitor each other. Peer-monitoring is costly and increasing in the number of other skilled members in the coalition. The level of equity is determined by the trade-off faced by the skilled investors - cost sharing (benefit) versus peer-monitoring (cost). Further, we have the optimal leverage ratio from the diversion constraint. Combining the two, we derive the optimal size of the bank, which is bounded.

Furthermore, bank equity is more expensive than deposit. This result is driven by the relative scarcity of the skilled investors who hold the bank equity. Thus, in this setting the higher return on equity is not related to risk. Instead, it is a premium for skill which is scarce.

We extend our analysis to the case in which type is not observable. The contracting variables (bank leverage ratio and payoff to depositors) are chosen simultaneously such that we always have separating equilibria in which only skilled investors manage banks. Further, we derive the conditions under which the regulator optimally intervenes to improve the net social welfare.

2 Literature

Diamond (1984) uses a diversification argument to justify the debt contract in the bank capital structure. As the number of depositors go to infinity, stochastic returns across uncorrelated projects become deterministic and the banker can offer riskless payoffs to depositors. The debt contract is optimal in this model and there is no equity capital.

Calomiris and Kahn (1991) derive conditions under which the demandable debt contract (with sequential service constraint) is optimal in banking. To restrict the banker from absconding with the banks' profits in the bad state, uninsured depositors monitor the banker and pull out their deposits (run) when they fear absconding. The sequential service constraint circumvents the free rider problem of small depositors in incurring monitoring costs. Monitoring depositors are first in line to withdraw if they get a negative signal. A free riding depositor is later in the queue and hence has a lower expected payoff upon withdrawal. A sequential service constraint thus preserves the monitoring incentives of depositors. Like Diamond (1984), there is no equity capital in this model either.

Diamond and Rajan (2000) provide a theory of bank capital structure where they differentiate between the demandable debt contract (sequential service constraint) and capital (standard debt or equity) by their renegotiability. The banker may threaten to withhold his specific skills and extract some rent from capital. Demandable debt gets around the hold-up problem as if the banker attempts to renegotiate the terms of the demandable debt contract, they run on the bank and pull out their deposits; this disintermediates the the banker and destroys his rents. Thus, the renegotiable capital sacrifices liquidity creation (loan-making) to provide stability in the poor state. Diamond and Rajan (2000) do not comment on the return on the different securities.

Holmstrom and Tirole (1997) study a model with effort moral hazard in which internal capital strengthens monitoring incentives and allows external funds to be raised. They do not consider the security design issues and in their model debt and equity are identical.

In Morrison and White (2005) the sound investors form the bank's equity capital and the unsound investors are depositors. We use this idea of different types of agents (set apart by skill and hence, outside options). However, once again their focus is not security design issues and in fact, they assume the debt contract and do not derive it endogeneously. Indeed, it is easy to show that the contract they refer to as the deposit contract in their model could equally be an equity contract.

A closely related and newly emerging strand of literature examines how bank capital contribute positively to bank value. Like Holmstrom and Tirole (1997), the central idea in these papers is that bank capital has a positive effect on monitoring, which leads to an increase in value. Allen, Carletti and Marquez (2011) show that improved monitoring incentives (due to higher capital) attracts more deposits and hence surplus extraction. Mehran and Thakor (2009) essentially reinforce the same point (capital improves monitoring incentives). They have a direct channel that higher bank capital leads to a higher survival probability of the bank (at an interim date) which increases the marginal benefit of monitoring. Further, this effect is magnified as the higher monitoring increases the value of the relationship loan portfolio. In our model equity capital positively contributes to value as equity holders share the fixed cost of learning.

We also have implications for the optimal size of bank. Cerasi and Daltung (2000) derive the optimal size of a bank by trading off the costs and benefits of a larger (diversified) loan portfolio. Diversification increases the banker's incentive to monitor the loans. However, monitoring more loans also entails overload costs (since there is a limit to the number of loans the banker can monitor). In our model, the trade-off for the optimal size comes from the capital as opposed to the loan portfolio. Equity capital eases the diversion constraint which attracts higher level of deposits. On the other hand, equity capital entails a peer monitoring cost which is increasing in the number of equity holders. Hence, we relate capital to size.

