Remedies for Banking Crises
Part 1: Banks' Role and Subordinated Debt*

Levent Yıldıran†

December, 2001

Abstract

To the important question "What to do ex-ante to prevent (or to reduce the occurrence of) banking crises?" our answer is: Primarily, banks should be disciplined. We will argue that market discipline is necessary for inducing banks to exert effort, and we will explain, in a theoretical context, how and when subordinated debt can help establishing market discipline.

1 Introduction

Summarizing the huge literature on banks' problems very briefly, a banking crisis can be described as a chain of events: Possibility of a bank's failure triggers a run on that bank, and due to the interconnected nature of the banking sector, a bank run triggers a contagion to the other banks. (see. e.g., Diamond and Dybvig (1983), Jacklin and Bhattacharya (1988), Chari and Jagannathan (1988), Postlewaite and Vives (1987), Allen and Gale (1998), Aghion, Bolton and Dewatripont (1999), Rochet and Tirole (1996), Calomiris (1999))

In a world where uncertainty prevails there are essentially two ways to completely prevent banking crises:

1) Either bank failures should be prevented by obliging banks to invest only in riskless assets (narrow banking). But, banks are needed for their expertise in risky and profitable investments. Otherwise, investors can invest in riskless assets themselves anyway.

2) Or bank runs should be prevented by full state guarantee or full deposit insurance. But, in a world where banks' performances depend on their

*I am greatly indebted to Jean-Charles Rochet for his direction and support. I also thank to Eloïc Peyrache, Lucia Quesada and Stéphane Straub for their helpful discussions and suggestions.

†GREMAQ, Université Tolouse 1, Place Anatole France, 31042 Toulouse Cedex, France
Mail to: yildiran@univ-tlse1.fr

effort, this will cause moral hazard and create significant ex-post adverse effects on the social welfare.

Since the main objective is the maximization of the social welfare, neither of those ways is desirable. Thus, we will not talk about "how to prevent banking crises?", but rather, "how to reduce their occurrence to an optimal level?" Our answer to this question is that primarily banks should be disciplined and induced to exert effort, because their performance depends on their effort [1]. The fact that in recent banking crises, some banks were not affected or less affected than the others shows that the banks which had exerted effort to have higher quality assets and better risk management[2] were less prone to the crises. But, moral hazard alone does not suffice to explain why some banks choose to exert effort, while the others don't. There must also be some heterogeneity (in the cost of exerting effort) among banks. This heterogeneity can result from either some observable features (e.g., physical capital, banking technology) or unobservable features (e.g., human capital) of the banks. Then, the critical question is "Why do the market participants fail to discipline/eliminate the bad types banks, so that banking crises recur so frequently?" There can be two reasons for this: First, although the differences among banks are observable, market participants may be not caring about those differences because of the excessive protection they have. (We will not directly deal with this problem, but we will shortly address to it in the following sections). Second, which is the relevant case for our paper, market participants may be not (easily) observing those differences.

So, our premise is that in situations where their efforts and types are not observable (combined moral hazard, adverse selection problem), banks' optimal choice of effort may not always be aligned with the interests of investors, and in the cases, where market cannot itself eliminate the asymmetric information (and the probable conflict of interest), obliging banks to be monitored by some agents may increase the stability of the banking system and improve welfare. But, small depositors are not in a position to observe the soundness of a bank (Dewatripont and Tirole,1994, Freixas and Rochet, 1997). Bureaucrats (or politicians), on the other hand, may lack the necessary incentives and competence in observing and assessing the true risk of a bank, especially if it is involved in today's complex banking operations like arbitraging, derivatives, etc. Thus, the responsibility of (together with the necessary incentives for) monitoring and disciplining banks should be given to the more informed/skilled agents for whom the cost of this monitoring is lower. Other banks and financial institutions like pension funds, investment firms, etc, since they are doing the same job (investing in risky assets), know the intricacies of the banking business better than the

[1] also, actually, on the government's effort, but we will address to the government's role, which we beleive to be more influential in modern banking crises, in our companion paper.

[2] Portfolio risk, credit risk, interest rate risk, foreign exchange rate risk

other agents in the economy. Moreover, since they are wholesale investors, their unit cost of monitoring banks is lower. Making those agents the subordinated debt holders[3] of a bank, i.e., rewarding them sufficiently in case of success but leaving them at their own stake in case of failure is the way to provide them with the necessary incentives.

Market discipline[4] that will result from the subordinated debt holders' monitoring will optimally reduce the occurrence of crises, because

1) Banks will be forced to decrease their risk-taking, as the riskier banks will be obliged to pay higher risk premium to investors.

2) As the risks of banks will be observable, investors will be able give their decisions on whether/how much to take risk (or whether to run) with more precise information. This will, in turn, reduce the necessity of protecting them, through for example deposit insurance which causes moral hazard.

Many subordinated debt proposals[5] have been made by some Federal Reserve Banks and academics since the early eighties. Those proposals, more or less, agree on the basic issues like the minimum required amount (2-5% of the assets), maturity (1-3 years), issuance frequency (monthly, quarterly or semi-annually), to whom it must be sold, etc [6]. Increasing intensity of the discussions about those proposals signals the high likelihood that obligatory subordinated debt will be put into practise in the U.S. in the near future. However, to the best of our knowledge, there has been no theoretical model put forward yet to explain how and when obligatory subordinated debt can help establishing market discipline. So, our primary objective is to fill in this gap. Moreover, we intend to analyze the impacts of another supervisory instrument, minimum capital requirement, on the stability of the banking system and on the incentives of banks for effort.

Organization of our paper is as follows: We will first describe the framework of the model and the game between agents. Comparison of the two main building blocks, symmetric and asymmetric information equilibria, will follow. We will then discuss when market can itself overcome the asymmetric information problem, and when regulator should impose a minimum subordinated debt requirement. At the end we will analyze the impacts of minimum capital requirement. After some critiques about our assumptions, we will conclude.

[3]Being junior to debt holders and senior to equity holders, subordinated debt holders are served after debt holders and before equity holders in case of the bank's failure.

[4]market discipline,which was claimed as the main remedy for banking crises by Calomiris, Evanoff, Kaufman, etc, refers to the situation where investors are aware of the banks' behaviour and demand interest rates accordingly.

[5]Those proposals claim that, in order to establish market discipline, banks should be obliged to issue some minimum amount of subordinated debt

[6]See Federal Reserve System's report (1999) "Using Subordinated Debt as an Instrument of Market Discipline" for a broad review of the literature on and the proposals for subordinated debt.

2 The Model

There is uncertainty in our economy. Hence, the asset portfolios financed by banks are risky. The return to an asset portfolio depends on the state of nature and on the banker's effort level in selecting/managing his assets. Both the effort and the cost of effort are banker's private information. All other things are common knowledge and all agents have perfect foresight.

2.1 Framework

2.1.1 Bank

Since we intend to investigate the behavior of the banking sector as a whole, we assume that there is one single representative bank in the economy. It is owned and managed by a banker who has an initial wealth W_B and who is risk neutral with the following utility function:

$$V_B = C_{B0} + \rho E\left[C_{B1}\right] \qquad \text{where } \rho < 1 \tag{1}$$

The banker cares more about his consumption at t=0 than that at t=1. He performs classical banking operations: collecting deposits and investing in risky assets. Due to his expertise in screening and monitoring the banker has monopoly power in the risky assets market. Balance sheet of the bank in this set-up is as follows:

B/S

A	D E

where A, D and E stand for assets, deposits and equity, respectively. Investing \$1 in a risky asset of constant return to scale technology at period t=0 yields a random and observable return $\widetilde{R}$ at period t=1.