3 Model

3.1 Set-up

We consider a one-period economy in which all agents are risk-neutral. At $t = 0$ there is investment in a project and at $t = 1$ returns are realized. Returns are consumed at the end of the period. There are two types of agents: entrepreneurs and investors. Each entrepreneur has access to one project. Entrepreneurs do not have financial endowments and seek financing for their projects from investors. Each investor has an initial endowment of 1 unit. The project returns either X (success) or 0 (failure) per unit of investment. If the project is monitored, it returns X with probability p_h and 0 with probability $(1 - p_h)$. If not monitored, the success probability is p_l, where $p_l < p_h$. Monitoring the project requires exerting effort which imposes a cost, F, which is fixed for any scale of investment (economies of scale).

Only some investors (call them *skilled*) are able to monitor projects, while the *unskilled* investors lack the expertise to monitor. There are N investors. A proportion λ are skilled and the rest are unskilled.

Assumption 1: *The sum of endowments of all investors (skilled and unskilled) is less than the amount demanded by entrepreneurs.*

This assumption implies that the investors have all the bargaining power and the full surplus from the project accrues to the investors. Given this assumption, the entrepreneur has no preference over which project he wishes to manage, since he makes zero profit from either. Thus, the choice of project is based on the type of investor who provides the funds to the entrepreneur.

Assumption 2: *The cost to monitor a project, F is sufficiently low such that it is* *always efficient for the skilled investor to incur effort:*

$$(p_h - p_l)X > F \tag{1}$$

Indeed, the skilled investors are more productive than the unskilled and therefore they have a higher outside option. In this context, we define the outside option of an agent to be the expected payoff that they can get, if they were to invest on their own. So, the outside option of the skilled investor is $p_hX - F$, while that of the unskilled investor is p_lX. Note that due to their higher productivity, the net social surplus is maximized when all funds are managed by the skilled.

Assumption 3: *Skilled investors are relatively more scarce. The bargaining power lies entirely with the skilled in negotiations with the unskilled.*

This a simplifying assumption. All we need is that the skilled investors get a non-zero fraction of the surplus (incremental productivity of the funds of the unskilled, when managed by the skilled).

In the basic version of the model, the unskilled investors are compensated up to their outside option for participating in the bank. However, we will see that when we have adverse selection (skill is private information), the skilled bankers may separate themselves from the unskilled by offering a higher payoff to the unskilled than simply what their outside option entails.

Agents coalesce with one another to form a *bank* and the one managing such a bank is the *banker*. Forming a coalition is beneficial for the skilled investors primarily because the fixed cost of monitoring the augmented project may be shared (economies of scale in project monitoring). Additionally, the skilled investors retain the surplus from investing the funds of the unskilled. The unskilled investors only ever get their outside option (in expectation) and therefore they are indifferent to joining a coalition or investing on their own.

Assumption 4: *Agent types are observable and therefore there is no adverse selection.*

This is a simplifying assumption. In an extension we show that results are robust to types being private information. (Section 4)

Assumption 5: *There is no effort moral hazard concern.*

As long as banker invests his own wealth in the bank (which is optimal), he always incurs the cost, F. This is true since F is a fixed cost, irrespective of the scale of the project. Augmenting the project does not mis-align incentives in any ways.

Morrison and White (2005) use a cost which is increasing in the scale of the project. This leads to the moral hazard issue in their model. Skilled agents do not monitor if they have too much outside funds to manage.

Due to types being observable, it is clear that only the skilled become bankers. No skilled agent invests with a less productive unskilled. An unskilled agent is (weakly) better off by investing with a skilled banker. If the surplus from the incremental productivity goes to the skilled, then the unskilled is indifferent between a skilled and an unskilled banker. We rule out this uninteresting possibility.

Lemma 1: *A bank is always run by a skilled investor.*

The key friction in our model is *diversion*. Once returns are realized, the banker diverts a fraction, $(1 - \phi)$ of the operating cash-flow. The diverted amount may not be verified in the court of law. The other skilled members in the coalition observe the diversion by the banker and therefore receive a share in it. If this were not possible, all skilled agent will manage their own bank. Further, the banker cannot credibly commit to not divert funds from the unskilled even if it is beneficial for him to be able to do so ex-ante.