2.1.2 Investors

There exist two types of investors (depositors)[7]: A continuum of identical, risk averse retail investors and a risk neutral wholesale investor, with initial

[7] Until subordinated debt is introduced, the terms "investor" and "depositor" are equivalent, because all the investors will deposit in the bank (proof is given in Lemma1). But, when subordinated debt is introduced investors will be either subordinated debt holders or depositors.

wealths W_R and W_W, respectively ($W_R < W_W$). Their utility functions can be represented in the following way[8]:

$$V_i \underset{i=RorW}{|} = U_i(C_{i0}) + \rho E[U_i(C_{i1})] \quad \text{where } \rho < 1,\ U_i^{'} > 0\ ,\ U_R^{''} < 0, U_W^{''} = 0 \tag{2}$$

2.1.3 Contract

The proceeds of the risky investment are shared between investors and banker at t=1 according to the following debt contract:

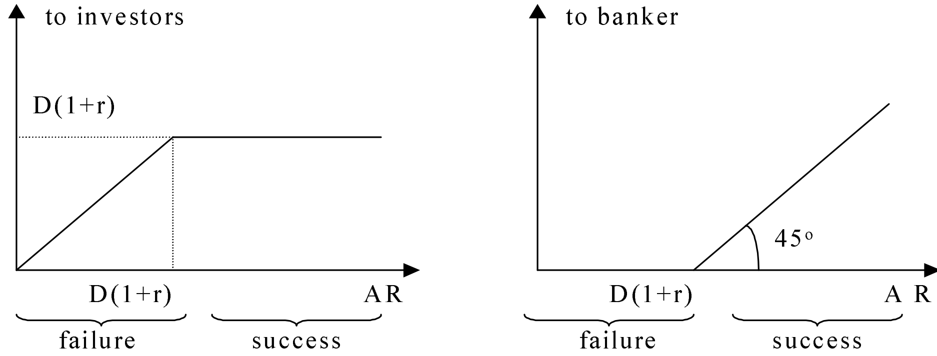

Figure 1: Debt Contract

The bank promises to pay an interest rate r to investors at t=1 for their deposits. But, if $A\widetilde{R}$ happens to be less than $(1+r)D$, then the bank is said to fail (become insolvent). The whole return is seized by investors in that case, and shared proportionally.[9]

[8] Having the same discount factor ρ for all agents in the economy has no impact on our conclusions.

[9] In a two period world, the above debt contract is the optimal risk sharing contract between risk averse investors and risk neutral banker who has a limited liability.

Optimal risk sharing contract between a risk averse and a risk neutral agent is the one with which risk neutral agent assumes the whole risk and gives a constant payoff to the risk averse agent for all states. But, if risk neutral agent is protected by limited liability, then risk averse agent gets all what is available in the states of failure and a constant payoff in all the states of success. Risk neutral agent, hence, gets what remains in the states of success.

Another remark about our choice of contract is that in 3 period models, where bank runs are generally modeled, the optimal risk sharing contract is a deposit contract (Allen and Gale, 1998). With this contract, which is the one we have in real life, investors can withdraw their deposits at an interim period. But, since we will focus only on bank failures, which is the starting ring of the above mentioned chain of events, but not on bank runs, as our modelling choices we simply have two periods and debt contract.

2.1.4 Technology

There are two available investment possibilities:

1) Riskless asset (say, TBills), in which investors can directly invest themselves. It yields a riskless return r_f, which is normalized to zero[10].

2) CRS risky assets, where investment requires an expertise, which only the bank has, in screening and monitoring. Return to a risky asset depends on the bank's effort as well as on the state of nature. Prior distribution of the random return $\widetilde{R}$ obtained from investing \$1 in any risky asset is $f\ _L(\widetilde{R})$ over $[0, \overline{R}]$. If the banker agrees to incur the cost of exerting effort c_q(per unit of investment), properly carries out his screening activities to select higher quality assets, and keeps those assets under close surveillance, then he can shift the probability distribution of the random return $\widetilde{R}$ in a FOSD manner from $f_L(\widetilde{R})$ to $f_H(\widetilde{R})$[11] over the same range. But, neither the effort (i.e.,the choice between the distributions) nor the cost of effort (which is dependent on the banker's human capital) is observable by investors, though the support of $c_q \in \{\underline{c}, \overline{c}\}$, where $\underline{c} < \overline{c}$, is common .knowledge

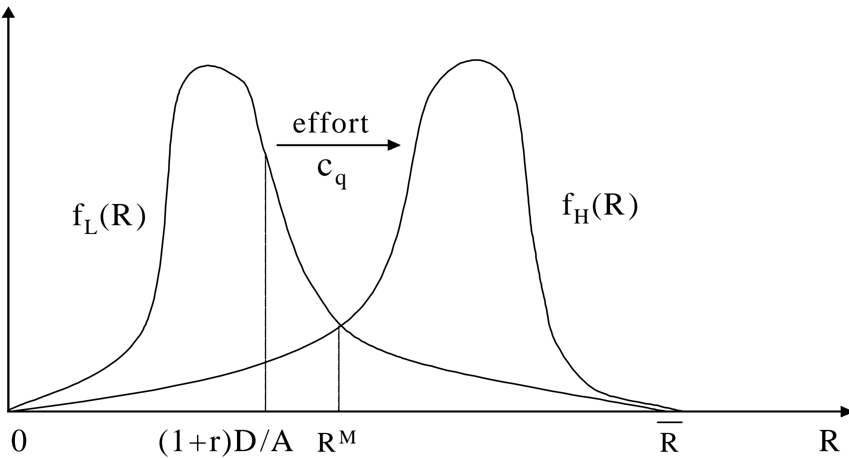

Figure 2: Risky Assets

$$E_L(\widetilde{R}) < 1 < E_H(\widetilde{R}) - \overline{c} \qquad (3)$$

Since low quality assets yield a negative net present value, investors will refuse to finance those assets. Only high quality assets have positive NPV's (Having a positive NPV is necessary condition for financing, sufficient condition will be given in Lemma 1).

[10]Note that, in this set-up, with $r_f = 0$ and $\rho < 1$, risk neutral agents, banker and wholesale investor, will not invest in riskless asset in equilibrium. But, this will not change any of our arguments or conclusions.

[11]Due to the first order stochastic dominance, probability of failure is less with f_H than with f_L, i.e., $F_H[(1+r)D/A] < F_L[(1+r)D/A]$ For all possible values of r, D, A

Lastly, but not least importantly, notice that, from the investors' viewpoint, risk of a bank, which is offering an interest rate r, is its probability of failure.

$$\Pr(Failure) = \Pr(\widetilde{R} < (1+r)D/A) = F_e((1+r)D/A), \quad e = L \ or \ H \quad (4)$$

This probability depends on three factors: the state of nature, bank's liability portfolio (leverage) and bank's asset portfolio (effort level). Evidently, risk of a bank increases with leverage and decreases with effort. So, (informed) depositors will be less willing to lend to a highly leveraged bank and/or to a bank which has low quality assets.

2.2 Game and Equilibria

The game between the banker (who has monopoly power) and the investors is a Stackelberg game, with informed principle. Timing is as follows:

1: Having anticipated the investors' supply function of deposit, banker decides on r and E (optimal capital structure) for his liability portfolio and on e (e_H =high quality asset portfolio, e_L =low quality asset portfolio)[12] for his asset portfolio, in order to maximize his ex-ante consumption.

2: Investors observe r and E, but being unaware of the banker's effort level, they decide on how much to deposit and how much to invest in Tbills in order to maximize their ex-ante utility.

2.2.1 Benchmark Case: Symmetric Information (e and c_q are also observable)

With symmetric information, from their following problem, investors will derive two (sets of) supply functions, depending on the banker's effort level [13]:

$$\begin{aligned}
\{D_i^{e*}(r,E), T_i^{e*}(r,E)\}_{e=H\text{or}L} &\in \underset{D_i,T_i}{Arg\max} V_i^e = U_i(C_{i0}) + \rho E_e U_i(C_{i1}) \qquad \text{(P1)} \\
& \quad s.t \\
C_{i0} &= W_i - D_i - T_i \\
C_{i1} &= \min[T_i + \frac{(E+D)\widetilde{R}}{D} D_i \ , \quad T_i + (1+r)D_i] \\
D_i + T_i &\leq W_i, \ D_i \geq 0, \ T_i \geq 0 \quad \text{(No borrowing conditions)}
\end{aligned}$$

where,

[12] high effort level of the banker and high quality of his asset portfolio are used interchangibly throughout the text.

[13] In our notation, subscripts refer to the agents and superscripts refer to the return distributions.

D_i is the investor i's supply of deposit
D is the aggregate supply of deposit
T_i is the amount investor i will invest in Tbills

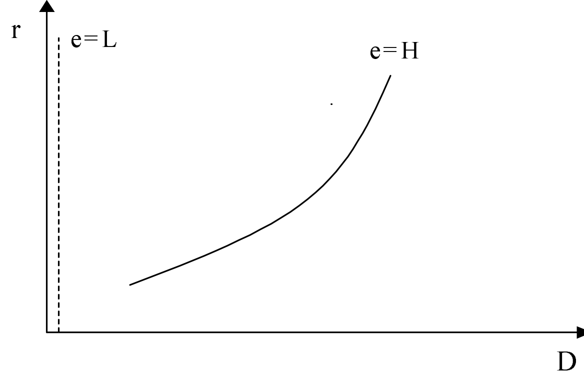

Figure 3: Deposit Supply Functions of Investors

Recall that low quality assets do not satisfy the necessary condition for financing.(equation 3)

Lemma 1 *If deposits yield a higher expected return than TBills,*

$$\int_{0}^{(1+r)D/A} \frac{A\widetilde{R}}{D} f(\widetilde{R}) d\widetilde{R} + (1+r) \int_{(1+r)D/A}^{\overline{R}} f(\widetilde{R}) d\widetilde{R} > 1 \;\Rightarrow\; D_i^* > 0 \qquad (5)$$

then investor i, even if he is risk averse, will invest some part of his wealth in risky assets in the form of bank deposit.

Proof. *see appendix* ■

Above condition (5) can be called as investors' participation condition (sufficient condition for financing). We assume that when f_H is chosen interest rate (r) offered by the banker, satisfies this condition. Note also that investors' borrowing is not allowed (or, better to say, investors' borrowing is not an equilibrium phenomenon) in this model, because, as investors can not invest in profitable risky assets themselves, they can not offer an expected return higher than that of TBills'.

Lemma 2 *For small values of r (which we assume to be the relevant case), investor i will have an increasing $D_i^*(r)$. For large values of r (as it is the case during crises), investor's deposit supply function $D_i^*(r)$ may be decreasing, depending on his utility function.*

Proof. *see appendix* ■

Given the depositors' aggregate deposit supply functions $D^{L*}(r,.)$ and $D^{H*}(r,.)$, the banker will decide whether/how to participate (be a banker) by solving the following problem

$$\{r^*, E^*\} \in \underset{r,E}{Arg\max} V_B = V_B^H - c_q A = C_{B0} + \rho E_H(C_{B1}) - c_q A \qquad \text{(P2)}$$

$$\begin{aligned} & s.t. \\ C_{B0} &= W_B - E \\ C_{B1} &= \max[0, A\widetilde{R} - (1+r)D^{H*}(r,E)] \\ A &= E + D^{H*}(r,E) \quad \text{(Balance Sheet constraint)} \end{aligned}$$

and he will not participate if $V_B < V_{B0}$ (participation constraint). The trade-offs he faces are the following: To be able to increase his ex-ante utility, banker knows that he would better

1) choose high quality assets, but this is costly

2) invest as much as possible in risky assets, but he cannot put too much equity because of the discount factor $\rho < 1$ (consumption at t=0 is more valuable), and he cannot collect to much deposit because of the increasing cost of borrowing.

From now on, with some abused notation, we will denote the total cost of effort ($c_q A$) by the variable $C_Q \in \{\underline{C}, \overline{C}\}$, where the arguments are also variables.

Proposition 3 *In symmetric information, depending on the banker's cost of effort, there are four possible subgame perfect Nash equilibria, out of which only two are interesting:*

1) Both $\underline{c}$ and $\overline{c}$ participate (pooling).

$$\{e^* = H,\ r^*, E^*, D^{H*}(r,E), T^{H*}(r,E)\}$$

2) $\underline{c}$ participates while $\overline{c}$ not(separating).[14]

$$\begin{array}{lcll} if\, c_q & = & \underline{c} & \{\underline{e}^* = H,\ r^*, E^*, D^{H*}(r,E), T^{H*}(r,E)\} \\ if\, c_q & = & \overline{c} & \{D^{L*}(.) = 0,\ T^{L*}(.)\} \end{array}$$

These equilibria are the simultaneous solutions of the investors' problem P1 and the banker's problem P2

Proof. *In symmetric information, banker is allowed to perform banking operations only if he exerts effort. He will then exert effort only if his utility with effort is greater than his reservation utility. In other words, only if his benefit from participating (being a banker) B_P^* is greater than his cost of exerting effort C_Q, where B_P^* solves:*

[14] Note that problem in this case boils down to a pure adverse selection problem.

$$B_P^* = V_B^H(D^{H*}(r^*), E^*) - V_{B0} \tag{6}$$

So, if $\underline{C} < \overline{C} < B_P^*$*, pooling equilibrium, or else if* $\underline{C} < B_P^* < \overline{C}$*, separating equilibrium will take place.*

The other pooling equilibrium where neither participates ($B_P^* < \underline{C} < \overline{C}$*), is not plausible, as it implies that there is no good bank (or that there is no good project) in the economy. And, the other separating equilibrium, where* $\overline{C}$ *exerts effort and* $\underline{C}$ *not, (i.e.,* $\overline{C} < B_P^* < \underline{C}$*) contradicts to our assumption (*$\underline{c} < \overline{c}$*).*■

As it is more interesting from economic point of view, we will concentrate on the pooling equilibrium, where both types acquire high quality assets, as our first-best benchmark case.[15] Note lastly that, the arguments for the necessity of protecting small depositors through, for example, deposit insurance are not valid in this symmetric information case, because depositors are, consciously and voluntarily, taking risk (though they can avoid the risk by investing in TBills).

2.2.2 Asymmetric information

e and c_q are unobservable, but the support of $c_q \in \{\underline{c}, \overline{c}\}$ and the types' prior probabilities λ and $1-\lambda$, respectively, are common knowledge. In order to introduce a conflict of interest and make the problem economically more appealing we will assume here that

$$\underline{C} < B_e^* < \overline{C} < B_P^* \tag{7}$$

where B_e^* solves:

$$B_e^* = V_B^H(D^{H*}(r^*), E^*) - V_B^L(D^{H*}(r^*), E^*) = \rho A^* \int_{(1+r^*)\frac{D^{H*}(r)}{A^*}}^{\overline{R}} \widetilde{R}\,[f_H(\widetilde{R}) - f_L(\widetilde{R})]dR \tag{8}$$

In words, our benchmark equilibrium, where the both types of bankers make effort and the investors supply deposit with $D^{H*}(.)$, is not a perfect Bayesian equilibrium in asymmetric information. The investors know that if they supply deposit with $D^{H*}(.)$, bad type banker will not exert effort, because his marginal benefit of exerting effort B_e^* is less than his cost of effort

[15] Then, the socially optimal equilibrium probability of having a bank failure is $F_H\left[(1+r^*)\frac{D^{H*}(r^*)}{E^*+D^{H*}(r^*)}\right]$ (i.e., the probability of failure when the bank finances only the socially preferred assets)

$\overline{C}$, (i.e. his incentive compatibility condition is not met.).[16] The possibility that the banker will not exert effort will induce investors either to shift their supply function toward left (lowering the equilibrium aggregate deposit to D^{AI} and raising the equilibrium interest rate to r^{AI}), or not to supply any deposit at all.

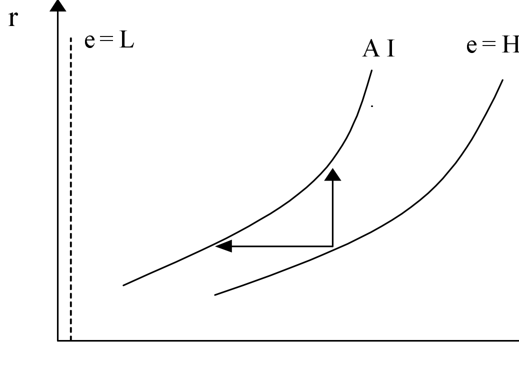

Figure 4: Dep.Sup.Function in Asymmetric Information

As long as investing in the bank's assets produces, in expectation, a positive NPV

$$\lambda \left[\int_0^{\overline{R}} \widetilde{R}\ dF_H(\widetilde{R}) - \underline{c} \right] + (1-\lambda) \int_0^{\overline{R}} \widetilde{R}\ dF_L(\widetilde{R}) > 1$$

and the banker's interest rate offer r satisfies, in expectation, investors' participation condition (i.e., as long as percentage of good types is high enough to subsidize bad types[17]), investors will continue to invest in bank's risky assets. Their problem, in this case, will be:

[16] $V_B^H(D^{H*}(r^*), E^*) - \underline{C} > V_B^L(D^{H*}(r^*), E^*) > V_B^H(D^{H*}(r^*), E^*) - \overline{C} > V_{B0}$ is the compact way of expressing equations 6, 7 and 8

[17] λ can be interpreted as the percentage of good type banks in the economy

$$\{D_i^{AI}(r,E), T_i^{AI}(r,E)\} \in \underset{D_i,T_i}{Arg\max} V_i^{AI} = U_i(C_{i0}) + \rho\left[\lambda E_H U_i(C_{i1}) + (1-\lambda) E_L U_i(C_{i1})\right] \tag{P3}$$

$$\begin{aligned}
& s.t. \\
& C_{i0} = W_i - D_i - T_i \\
& C_{i1} = \min[T_i + \frac{A\widetilde{R}}{D} D_i \ , \ T_i + (1+r) D_i] \\
& D_i + T_i \leq W_i \\
& V_i^{AI}\left[D_i^{AI}(.), T_i^{AI}(.)\right] \geq V_i^L\left[0, T_i^L(.)\right] \ \text{(Participation constraint)}
\end{aligned}$$