A skilled banker may not divert from the other skilled members in the bank due to peer-monitoring. Each skilled agent in the coalition monitors all the other skilled agents (not only the banker) in the bank as any one of them will divert funds from him, if not monitored. The banker need not expend this peer-monitoring cost, since he is in charge and any diversion of funds goes through him. The unskilled agents do not have access to the peer monitoring technology and therefore are vulnerable to diversion of funds by the skilled. Peer-monitoring is costly and increasing in the number of other skilled members in the coalition. A skilled agents incurs a cost, γ, to monitor one skilled agent. In a coalition of S skilled members, each (apart from the banker) incurs a cost $(S-1)\gamma$. Due to the way we set up the cost, there are no possibilities for collusion, as would be the case if each skilled member was to only monitor one other (and form a chain in a way that each skilled member is monitored by another). The total peer-monitoring cost incurred by the (skilled) bank members is $(S-1)^2\gamma$.

3.2 Benchmark: all-equity banks

In this section we consider an all-equity bank. To focus on the point we make here, we assume for now that the bank is made up of only 1 skilled investor and K_u unskilled investors (later, we allow for other skilled investors to join the bank).

At $t = 0$, the skilled banker accepts outside funds from K_u unskilled investors. The total funds in the bank including the banker's endowment is $(K_u + 1)$. The banker incurs the fixed cost of monitoring the project, F. There is no peer monitoring cost as the banker is the only skilled investor in the coalition.

The expected payoff to the bank is,

$$p_h(K_u + 1)X - F \tag{2}$$

The operating cash flow in the bank is $p_h(K_u + 1)X$. The skilled banker diverts a fraction $(1 - \phi)$ out of the operating cash-flow (non-verifiable). The fraction that remains is distributed among all the bank members (including the banker), as they have the claim of the same seniority (the equity claim). Given that the banker cannot credibly commit to not divert, the expected payoff to each unskilled member is $\phi p_h X$.

If the expected payoff to the unskilled meets their outside option, $\phi p_h X \geq p_l X$, diversion by the skilled is harmless and it does not matter in terms of expected payoffs whether the unskilled members in the coalition have the equity claim (as above) or any other, like a debt claim. So, the bank's capital structure is not relevant in this context. We do not consider this case in the rest of the paper.

Assumption 6: *Diversion is large enough such that* $\phi < \frac{p_l}{p_h}$.

If this is the case, the equity claim no longer meets the outside option of the unskilled agent, $\phi p_h X \leq p_l X$. The unskilled investors do not participate in the all-equity bank. From the perspective of the skilled investors this is not desirable as coalescing with the unskilled presents them with the opportunity to extract surplus from them. Further, from the point of view of the society, it is desirable that maximum funds are invested by the skilled agents and therefore, this is an inefficient outcome in terms of the net social surplus.

The above discussion leads us to the following Lemma:

Lemma 2: *Suppose that the banker diverts a fraction* $(1 - \phi)$ *of the operating cash-flows, where* $\phi < \frac{p_l}{p_h}$. *An unskilled investor does not participate in the bank as an equity holder and prefers to invest on his own.*

3.3 Optimal Contracts

In this section we derive the optimal contract for each type of agent. To start with, there is one skilled banker and K_u unskilled investors in the bank. In event that the project fails, no one gets anything. If it succeeds (w.p. p_h) the banker promises a payment R_u to each unskilled members and the banker gets the residual claim, R_s.

The banker maximizes his profit function subject to a constraint which we call the diversion constraint and the unskilled investor's participation constraint (the skilled investor's participation constraint never binds). The diversion constraint states that the total verifiable cash-flow (after diversion) to be distributed must be weakly greater than the total promised payments to the unskilled and the skilled.

$$\begin{aligned} \underset{K_u}{\text{Max}} \quad & p_h(K_u+1)X - p_h R_u K_u - F \\ \text{subject to} \quad & \phi p_h(K_u+1)X \geq p_h R_u K_u + p_h R_s \\ & p_h R_u = p_l X \end{aligned}$$

Solution: Set the payment to the skilled members (out of the verifiable fraction of the cash-flow) as $R_s = 0$. We clarify below that this is equivalent to saying that the skilled banker gets the residual claim, which is an equity-like contract.