(The above participation constraint of investors is equivalent to the condition (5) given in Lemma 1). Deducing investors' supply function $D_i^{AI}(r,E)$, banker's problem will be:

$$\{e^{AI}, r^{AI}, E^{AI}\} \in \underset{e,r,E}{Arg\max} V_B^{AI} = Max\left[V_B^L = C_{B0} + \rho E_L(C_{B1}), \quad V_B^H - C_Q = C_{B0} + \rho E_H(C_{B1}) - C_Q\right] \tag{P4}$$

$$\begin{aligned}
& s.t. \\
& C_{B0} = W_B - E \\
& C_{B1} = \max[0, A\widetilde{R} - (1+r) D^{AI}(r,E)] \\
& A = E + D^{AI}(r,E) \\
& V_B^{AI} \geq V_{B0}
\end{aligned}$$

Proposition 4 *In asymmetric information, depending on the parameters, there will be two types of PBE:*

1) bank types will separate on effort, but investors will pool on $D^{AI}(.)$

$$\begin{aligned}
\text{if } c_q &= \underline{c}, \quad \{\underline{e}^{AI} = H, \ r^{AI}, E^{AI}, D^{AI}(r,E), T^{AI}(r,E)\} \\
\text{if } c_q &= \overline{c}, \quad \{\overline{e}^{AI} = L, \ r^{AI}, E^{AI}, D^{AI}(r,E), T^{AI}(r,E)\}
\end{aligned}$$

where, $r^{AI} > r^*$ and $D^{AI} < D^{H*}$.

2) Neither type prefers to make effort, and financial market collapses:

$$\{D^{AI}(.) = 0, \quad T^{AI}(.) = T^{L*}(.)\}$$

These equilibria are the simultaneous solutions of the investors' problem P3 and the banker's problem P4.

Proof. *When banker's effort is not observable, his decision whether to exert effort depends on his incentive compatibility condition. Investors know that bankers' pooling on effort strategy is not credible, because bad type's IC*

condition is not satisfied in that equilibrium (assumption 7). Hence, pooling on effort is not PBE.

If the parameters of the model and the types' costs of effort are such that $\underline{C} < B_e^{AI} < \overline{C}$, *where* B_e^{AI} *solves*[18]*:*

$$B_e^{AI} = V_B^H(D^{AI}(r^{AI}), E^{AI}) - V_B^L(D^{AI}(r^{AI}), E^{AI}) \tag{9}$$

then $\underline{c}$ *makes effort and* $\overline{c}$ *not. Since investors cannot discriminate between the types, they will always supply deposit with* $D^{AI}(.)$.[19] *Otherwise, neither type prefers to make effort. Since investors will foresee this, and they will not deposit in that case.*■

We discard the second equilibrium as it is not interesting for our purposes.

As a result, the point we want to emphasize here is that, in asymmetric information, banker's optimal choice of effort may not always be aligned with the investors's interests, and socially inferior assets may be financed in equilibrium. That's why, to decrease the probability of having a bank failure to its socially optimal level, the bad type banker must be disciplined and induced to make effort.

2.3 Market Solutions for Asymmetric Information

All the market participants, except the bad type banker, have incentives to eliminate asymmetric information and establish market discipline. Actually, they are not completely helpless in this respect. Investors, for instance, if they accept to incur the fixed cost C_M and monitor the banker, they can identify his type and effort.[20] (Note that because of the decreasing per dollar cost of monitoring with the amount deposited, the wholesale investor has stronger incentives than the retail investors to monitor the bank.[21]) The good type banker, on the other hand, may send a costly signal (that bad type cannot afford) to the investors to discriminate himself. Whether/with which tool the market can overcome this asymmetric information problem depends on the difficulty and the cost of monitoring bank's activities, and on the investors' incentives.

[18] B_e^{AI} refers to the marginal benefit of effort in asymmetric information.

[19] $V_B^H(D^{AI}(r^{AI}), E^{AI}) - \underline{C} > V_B^L(D^{AI}(r^{AI}), E^{AI}) > V_B^H(D^{AI}(r^{AI}), E^{AI}) - \overline{C}$ is the other way of expressing the above condition.

[20] The fact that the banker has a variable cost of effort c_e, whereas the investors have a fixed cost C_M of monitoring the bank is not contradictory. Banker's effort increases with his assets because he has to screen/monitor every firm to which he gives credit. Investors, on the other hand, have to exert the same effort, irrespective of the size of their deposits, in order to monitor the banker's effort and/or type.

[21] Although we have not included it in the model, another advantage the wholesale investor has in monitoring the bank is that since in real life he is doing similar jobs (investing in risky assets), he can assess the true riskiness of a bank better than any other agent (including the supervisor) in the economy.

2.3.1 Screening

If, for the wholesale investor, the cost of monitoring the banker (C_M) is less than the value of the exit option (the right not to deposit if the banker has low quality assets) in asymmetric information, i.e., if

$$C_M < C_1 = \lambda V_w^H \left[D_w^{H*}(r^{AI}), T_w^{H*}(r^{AI})\right] + (1-\lambda)V_w^L \left[0, T_w^{L*}(r^{AI})\right] - V_w^{AI} \left[D_w^{AI}(r^{AI}), T_w^{AI}(r^{AI})\right]$$

then the wholesale investor, without any external incentives, monitors the banker, and screens the types. Since the wholesale investor's action is observable, retail investors will free-ride and follow the wholesale investor.

Proposition 5 *If $C_M < C_1$, PBE in asymmetric information is pooling on effort*[22]

$$\{e^S = H, r^*, E^*, D^{H*}(r,E), T^{H*}(r,E)\}$$

Proof. *In case the wholesale investor prefers to monitor the bank, both types will choose to exert effort due to their participation constraint (see equations 6 and 7).*

Hence, if monitoring the banker is not difficult and costly, and if the investors have strong enough incentives to monitor, then market discipline arises spontaneously. (Note that investors's incentives to eliminate asymmetric information depend, in essence, on the difference in their pay-offs between the states of success and failure. So, for instance, if there were a deposit insurance in our model, as it would decrease this difference, would reduce the wholesale investor's incentives to monitor and the retail investors's incentives to follow the wholesale investor. This, in turn, would reduce the probability that market discipline would be established spontaneously.) Note lastly that even though the equilibrium strategies in this case are the same as those in the benchmark case, this outcome is inferior to the first-best, because the society (wholesale investor) incurs the cost C_M.

2.3.2 Signalling by Investing More Equity

If there exists an equity level E^S $(> E^*)$[23],which will satisfy the following inequalities and the equation

$$V_B^H(D^{H*}(r^S), E^S) - \underline{C} > V_B^H(D^{AI}(r^{AI}), E^{AI}) - \underline{C} > V_B^L(D^{H*}(r^S), E^S) = V_{B0} > V_B^H(D^{H*}(r^S), E^S) - \overline{C} \tag{10}$$

[22] S in e^S stands for screening

[23] When investors are supplying deposit with D^{H*}, it's optimal for the banker to choose E^* and r^*. So, with $E^S > E^*$ (and $r^S < r^*$), good type banker forgoes some of his rent, i.e. $V_B^H(D^{H*}(r^S), E^S) < V_B^H(D^{H*}(r^*), E^*)$, to be able to discriminate himself.

in words, if there exists an equity level E^S, at which the bad type banker will not participate even if the investors supply deposit with D^{H*}, and the good type banker will be better off than the asymmetric information case[24], then the good type banker chooses to invest E^S to discriminate himself.

Proposition 6 *If the conditions in (10) are satisfied, then the PBE of the signalling game is a separating equilibrium, where $\underline{c}$ signals himself by investing E^S, while $\overline{c}$ can not and is eliminated*

$$\begin{aligned} \textit{if } c_q &= \underline{c}, \quad \{\underline{e} = H,\ r^S, E^S, D^{H*}(r,E), T^{H*}(r,E)\} \\ \textit{if } c_q &= \overline{c}, \quad \{\ D^{L*}(.) = 0,\ \ T^{L*}(.)\} \end{aligned}$$

Proof. *Evident*

2.3.3 Signaling by Certification

If the conditions in (10) are not satisfied, or if the cost of monitoring the banker C_M is not small enough for the investors to screen between the types, but nevertheless smaller than the difference in the good type banker's utility between symmetric and asymmetric information, i.e., if

$$C_1 < C_M < C_2 = V_B^H(D^{H*}(r^*), E^*) - V_B^H(D^{AI}(r^{AI}), E^{AI})$$

then the good type banker may prefer to pay C_M in order to be monitored and certified. Whether this alternative will work depends on the existence of a rating agent in the economy. Since this agent receives his monitoring fee before he monitors the banker, his IC condition (whether he will indeed monitor) depends on his cost of losing reputation in case of the bank's failure. Although we have not modeled reputation in this paper, in the case where the rating agent's participation and IC conditions hold:

Proposition 7 *In the signaling game, where $C_M < C_2$, depending on the parameters of the model, there will be two possible perfect Bayesian equilibria:*

1) Pooling equilibrium : Both $\underline{c}$ and $\overline{c}$ signal and exert effort[25]

$$\{e^C = H,\ r^*, E^*, D^{H*}(r,E), T^{H*}(r,E)\}$$

2) Separating equilibrium: $\underline{c}$ signals, while $\overline{c}$ doesn't and is eliminated.

$$\begin{aligned} \textit{if } c_q &= \underline{c}, \quad \{\underline{e}^C = H,\ r^*, E^*, D^{H*}(r,E), T^{H*}(r,E)\} \\ \textit{if } c_q &= \overline{c}, \quad \{D^{L*}(.) = 0,\ \ T^{L*}(.)\} \end{aligned}$$

[24]Ignoring all the terms in between, the constraints in (10) can actually be translated into a simple condition: $\overline{C} \gg \underline{C}$, (i.e., the difference between the types is so high that the good type doesn't have to give up too much rent to discriminate himself)

[25]C in e^C stands for certification.

Proof. *In the case, where good type banker prefers to signal himself by being monitored, equilibrium strategy for the bad type depends on whether the cost of being monitored enables him to participate. If* $\overline{C}+C_M < B_p^*$ *(see eqn 6) bad type also prefers to be monitored, and pooling equilibrium takes place. Otherwise, separating equilibrium occurs.*■

So, if monitoring banks is moderately costly, good type banker prefers to signal himself, and market discipline arises again in equilibrium.

2.3.4 Signaling by a Menu of Contracts:Voluntary Subord. Debt

In the absence of a credible rating agent in the economy, good type banker may prefer to signal himself by offering a menu of contracts to the investors: a debt contract to the retail investors and a subordinated debt contract to the wholesale investor.[26]

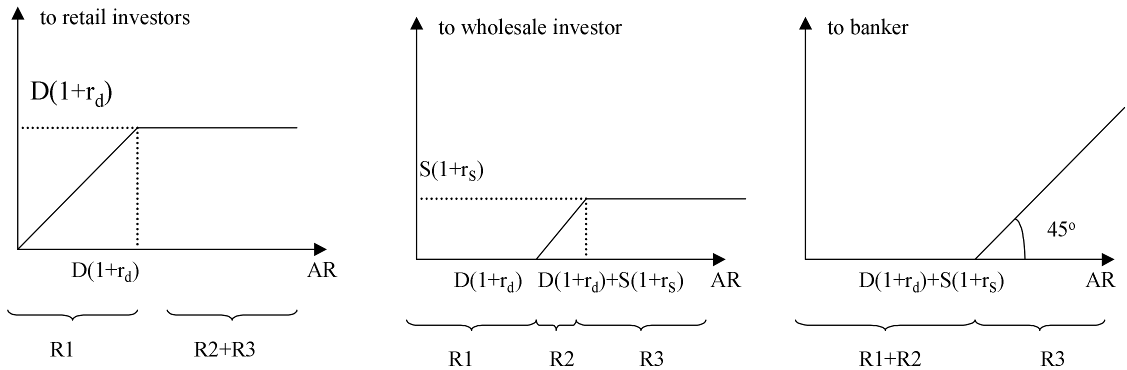

Figure 5: Menu of Contracts

The fact that the wholesale investor's pay-off depends on the outcome gives him incentives to monitor.

Timing of this new game is as follows:

1) Having anticipated retail investors' and wholesale investor's supply functions, banker will choose $\{e, r_d, r_s, E\}$.

2) Having observed the banker's choices $\{r_d, r_s, E\}$ and anticipated the retail investors' supply function, wholesale investor, if the banker's offer is incentive compatible, will incur the cost C_M and monitor the banker's type and effort. If he observes that banker exerts (will exert) effort, he will supply S.

3) Retail investors will observe the wholesale investor's decision together with banker's decisions on r_d and E, and will supply deposit accordingly.

[26] It is not obvious in the figure, but recall that S, if it is within the range recommended by the proposals, is very small compared to D, so is $R2$ compared to $R1$.

So, the retail investors decide whether/how much to deposit (take risk):

$$\begin{aligned}
\{D_R^{H*}(.), T_R^{H*}(.)\} &\in \underset{D_R,T_R}{Arg\max} V_R^H = U_R(C_{R0}) + \rho E_H U_R(C_{R1}) \quad \text{(P5)} \\
& s.t. \\
C_{R0} &= W_R - D_R - T_R \\
C_{R1} &= \min[T_R + \frac{A\widetilde{R}}{D} D_R \ , \ T_R + (1+r_d) D_R] \\
D_R + T_R &\leq W_R \\
V_R^H &\geq V_R^L \left[0, T_R^L(.)\right] \quad \text{(Participation C.)}
\end{aligned}$$

the wholesale investor decides whether to monitor, and whether/how much to invest in bank's assets:

$$\{S_w^{H*}(.), T_w^{H*}(.)\} \in \underset{S_W,T_W}{Arg\max} V_w^H = C_{wo} + \rho E_H \left[C_{w1}\right] \tag{P6}$$

$$s.t.$$

$$C_{wo} = W_w - S_w - T_w$$

$$C_{w1} = \max\left[T_w, \quad \min[T_w + A\widetilde{R} - (1+r_d) D^{H*}(.) \ , \ \ T_w + (1+r_s) S_w]\right]$$

$$S_w + T_w \leq W_w$$

$$V_w^H \left[S_w^{H*}(r_s), T_w^{H*}(r_s)\right] - C_M \geq V_w^H \left[D_w^{H*}(r_d), T_w^{H*}(r_d)\right] \quad \text{(IC C.)}$$

$$V_w^H \geq V_w^L \left[0, T_w^L(.)\right] \quad \text{(Participation C.)}$$

Remark 1 $r_s > r_d$, *because subordinated debt holder receives less (in expectation) than the depositors in case of failure. He also incurs the monitoring cost* C_M*. His incentive compatibility condition will then guarantee that he will receive more than the depositors in case of success. Rewarding the monitor sufficiently in case of success, but leaving him at his own stake in case of failure, is the way to provide him with the necessary incentives to monitor.*

And, the banker decides whether/with which conditions to participate:

$$\{r_d^{**}, r_s^{**}, E^{**}\} \in \underset{r_d,r_s,E}{Arg\max} V_B = V_B^H - C_Q - C_M = C_{B0} + \rho \ E_H(C_{B1}) - C_Q - C_M \tag{P7}$$

$$\begin{aligned}
& s.t. \\
& C_{B0} = W_B - E \\
& C_{B1} = \max[0, \ A\widetilde{R} - (1+r_d) D^{H*}(.) - (1+r_s) S^{H*}(.)] \\
& A = E + D^{H*}(.) + S^{H*}(.) \\
& V_B \geq V_{B0} \quad \text{(Participation C.)}
\end{aligned}$$

Proposition 8 *If $C_M < C_2$ and good type banker signals himself by offering a menu of contracts, depending on the parameters of the model, there will be two possible perfect Bayesian equilibria:*

1) Pooling equilibrium : Both $\underline{c}$ and $\overline{c}$ offer the same menu of contracts and exert effort[27]

$$\{e^{**} = H,\ r_d^{**} = r^*, r_s^{**}, E^*, S^{H*}(e, r_d, r_s, E), D^{H*}(S^{H*}, r_d, E)\}$$

2) Separating equilibrium: $\underline{c}$ offers the menu of contracts, while $\overline{c}$ doesn't and is eliminated.

$$\begin{aligned} \textit{if } c_q &= \underline{c}, \quad \{\underline{e}^{**} = H,\ r_d^{**} = r^*, r_s^{**}, E^*, S^{H*}(e, r_d, r_s, E), D^{H*}(S^{H*}, r_d, E)\} \\ \textit{if } c_q &= \overline{c}, \quad \{S^{L*}(.) = 0,\quad D^{L*}(.) = 0\} \end{aligned}$$

These equilibria are the simultaneous solutions of the retail investors' problem P5, the wholesale investor's problem P6 and the banker's problem P7.

Proof. *Recall from symmetric information that when investors are supplying deposits with $D^{H*}(.)$, optimal strategy for the banker is to invest E^* and offer r^* to investors. If banker offers another contract to the wholesale investor, ensuring him to receive C_M as extra in expectation (see wholesale investor's IC condition above), then wholesale investor monitors the banker. So, the only difference between this equilibrium and the certification one is that banker does not pay C_M all in advance to the monitor but pays it as an interest rate (r_s) whose expected value is C_M.*

As before, equilibrium strategy for the bad type depends on whether the cost of being monitored enables him to participate. If $\overline{C} + C_M \leq B_p^*$ (see eqn 6) bad type also prefers to signal by offering the same menu of contracts, and pooling equilibrium takes place. Otherwise, separating equilibrium occurs. ■

In summary, if monitoring the banker is not very difficult and costly, market participants find a way to cope with the asymmetric information problem, and market discipline is established spontaneously. Even though the equilibrium decisions (r^*, D^{H*}, E^*, A^*) induced by the market discipline are identical to those in the first-best, the outcome induced by the market discipline is socially inferior to the first-best outcome, because society incurs the additional cost C_M.