Proof. First note that banker's profit function is strictly increasing in the unskilled funds, K_u in the bank. This is true because given Assumption 3 (bargaining power lies with the skilled), it is always the case that the banker retains the full incremental profitability (due to monitoring), $(p_h X - p_l X)$, of each unskilled investor's funds. It is inconsequential to the banker if he diverted the cash-flow or got it legitimately. Therefore, the banker maximizes the the amount of unskilled funds in the bank such that the diversion and participation constraints are not violated. By substituting the participation constraint into the diversion constraint, we get:

$$(p_l X - \phi p_h X) K_u \leq \phi p_h X - p_h R_s \tag{3}$$

Given that diversion is large enough, $\phi < \frac{p_l}{p_h}$, the LHS increases with unskilled funds, K_u. Hence, in order to maximize K_u consistent with the diversion constraint being satisfied we set $R_s = 0$ □

The unskilled investors have the senior claim (relative to the banker) and the priority over the verifiable fraction of the cash-flow, so it is a debt-like contract. It is a risky debt contract with face value $R_u = \frac{p_l X}{p_h}$. This credibly ensures that the unskilled investors in the bank earn their outside option (as opposed to the all-equity bank). The banker gets the equity-like residual claim.

Lemma 3: *The optimal contract to the unskilled is the deposit contract.*

Now, we consider the case in which other skilled investors may join the bank (only if it is a profit-maximizing strategy for the banker). While more skilled investors increases the peer-monitoring costs, the benefit is that the fixed cost of monitoring the project is shared among more investors. We derive the optimal size of the bank in the next section.

A skilled investor has the choice between a deposit or equity contract. The deposit contract has set payoff $(0, R_u)$, so no peer-monitoring costs are incurred but of course, it does not meet the outside option of the skilled investor. The equity claim brings with it the cost of peer-monitoring. However, as long as the benefits to peer-monitoring outweigh the costs, the equity claim surpasses the skilled investor's outside option. If peer-monitoring is inefficient, banker does not offer further equity contracts as the same costs apply to him. Therefore, the skilled investor becomes an equity holder in the bank.

Lemma 4: *A passive skilled investor in the bank holds the equity claim (which is of the same priority as the skilled banker).*

Banker's compensation: The banker incurs the entire fixed cost of monitoring, F at $t = 0$. At the same time, by virtue of being the banker, he does not need to monitor his peers (the other skilled agents in the bank), thus saving himself, $(K_s - 1)\gamma$. The compensation package of the banker is designed to ensure that the skilled investor is indifferent between becoming a banker and investing passively in the bank. The banker's compensation is set at $(K_s - 1)[\frac{F}{K_s} - \gamma]$, where there are K_s skilled investors (including the banker) who form the bank's capital base. The banker receives this amount at $t = 0$. This ensures that all the skilled investors in the bank have the same payoff in expectation, irrespective of if they are active bank managers or passive equity-holders. Further, the banker's incentives are still perfectly aligned with the bank's equity holders.

We summarize the above discussion in the following proposition:

Proposition 1: *Both skilled and unskilled investors participate in a bank:*

1. There are d unskilled depositors and,

2. The bank's capital base is made of k skilled investors, one of who manages the bank.

3. The banker incurs the full monitoring cost F and has a compensation contract, $(K_s - 1)[\frac{F}{K_s} - \gamma]$.

3.4 Optimal Bank Structure

Proposition 2: *Bank capital structure is relevant and there is a unique optimal leverage ratio which decreases in diversion and is given as follows:*

$$\left\{\frac{d}{k}\right\}^* = \frac{\phi p_h}{p_l - \phi p_h} \tag{4}$$

Proof. To see why this is true we re-write the diversion constraint (equation 3. Setting $K_u = d$, $K_s = k$, $R_s = 0$ and $R_u = p_l X$):

$$\frac{d}{k} \leq \frac{\phi p_h}{p_l - \phi p_h} \tag{5}$$

The skilled investors' payoffs increase in d. Thus, given that $p_l - \phi p_h > 0$, the constraint binds with equality. Hence, the diversion constraint determines the optimal debt-equity ratio (capital structure) of the bank. □

The intuition is straightforward. Given the level of equity capital in the bank, the bank can accept up to a certain level of debt due to the diversion constraint. It chooses the maximum level of debt that the constraint allows.