2.4 Regulatory Solutions for Asymmetric Information

2.4.1 Minimum Subordinated Debt Requirement

The necessary condition for the market to solve the asymmetric information problem itself is that the investors have strong incentives for that If investors

[27] Investors' decisions on TBills are omitted for simplicity.

lack those incentives because of the excessive protection they already have, through for instance deposit insurance, then market fails to bring about the disciplinary mechanisms itself.

Necessity of protecting small depositors by deposit insurance is a valid argument in asymmetric information. But, protecting them this way reduces the chances that asymmetric information is eliminated by the market. Obligatory subordinated debt may be a remedy for this dilemma. Imposing a minimum subordinated debt requirement on the bank serves for the two purposes at the same time. It reduces the asymmetric information and it provides protection to the retail investors. Depositor protection, (in its narrow sense) implies that when the bank fails, the funds should be redistributed from risk-bearing agents to depositors.[28] Those funds can come from three sources: Banker, junior lenders or third parties (i.e., deposit insurance fund or tax-payer). Protecting depositors at the expense of the banker is already incorporated in the debt contract. So, by choosing obligatory subordinated debt over deposit insurance, regulator can both avoid moral hazard effects of deposit insurance (i.e., increase incentives to eliminate asymmetric information) and provide protection to the retail investors.[29]

However, even in the absence of deposit insurance, if good type banker can not signal himself by investing more equity and if monitoring the banker is difficult and expensive ($C_M > C_2$), as it is the case in the deregulated banking systems, where banks are allowed to engage in complex operations, then market fails to eliminate the asymmetric information. In those cases, providing extra incentives (if it is worth) to the informed/skilled agents to monitor the banker may increase the stability of the banking system and improve welfare. The comparison of the social costs and benefits of the obligatory subordinated debt[30] depends on which equilibrium will result. In the pessimistic equilibrium, where the additional cost of being monitored C_M doesn't enable the bad type bank to participate, i.e., $C_M + \overline{C} > B_p^*$, the comparison of those costs and benefits becomes

$$C_M \lesseqgtr A^* \int_0^{\overline{R}} \widetilde{R} dF_H(\widetilde{R}) - \underline{C} - A^{AI} \left[\lambda \left(\int_0^{\overline{R}} \widetilde{R} dF_H(\widetilde{R}) - \underline{C} \right) + (1-\lambda) \int_0^{\overline{R}} \widetilde{R} dF_L(\widetilde{R}) \right]$$

[28] Depositor protection, more generally, implies both the ex-ante measures that aim at preventing bank failures (eg, supervison, which includes instruments like lisensing requirements, capital standards, accounting principles, auditing, early warning systems, prompt corrective action plan, etc), and the ex-post measures that will redisribute the funds from risk bearing agents to depositors.

[29] See (Birchler, 2000) for a broad discussion on the depositor protection, through deposit priority rules (senior vs junior) or deposit insurance.

[30] Deposit insurance and its adverse effects are not included in our formal analysis.

Even though $A^* \geq A^{AI}$, assuming them to be equal doesn't change our conclusions. With this assumption, we observe that benefits of subordinated debt overweight its costs, if C_M[31] is lower than C_3, where C_3 solves

$$C_M < C_3 = (1-\lambda)\left[A^* \int_0^{\overline{R}} \widetilde{R}\ \left[dF_H(\widetilde{R}) - dF_L(\widetilde{R})\right] - \underline{C}\right] \quad (11)$$

Apparently, benefits from subordinated debt increase as the percentage of bad type banks and as the difference between high quality and low quality assets increase. As a result, we conclude that if $C_2 < C_M < C_3$, then the regulator (to the harm of the banker but to the benefit of the investors) can improve the social welfare by imposing a minimum subordinated debt requirement on the banks.[32]

Remark 2 *There are two relevant questions to be asked here. First, "Can selling equity claims (instead of junior claims) to the informed/skilled agents also eliminate the asymmetric information and reduce the occurrence of banking crises to its optimal level?" In our model, which was not designed for this question, the answer is "yes", because in this model, due to the FOSD of the high quality assets over the low quality ones, all the agents (except the bad type banker who will incur the cost of effort $\overline{C}$) will prefer to have high quality assets, irrespective of their pay-offs. However, generally speaking[33], for the informed/skilled agents to act in the depositors' interests, their pay-off structure should be similar to those of the depositors. But, making them the partners of the banker (offering them the same pay-off as the banker's) will drive their preferences toward those of the banker. This will, in turn, reduce their incentives to force the banker (when there is a conflict of interest) to behave in the society's interests.*

Second, " Can peer monitoring in the interbank loans market substitute the monitoring by the subordinated debt holders?" The answer is "not exactly", because in (domestic) interbank markets the loans are of quite short maturities (not longer than a few months) and the interest rates do not reflect any risk adjusted premiums. Hence, the information revealed by the

[31] Actually, the social cost of subordinated debt is not only the monitoring cost C_M. If junior claims of a bank is sold to the other banks, risk of contagion increases. Thus, there is also the cost of increased likelihood of contagion. But this cost, also maybe the optimal level of minimum subordinated debt (high enough to serve as a good incentive for the wholesale investor to monitor and low enough not to add to the risk of contagion), can only be analyzed in a richer model with several banks.

[32] The optimal level of this minimum requirement, in this set-up, is actually determined in the previous case $\frac{S^{H*}(r^*, r_s^{**}, E^*)}{A^*}$

[33] Conflict of interest between banks and investors can be modeled using the mean preserving spread property of the distributions instead of FOSD

interbank loans about the riskiness of a bank is not informative as that by the subordinated debt.

2.4.2 Minimum Capital Requirement

Instead of obliging to issue subordinated debt, supervisor/regulator, with the aim of limiting the risk of failure, may constrain the banker to finance at least k% of his assets with his own equity. (In this case, banker will solve P4 with an additional equity constraint $E \geq kA$.)

Investigating the impacts of this constraint on the risk of failure (which is, as explained by equation (4), dependent on the leverage and the quality of asset portfolio) is the objective of this section. Impact of minimum capital requirement on the leverage is obvious. First of all, empirical evidence (Jackson et al. (1999)) shows that in response to 1988 Basle Accord banks decreased their leverage($\frac{D}{A}$).[34] Reaching the same result analytically is also simple. Having a binding equity constraint (given that bank capital is expensive, and that's why, bank equity level is rather constant in time), decreases banks' demand for deposit. This, in turn, decreases both their leverage and the equilibrium interest rate.

However, exploring the impact of minimum capital requirement on the quality of asset portfolio, i.e., on the banker's effort, theoretically is not trivial. Whether the changes in equilibrium conditions (fall in the aggregate deposit and in the interest rate) increase or decrease the banker's incentives for effort depends on the modeling choices and the parameters. To see this, recall from our benchmark case that banker's (unconstrained) optimal response to investors' supply function $D^{H*}(r, E)$ was r^* and E^*, and the types' IC conditions were

$$\underline{C} < \; B_e^* = \rho(E^* + D^*) \int_{(1+r^*)\frac{D^*}{(E^*+D^*)}}^{\overline{R}} \widetilde{R}\; [f_H(\widetilde{R}) - f_L(\widetilde{R})] dR < \overline{C}$$

The new equilibrium conditions will increase/decrease the types' marginal benefit of effort B_e^*,according to whether

$$(\frac{\partial B_e^*}{\partial r})dr + (\frac{\partial B_e^*}{\partial D})dD \lesseqgtr 0 \quad \text{where, } dr < 0 \text{ and } dD < 0 \tag{12}$$

[34] In their comprehensive research about the impacts of 1988 Basle Accord on the banks' behavior, Jackson et al. document that in the countries which adopted the Basle Accord, the average capital ratio of the banks increased from 9.3% in 1988 to 11.2% in 1996, while preserving the standard deviation at 1.6%.

$$\frac{\partial B_e^*}{\partial r} = -\rho \frac{(1+r)D^2}{(E+D)}[f_H(\frac{(1+r)D}{(E+D)}) - f_L(\frac{(1+r)D}{(E+D)})] \tag{13}$$

$$\frac{\partial B_e^*}{\partial D} = \rho \left[\int_{(1+r)\frac{D}{(E+D)}}^{\overline{R}} \widetilde{R}\, [f_H(\widetilde{R}) - f_L(\widetilde{R})]dR - \frac{(1+r)^2 ED}{(E+D)^2}[f_H(\frac{(1+r)D}{(E+D)}) - f_L(\frac{(1+r)D}{(E+D)})] \right] \tag{14}$$

Apparently, there are three factors affecting B_e^* : interest rate effect, which is described by equation (13) and negative for $\frac{(1+r)D}{A} > R^M$; scale effect, which is described by the first term in equation (14) and always positive (due to FOSD); leverage effect, which is described by the second term in equation (14) and negative for $\frac{(1+r)D}{A} > R^M$.

So, in the case $\frac{(1+r^*)D^*}{A^*} > R^M$ (when the probability of failure is high), the fall in the interest rate increases the banker's incentives for effort, and the fall in the aggregate deposit decreases them through scale effect and increases them through leverage effect. The overall effect is, that's why, ambiguous. And in the case $\frac{(1+r^*)D^*}{A^*} < R^M$ (when the probability of failure is low), as all those three effects are positive, the fall in the aggregate deposit and in the interest rate unambiguously decrease the banker's incentives for effort. However, if we introduce the conflict between the banker and the investors by means of the mean preserving spread property of the distributions instead of FOSD, then this case also becomes ambiguous.

As a result, theoretically it is possible that minimum capital requirement will induce the banker to switch to the high quality assets. However, empirical evidence suggests the opposite. In their work comprising G-10 countries, Jackson et Al.,(1999) find that banks increased their equity and liquidity ratios in response to 1988 Basle Regulatory Act. But, they also find strong evidence showing that some banks, in order to increase their return on equity, used some arbitraging techniques and switched to the higher risk-higher return projects within the same risk weighing group of investments. Jones, (2000) explicitly demonstrates how banks use those techniques, and points out the difficulties faced by bank supervisors in dealing with such activities.

We conclude that minimum capital requirement decreases the probability of the bank's failure by decreasing its leverage, but may not do so by improving the quality of its assets. So, its overall impact on the probability of failure is ambiguous.

2.5 Critiques on Assumptions

As self critiques, we know that we made some bold assumptions on the monitoring of the informed agents. Notice that we assumed:

1) informed agents carry out a retrospective monitoring, i.e., they only focus on the banker's behavior, and determine which effort level was chosen,

2) these monitors can perfectly observe the reality,

3) they reflect their observations in the subordinated debt market without any distortion.

The problem with the first assumption is that such agents generally do prospective monitoring, i.e., they not only focus on the banker's choices, but also, by considering the general economic conjuncture, they estimate the bank's chances of success. So, it is natural to expect that those agents' decisions are biased, tend to overestimate the state of the bank during periods of boom (say, they guess that bank has $f_H(\widetilde{R})$ distribution instead of $f_L(\widetilde{R})$), and hence, accentuate the excessive lending in such periods. During recessions, on the contrary, they tend to underestimate the state of the bank (say, guess that bank has $f_L(\widetilde{R})$ distribution although it had $f_H(\widetilde{R})$), and accentuate the credit crunch. The action that the regulator should take against this drawback can be to employ a filtering mechanism, and impose tougher constraints during booms and looser ones during recessions.

The problem with the third assumption is that, although those informed agents (other banks and financial institutions, in real life) are not influenced by the economic cycles, and although they can acquire perfect information after monitoring, sometimes they may, strategically, prefer not to reveal that information truthfully. One possible scenario[35] can be as follows: Some banks collude against a particular bank in order to drive that bank out of market and, hence, increase their oligopoly power. For this purpose, knowing that this particular bank is obliged to sell junior claims, they may refuse to buy those claims, or require excessive interest rates. This behavior of them will, then, give a misleading signal both to the depositors and the regulator, implying that this particular bank had chosen $f_L(\widetilde{R})$ distribution although it had chosen $f_H(\widetilde{R})$. As a result, the victim bank will either suffer from the increased cost of borrowing or even be forced out of the market. The regulator, in response to such a case, can allow foreign banks to operate in the domestic banking system, and make it difficult for such a hostile collusion to be formed or to succeed.

The problem with the second assumption, on the other hand, is that, although the informed agents are not influenced by the cycles, and although they reveal their information truthfully, they may have some positive probabilities of making mistakes in their decisions about whether the bank had chosen $f_L(\widetilde{R})$ or $f_H(\widetilde{R})$. Unfortunately, we have no policy recommendations for this quite probable case, because it stands at the limit of our model and view. The regulator employed the best monitor, and ensured that the

[35] During the banking crisis occured in Turkey in 2001, Demirbank, one of the biggest banks, after failing to fulfill its obligations and being seized by the regulator, accused a few other big banks of being engaged in such a hostile collusion against it in the interbank market.

monitor will do his best. So, just like preventing bank failures is not possible in practice, acquiring perfect information is impossible too, and the risk that the monitor will make a mistake is part of the unavoidable risk of our uncertain world.

3 Conclusion

Asymmetric information and the (probable) conflict of interest between banks and investors are the primary problems to be tackled with for the optimal functioning of the banking system. If investors have strong enough incentives to eliminate the asymmetric information (i.e., if they are not excessively protected), and if monitoring banks' activities is not difficult and costly, then market can itself eliminate this asymmetric information, and approach the first-best outcome. Otherwise, there is some space for the regulatory action. Minimum capital requirement decreases the probability of banks' failure by decreasing their leverage, but may not induce them to acquire high quality assets. To eliminate the asymmetric information and induce the banks to have socially preferable assets, the best the regulator can do is to

1) entrust the responsibility of monitoring the bank to the agents who have the highest skills and the lowest cost for this job

2) provide those agents with the necessary incentives.

Making the other banks or the financial institutions the subordinated debt holders of a bank, i.e., rewarding them sufficiently in case of success, but leaving them at their own stake in case of failure of that bank, is the optimal way to achieve these objectives. Since those agents are doing the same thing as that bank and since they are at their own risk in case of failure, they are the ones who will perform this monitoring in the best way, with the lowest social cost.

However, firstly, information extracted by the subordinated debt holders, although it is the best, is not perfect. Regulator can take some actions against the procyclicity and/or the strategic revelation of that information, but it is impossible to extract perfect information from monitoring banks. Secondly, introducing subordinated debt entails some social costs. But, if the percentage of bad type banks is high (as it may be the case in developing countries) and/or the difference between high quality and low quality assets is high(as it may be the case in the deregulated banking systems), gains from eliminating the asymmetric information by subordinated debt (i.e., increase in the welfare and in the stability of the banking sector) may justify its costs.

References

[1] Aghion, Philippe -Bolton,Patrick and Mathias Dewatripont , 1999,”Contagious Bank Failures” March, Mimeo.

[2] Allen, Franklin and Douglas Gale, 1998, ”Optimal Financial Crises”, August, Journal of Finance.

[3] Birchler, U.W., 2000, ”Bankruptcy Priority for Bank Deposits: A Contract Theoretic Explanation”, Review of Financial Studies, 13, 813-840.

[4] Calomiris, Charles W., 1999, ”Building an incentive-compatible safety net”,Journal of Banking and Finance, 23, 1499-1519

[5] Chari, V.V. and Ravi Jagannathan, 1988, ”Banking Panics, Information, and Rational Expectations Equilibrium”,Journal of Finance, Vol. XLIII, No 3, July .

[6] Dewatripont, Mathias and Jean Tirole, 1994, ”The Prudential Regulation of Banks”, The MIT Press

[7] Diamond, Douglas.W. and Philip H. Dybvig, 1983, ”Bank Runs, Deposit Insurance and Liquidity”, Journal of Political Economy, Vol. 91, No3.

[8] Freixas, Xavier and Jean-Charles Rochet, ”Microeconomics of Banking”, 1997, The MIT Press

[9] Jacklin, Charles J. and Sudipto Bhattacharya, 1988, ”Distinguishing Panics and Information-based Bank Runs: Welfare and Policy Implications”, Journal of Political Economy, Vol 96, No3.

[10] Jackson Patricia et al., 1999, ”Capital Requirements and Bank Behaviour: The Impact of Basle Accord”, BIS Working Paper, April .

[11] Jones, David, 2000, ”Emerging problems with the Basel Capital Accord: Regulatory capital arbitrage and related issues”, Journal of Banking and Finance, 24, 35-58.

[12] Postlewaite, Andrew and Xavier Vives, 1987, ”Bank Runs as an Equilibrium Phenomenon”, JPE, Vol 95, No 3.

[13] Rochet, Jean-Charles and Tirole Jean, 1996, ”Interbank Lending and Syatemic Risk”, Journal of Money, Credit and Banking, Vol 28, No 4

Appendix

Proof of Lemma 1.