The skilled investors solve the following optimization program (generalized version of the program in the previous section):

$$\begin{aligned}
&\underset{k}{\text{Max}} && \frac{1}{k}[p_h(d+k)X - p_h d R_u - F - (k-1)^2\gamma] \\
&\text{subject to} && \frac{d}{k} = \left\{\frac{d}{k}\right\}^* = \frac{\phi p_h}{p_l - \phi p_h} \\
& && p_h R_u = p_l X
\end{aligned}$$

Solution: Substituting the constraints in to the profit function and taking the first order condition with respect to k, we derive the optimal size of bank equity, k^*:

$$k^* = \sqrt{\frac{F}{\gamma} + 1} \tag{6}$$

Lemma 5: *There is a unique Nash equilibrium in which there are $\frac{\lambda N}{k^*}$ banks and each bank has equity, $k^* = \sqrt{\frac{F}{\gamma} + 1}$, where λN is the number of skilled investors in the* *world.*

Proof. First consider the case that $k^* = 2$. We show that there is a unique Nash equilibrium in which there are $\frac{\lambda N}{2}$ banks each with $k = 2$. Suppose that we start with λN banks with $k = 1$. Then any banker will profitably deviate by coalescing with any other and form a bank which is twice as big the original banks and this is a strictly profitable strategy for the skilled investors (the unskilled investors are unaffected). Similarly, if we start with 1 bank with N skilled members, they profitably deviate to break up into smaller banks till eventually there are $\frac{\lambda N}{2}$ banks each with $k = 2$.

Now, we consider the case that $k^* \geq 3$. There is a unique Nash equilibrium in which there are $\frac{\lambda N}{k}$ banks each with $k = k^*$. We need to rule out the possibility that there is a coordination failure problem. Suppose that we start with λN banks with $k = 1$; each skilled investor manages his own bank. Consider then, a banker deviates by coalescing with another and forming a bank twice as big as the original banks. Is this a profitable deviation? The benefit to coalescing is $B = F - \frac{F}{k}$ and the cost is $C = (k-1)\gamma$. Coalition of skilled investors is possible if and only if benefits to doing so exceeds the cost, $B > C$. (Due to the concavity of B and the linearity of C in k) If $B > C$ for a certain size k^*, it must be true that $B > C$ for any $k < k^*$. Thus, there is no coordination failure problem and bank equity, k^* is achieved as a unique Nash equilibrium. □

Proposition 3: *There is a unique optimal size of the bank which is bounded and related to the various monitoring costs and the diversion parameter. It is given as follow:*

$$(d+k)^* = \frac{\phi p_h \sqrt{\frac{F}{\gamma}+1}}{p_l - \phi p_h} + \sqrt{\frac{F}{\gamma}+1} \tag{7}$$

Proof. The expression for the optimal size of the bank is readily obtained by combining the results in Proposition 2 and Lemma 5. □

Intuitively speaking, the sound investors who are the equity-holders in the bank trade off the costs and benefits of being in the bank. The optimal k^* determines the participation of unskilled depositors, d^* in the bank via the optimal leverage ratio given in Proposition 2 (which comes from the diversion constraint).

Proposition 4: *Bank equity is more expensive than deposit.*

Proof. First, note that equity is only held by the skilled agents. Thus, equity requires a higher return than deposit since it is held by the skilled agents who have a better outside option. □

Thus, in this setting the higher return on equity is not related to risk. Instead, it is a premium for skill, which is scarce.

3.5 Empirical Implications

We can derive some interesting and potentially testable predictions by doing some simple comparative statics exercises:

Lemma 6: *Bank Leverage and Size decrease as diversion increases.*

Proof. Directly from the expressions of $\frac{d}{k}$ and $(d + k)$. □

Intuitively, as diversion increases, higher equity needs to be in place to attract the unskilled investors to buy the deposit contract.

One interpretation is that the parameter ϕ captures the strength of the legal system. The prediction in this model is that as the legal system becomes stronger (contract enforceability improves), banks become larger and more levered.

An alternative interpretation is that the parameter, ϕ reflects the verifiability of a project's cash-flow. The more innovative projects have higher fractions of non-verifiable cash-flows (lower ϕ and more diversion). Thus, our model predicts that such projects are smaller and have lower leverage than projects with relatively more verifiable cash-flows.

Lemma 7: *Bank Leverage and Size increase as probability of success, p_h increases.*

Proof. Directly from the expressions of $\frac{d}{k}$ and $(d+k)$. □

A higher p_h eases the diversion constraint such that for a given level of equity, higher debt is raised.

We may think of an increase in p_h as an improvement in the bank's monitoring technology. In this interpretation, as the monitoring technology improves, banks become larger and more levered.