Investor i's problem, in open notation, is:

$$\underset{D_i,T_i}{Max} V(D_i,T_i,r) = U(W_i - D_i - T_i) + \rho\Big[\int_0^{(1+r)D/A} U(T_i + \frac{AR}{D}D_i)f(R)dR + \int_{(1+r)D/A}^{\overline{R}} U(T_i + D_i(1+r))f(R)dR\ \Big]$$

$$s.t. \quad D_i + T_i \leq W_i$$

Since there is a continuum of investors, individual investor has no impact on the aggregate variables D and A. Function $V(.)$ has all the nice properties due to assumption (2). Moreover, risk aversion and the discount factor ρ guarantee that the constraint is not binding. (Binding constraint means that investor consumes nothing at t=0. But, as risk aversion implies the smoothness of the consumption pattern, this is not possible for the risk averse investor. Nor is it possible for the risk neutral investor, as he values the consumption at t=0 more than that at t=1 due to the discount factor ρ)

If investor i has no possibility of investing in risky assets, his optimal level of investment in Treasury bills is found from the following FOC:

$$\frac{dV(D_i,T_i,r)}{dT_i}\Big|_{D_i=0} = -U'(W_i - T_i) + \rho U'(T_i) = 0 \qquad \Rightarrow U'(W_i - T_i^*) = \rho U'(T_i^*)$$

which gives the point where marginal benefits of saving and consumption are equal. SOC confirms that this point is maximum.

$$\frac{dV^2(D_i,T_i,r)}{dT_i^2}\Big|_{D_i=0} = U''(W_i - T_i^*) + \rho U''(T_i^*) < 0$$

But, if he is given the possibility of investing in risky assets, for this investment to be positive the following condition must hold

$$\frac{dV(D_i,T_i^*,r)}{dD_i}\Big|_{D_i=0} > 0 \ \Rightarrow -U'(W_i - T_i^*) + \rho U'(T_i^*)\Big[\int_0^{(1+r)D/A} \frac{AR}{D} f(R)dR + (1+r)\int_{(1+r)D/A}^{\overline{R}} f(R)dR\Big] > 0$$

Plugging the result obtained from the FOC into the above inequality will, then, transform the necessary condition to

$$\int_0^{(1+r)D/A} \frac{AR}{D} f(R)dR + (1+r) \int_{(1+r)D/A}^{\overline{R}} f(R)dR \; > 1$$

■

Proof of Lemma 2.

As before, investor i's problem, in open notation, is:

$$\underset{D_i,T_i}{Max} V(D_i,T_i,r) \;=\; U(W_i - D_i - T_i) + \rho[\int_0^{(1+r)D/A} U(T_i + \frac{AR}{D} D_i) f(R)dR + \int_{(1+r)D/A}^{\overline{R}} U(T_i + D_i(1+r)) f(R)dR \;]$$

$$s.t. \quad D_i + T_i \leq W_i$$

Since there is a continuum of investors, individual investor has no impact on the aggregate variables D and A. Function $V(.)$ has all the nice properties due to assumption (2). Also, risk aversion agent and the discount factor ρ guarantees that the constraint is not binding. (Binding constraint means that investor consumes nothing at t=0. But, as risk aversion implies the smoothness of the consumption pattern, this is not possible for the risk averse investor. Nor is it possible for the risk neutral investor, as he values the consumption at t=0 more than that at t=1 due to the discount factor ρ) So, best response supply functions $D_i^*(r)$ and $T_i^*(r)$, (T is numeraire here because r_f is normalized to 0) exist, and they are the solutions of

$$\{D_i^*(r), T_i^*(r)\} \in \; \underset{D_i,T_i}{Arg\max} V(.)$$

The first order conditions are

$$0 = \frac{\partial V(D_i,T_i,r)}{\partial D_i} = -U^{'}(W_i - D_i - T_i) + \rho[\int\limits_0^{(1+r)D/A} \frac{AR}{D} U'(T_i + \frac{AR}{D} D_i) f(R) dR +$$

$$(1+r)U^{'}(T_i + D_i(1+r)) \int\limits_{(1+r)D/A}^{\overline{R}} f(R)dR \;]$$

$$0 = \frac{\partial V(D_i,T_i,r)}{\partial T_i} = -U^{'}(W_i - D_i - T_i) + \rho[\int\limits_0^{(1+r)D/A} U'(T_i + \frac{AR}{D} D_i) f(R) dR +$$

$$U^{'}(T_i + D_i(1+r)) \int\limits_{(1+r)D/A}^{\overline{R}} f(R)dR \;]$$

Total differentials, at the maximizing point, are then

$$\frac{\partial V^*}{\partial D_i} = 0 \Rightarrow \frac{\partial^2 V^*}{\partial D_i^2} dD_i + \frac{\partial^2 V^*}{\partial T_i \partial D_i} dT_i + \frac{\partial^2 V^*}{\partial r \partial D_i} dr = 0$$
$$\frac{\partial V^*}{\partial T_i} = 0 \Rightarrow \frac{\partial^2 V^*}{\partial D_i \partial T_i} dD_i + \frac{\partial^2 V^*}{\partial T_i^2} dT_i + \frac{\partial^2 V^*}{\partial r \partial T_i} dr = 0$$

Since what we are specifically interested in are the signs of $\frac{dD_i}{dr}$ and $\frac{dT_i}{dr}$, we have to solve the following system,where the first matrix is the Hessian Matrix of V

$$\begin{pmatrix} \frac{\partial^2 V^*}{\partial D_i^2} & \frac{\partial^2 V^*}{\partial T_i \partial D_i} \\ \frac{\partial^2 V^*}{\partial D_i \partial T_i} & \frac{\partial^2 V^*}{\partial T_i^2} \end{pmatrix} \begin{pmatrix} \frac{dD_i}{dr} \\ \frac{dT_i}{dr} \end{pmatrix} = \begin{pmatrix} -\frac{\partial^2 V^*}{\partial r \partial D_i} \\ -\frac{\partial^2 V^*}{\partial r \partial T_i} \end{pmatrix}$$

$$\frac{dD_i}{dr} = \frac{-\frac{\partial^2 V^*}{\partial r \partial D_i} * \frac{\partial^2 V^*}{\partial T_i^2} + \frac{\partial^2 V^*}{\partial r \partial T_i} * \frac{\partial^2 V^*}{\partial T_i \partial D_i}}{|H|} \; and \; \frac{dT_i}{dr} = \frac{\frac{\partial^2 V^*}{\partial r \partial D_i} * \frac{\partial^2 V^*}{\partial D_i \partial T_i} - \frac{\partial^2 V^*}{\partial r \partial T_i} * \frac{\partial^2 V^*}{\partial D_i^2}}{|H|}$$

$V(.)$ is maximized by $D_i^*(r)$ and $T_i^*(r)$, so

$$|H| > 0, \; \frac{\partial^2 V^*}{\partial D_i^2} < 0, \; \frac{\partial^2 V^*}{\partial T_i^2} < 0$$

Regularity of $V(.)$ implies that

$$\frac{\partial^2 V^*}{\partial T_i \partial D_i} = \frac{\partial^2 V^*}{\partial D_i \partial T_i} = U^{''}(.) + \rho[\int_0^{(1+r)D/A} \frac{AR}{D} U''(.) f(R) dR + (1+r) U^{''}(.) \int_{(1+r)D/A}^{\overline{R}} f(R) dR \,] \leq 0$$

Fortunately, $\frac{\partial^2 V^*}{\partial r \partial T_i}$ comes out to be unambiguously nonpositive

$$\frac{\partial^2 V^*}{\partial r \partial T_i} = \rho D_i U^{''}(T_i + (1+r)D_i) \int_{(1+r)D/A}^{\overline{R}} f(R) dR \leq 0$$

Before computing the last differential, $\frac{\partial^2 V^*}{\partial r \partial D_i}$, whose sign is ambiguous, note that

$$\begin{aligned} \frac{\partial^2 V^*}{\partial r \partial D_i} &> 0 \Rightarrow \frac{dD_i}{dr} > 0 \; and \; \frac{dT_i}{dr} \leq 0 \\ \frac{\partial^2 V^*}{\partial r \partial D_i} &< 0 \Rightarrow \frac{dD_i}{dr} \lesseqgtr 0 \; and \; \frac{dT_i}{dr} \lesseqgtr 0 \end{aligned}$$

So, in the region where $\frac{\partial^2 V^*}{\partial r \partial D_i} > 0$, i.e. when

$$U^{'}(T_i + (1+r)D_i) \; + (1+r) D_i U^{''}(T_i + D_i(1+r)) > 0$$

$\frac{dD_i}{dr} > 0$ and $\frac{dT_i}{dr} < 0$. Note that for small positive values of r above condition is satisfied. For high values of r, whether the condition will be satisfied depends on the utility function $U(.)$.