3.6 Audit

The regulator can audit the bank against diversion at a cost. The banker has to compensate the regulator for incurring this cost. The regulator maximizes the net social surplus by easing the diversion constraint of the bank and ensuring that more funds are invested by the skilled banker (more efficient).

The auditing technology is as follows: A regulator can actively monitor the bank at a cost, C for which the banker pays a fee $\frac{C}{p_h}$ to the regulator at $t = 1$, such that the regulator breaks even in expectation. If the regulator audits a bank's books, he captures a fraction δ of the diverted cash-flow and redistributes it to the unskilled depositors. Thus, the total cash-flow that is credibly promised to the depositors is $(\phi + \delta(1-\phi))(d+k)X$. The diversion constraint eases:

$$d \leq \frac{k(\phi + \delta(1-\phi))p_h}{p_l - (\phi + \delta(1-\phi))p_h} \tag{8}$$

Due to easing of the diversion constraint, more unskilled agents participate in the bank (as depositors). The increase in the surplus of the bank is $\Delta d(p_h X - p_l X)$ (where Δd is the increase in the number of unskilled depositors in the bank due to auditing). As long as auditing cost is less than the incremental surplus, $(C < \Delta d(p_h X - p_l X))$, the equity holders (the skilled) are better off. The net social surplus as more funds are managed efficiently (by the skilled banker).

Lemma 8: *There exists a balanced budget intervention that increases net social surplus and is Pareto improving for some parameter values $(C < \Delta d(p_h X - p_l X))$:*
The Regulator audits the bank for a fee, $\frac{C}{p_h}$ (the banker pays the fee only if the project succeeds). This eases the diversion constraint and attracts more unskilled investors to invest as depositors.

3.7 Cross-section variation

To examine the cross-section, we introduce heterogeneities in Project 2:

i. There are two levels of skill: high and low. If a highly skilled investor monitors the project, its success probability is p_{hh}. The project succeeds with probability p_{hl} if the low skilled investor monitors where $p_{hl} < p_{hh}$.

Assumption 4: *Peer monitoring only applies to investors of the same skill.*

Low skilled investors do not coalesce with high skilled investors as equity holders.

Lemma 9: *Leverage and Size are correlated in the cross-section and increase in p_h.*

Proof. $\frac{d}{k}$ and $(d+k)$ increase in p_h. Therefore, $\left\{\frac{d}{k}\right\}_h > \left\{\frac{d}{k}\right\}_l$ and $(d+k)_h > (d+k)_l$ where the subscripts indicate the skill level of the banker. □

Gropp and Heider (2010) note the above relation for banks.

ii. There are two levels of monitoring costs. Some projects need more monitoring than others. To monitor a project, the banker incurs a fixed cost F_h or F_l, where $F_h < F_l$.

Lemma 10: *Bank equity increases with the level of monitoring required.*

Proof. k increase in F. Therefore, $k_h > k_l$ where the subscripts indicate the monitoring levels. □

Existing literature states that higher equity levels leads to higher monitoring. In our model, the causality is in the opposite direction. A project that needs higher monitoring presents with higher cost saving for bank equity and therefore leads to higher bank equity.

4 Extension: Adverse Selection

In this section we consider the case that the type of investor is not observable and that skill is private information. There are N potential investors. An investor is skilled with probability λ and unskilled with probability $(1-\lambda)$; the distribution of the agents is common knowledge. Since skill is private information, an unskilled agent may mimic a skilled and manage a bank (we will see below that such an equilibrium does not exist).

Before classifying the different possible equilibria, we clarify once again how the diversion technology works: The banker (irrespective of skill) may divert from the unskilled in the coalition and share the diverted funds with the skilled. Since he is in charge, even if the banker is unskilled, the skilled equity-holders may not divert from him.

First of all, we note that irrespective of the banker's type, the same segregation between bank equity and deposits apply, since:

i) For the non-bankers in the coalition, the arrangement that the skilled are equity holders and the unskilled are depositors is still optimal.
ii) If an unskilled banker offers a different menu of contracts, he will reveal his type.

In the symmetric information version of the model, we set the return to the unskilled (call it R) to p_l. We were able to do so due to our assumption on the bargaining power between the skilled and the unskilled (Assumption 3). However, in this section, we do not constrain $R = p_l$. A banker who is skilled may choose to offer a higher return to the unskilled, ($R > p_l$) to separate himself from the unskilled banker and attract higher levels of deposit. Therefore, the two contracting variables, R and $\frac{d}{k}$, are determined simultaneously to satisfy the relevant constraints, which are outlined below.

We are looking for pure strategy Bayesian Nash equilibria, where each agent is maximizing their payoff given the actions of the other agents and given his beliefs about which types of agents take which actions. Of course, in equilibrium, every agent's belief must be correct.

There are two constraints that determine the bank size and capital structure: the diversion constraint and the incentive compatibility constraint of the unskilled.

When banker type is observed (or revealed), the general version of the diversion constraint (without setting $R = p_l$) is stated as follows:

$$\frac{d}{k} \leq \frac{\phi p_h}{R - p_l} \tag{9}$$

If banker type is not revealed, the average success probability of the bank is $\hat{p}$. The diversion constraint is modified as follows:

$$\frac{d}{k} \leq \frac{\phi \hat{p}}{R - p_l} \tag{10}$$

The second constraint is the incentive compatibility constraint for the unskilled investors. If an unskilled investor becomes a banker, the project he manages has a lower profitability (probability of success is p_l) but on the other hand, he diverts funds from the unskilled depositors (if there are any in the bank). The amount that an unskilled banker makes must be lower than what the unskilled agent would otherwise make by depositing in a bank, i.e. $\frac{1}{k}(1-\phi)p_l X(d+k) \leq RX$.

$$\frac{d}{k} \leq \frac{R - p_l + \phi p_l}{p_l - \phi p_l} \tag{11}$$

If the incentive compatibility condition is satisfied, the unskilled investor is strictly better off depositing in a bank and earning a payoff, RX. If, on the other hand, the condition is violated, the unskilled investor prefers to manage a bank. Despite the lower profitability of the bank (success probability is p_l), the unskilled banker diverts from the unskilled depositors in the coalition

The diversion constraints and the incentive compatibility constraint are illustrated in Figure 1. We consider two regions to look for potential equilibria.

Case 1: In Region A, the incentive compatibility constraint is violated. The diversion constraint may bind or be slack.

Case 2: In region B, neither constraint is violated.

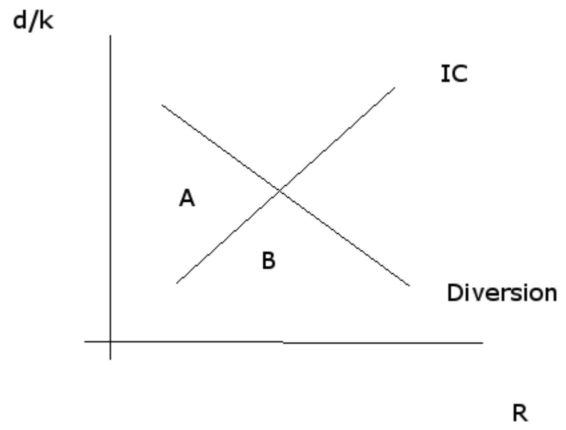

Figure 1: Constraints

4.1 Case 1

We show that there are no banking equilibria in the region A. If the IC is violated, unskilled agents would rather manage their own banks than deposit. As a response, the skilled agents choose the contracting variables such that the IC always binds.

Consider Region A on the figure. The IC condition is violated.

Note that it is a necessary condition for bank formation that the diversion constraint is not violated (it may bind or be slack). Further, this is not true for the Incentive compatibility condition. A pooling equilibrium may exist in which a banker may be skilled or unskilled.

However:

1. Since the incentive compatibility constraint of the unskilled investor is violated, the unskilled investors prefer to run their own banks to depositing. There is no depositing.

2. Skilled investors strictly prefer to attract deposits than no deposits (as long as

$R < p_h$).

3. Therefore, the skilled banker chooses the contracting variables (R and $\frac{d}{k}$) such that the incentive compatibility constraint always binds (we move to Region B).

Therefore, under no circumstances we have a pooling equilibrium, in which banker type is not revealed.

Proposition 5: *In an unregulated economy, there are no asymmetric pure strategy pooling equilibria. The two contracting variables (R and $\frac{d}{k}$) are always chosen such that the incentive compatibility constraint is never violated.*

4.2 Case 2

Now we consider region B. Neither constraint is violated in this region. Since the IC condition is not violated, we have separating equilibria, in which only skilled investors manage banks.

Note that in any separating equilibrium, $k = k^*$ and number of banks is $\frac{\lambda N}{k^*}$. This is true because the trade off of the equity holders (benefit: share F and cost: peer-monitoring) is identical to the symmetric information version of the model.
Hence, the net social welfare is maximized at the point at which the amount of deposit at each bank is maximized (given that k and number of banks are already determined).

A benevolent regulator wishes to maximize the nest social welfare (without regards to distribution) and will aim to achieve the maximum feasible $\frac{d}{k}$.

We describe the optimum below.

Proposition 6: *The diversion constraint and the incentive compatibility constraint intersect and the net social surplus is maximized at the point of intersection.*

The intersection of the constraints is characterized as follows:

$R = \phi(p_h - p_l) + p_l$ and

$\frac{d}{k} = \frac{\phi p_h}{p_l - \phi p_l}$

If diversion constraint is slack (i.e. to the left of the intersection point), skilled bankers could potentially accept more deposits (increasing efficiency). But, to be able to do so without violating the IC constraint, the skilled promise a higher return, R to the depositors. This would increase the net social surplus, as more funds would be managed by skilled investors.

To the right of the intersection point, the diversion constraint is violated for any $\frac{d}{k}$ which is higher than the intersection point. (It is a necessary condition for banking that the diversion constraint is satisfied)

Thus, the intersection point is the constrained optimum where the net social surplus is maximized, without violating the diversion constraint.

Now, we turn to the skilled banker's problem. The skilled investor maximizes his payoff and solves the following problem:

$$\begin{aligned}
\underset{R,\frac{d}{k}}{\text{Max}} \quad & \frac{1}{k}[p_h(d+k)X - p_h dRX - F - (k-1)^2\gamma] \\
\text{subject to} \quad & \frac{d}{k} < \frac{\phi p_h}{R - \phi p_h} \\
& \frac{d}{k} < \frac{R - p_l + \phi p_l}{p_l - \phi p_l} \\
& p_l \leq R \leq p_h
\end{aligned}$$

Solution: For a give R, the skilled banker maximizes the depositors in the bank (or maximizes $\frac{d}{k}$, since k is fixed). Therefore, the IC holds with equality. Substituting in the objective function and taking FOC (wrt R), we get:

$R = \frac{1}{2}[p_h + (1-\phi)p_l]$ and

$\frac{d}{k} = \frac{p_h - (1-\phi)p_l}{2(1-\phi)p_l}$

Further, to ensure that the Participation constraint binds and that the diversion constraint is never violated, at the maximization point,

$R = R_{max} = min[max(p_l, \frac{1}{2}[p_h + (1-\phi)p_l)), \phi(p_h - p_l) + p_l]$

Therefore, if $R_{max} < \phi(p_h - p_l) + p_l$, there is scope for government intervention.

Proposition 7: *Suppose that $R_{max} < \phi(p_h - p_l) + p_l$. The Regulator improves the net social welfare by imposing the optimal equilibrium (at the intersection point). To achieve this the regulator either*

i. sets $\frac{d}{k} = \frac{\phi p_h}{p_l - \phi p_l}$ or

ii. sets $R = \phi(p_h - p_l) + p_l$.

Since both the constraints bind at this point, it is a feasible equilibrium. However, this is not a Pareto improvement as there is some transfer of value from the skilled to the unskilled investors.

5 Conclusion

We present a model of bank capital structure in which the investors' outside option determines their choice of security in the bank. The skilled agents may divert from the unskilled in a banking coalition. If diversion is large enough, the optimal arrangement entails the following: the skilled investors hold equity capital and the unskilled investors are the depositors (markets for equity and deposits are segmented). Due to their higher outside option, the skilled command a skill premium and equity is therefore more expensive than deposit.

The bank's leverage ratio is determined by the diversion constraint. Further, the level of equity is determined by the trade-off faced by the skilled agents - cost sharing (benefit) versus peer-monitoring (cost). These two results are combined to deduce the optimal levels of debt and equity from which we get the optimal size of bank.

Our model has some novel and potentially testable empirical implications: First, as the legal system becomes stronger, banks become larger and more levered. Second, banks that finance the more innovative projects are smaller and have lower leverage. Finally, as the monitoring technology improves, banks become larger and more levered.

In the extended version of the model (adverse selection case), we show that the results generally hold (skilled investors manage banks and command a higher return on their funds). Further, we derive the conditions under which the regulator optimally intervenes to improve net social welfare.

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