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**Fair Pricing of Deposit Insurance. Is it
Possible? Yes. Is it Desirable? No.†**

Xavier Freixas†

and

Jean-Charles Rochet**

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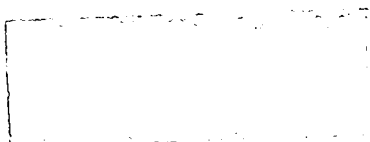
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‡Universitat Pompeu Fabra.

**GREMAQ and IDEI.

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Abstract

This note elaborates on a recent article by Chan, Greenbaum and Thakor (1992) who contend that fairly priced deposit insurance is incompatible with free competition in the banking sector, in the presence of adverse selection. We show here that at soon as one introduces a real economic motivation from private banks to manage the deposits from the public, then fairly priced deposit insurance becomes possible. However, we also show that such a fairly priced insurance is never desirable, precisely because of adverse selection. We compute the characteristics of the optimal premium schedule, which trades off between the cost of adverse selection and the cost of “unfair competition”.

1 Introduction

In an interesting recent paper, Chan, Greenbaum and Thakor ((1992), thereafter CGT) analyze risk-sensitive deposit insurance schemes in the case where depository institutions (DIs) have private information about their investment portfolios. Assuming that competition between DIs is such that they make zero profit on their deposit activity, they show that incentive compatible fairly priced insurance is impossible, unless DIs do not attract any deposits (which is of course paradoxical). The reason is that, because of their private information, DIs can obtain positive rents as soon as they attract deposits. Therefore the aggregate rent of the banking sector must be positive, which is incompatible with zero profit and fair pricing of insurance.

However, in CGT's model, one does not understand why there are DIs (for simplicity, we will call them banks from now on) in the first place. Indeed, it is a standard result that when capital markets are perfect, and banks' stockholders can borrow any amount at the riskless rate of interest then DIs are redundant. Similarly, in CGT's model, the management of deposits is costless and the interest rate demanded by depositors is also equal to the riskless rate. Therefore if information was symmetric the (first best) allocation of deposits would be completely undeterminate.

We study here a slight modification of CGT's model, in which this indeterminacy disappears. In our view, any reasonable model of banking should incorporate some imperfections of capital markets. We do this in the simplest possible way, by assuming imperfect substitutability between deposits and securities, both from depositors' and bankers' view point. The idea is that deposits provide payment services, which are both costly to banks and useful to depositors. Implicitly, depositors have an imperfect access to capital markets : for instance they have to pay a fixed transaction cost when they sell securities. As a consequence they will optimize the composition of their portfolio (deposits + securities) as a function of (among other things) the interest rates on securities (r) and on deposits (r_D).

Another important change with respect to CGT is that we assume decreasing returns to scale in the deposit activity (and also in the credit activity, but this is not crucial for our purpose). This is also needed if we want to get out of the indeterminacy of deposits allocation in CGT. Of course increasing returns to scale are also worth studying, but the simplicity of competitive equilibrium would be lost.

In our vision of banking, there is a scarce factor and that was absent in CGT, namely the banker's "know how" (or reputation, or talent, and it also can include physical capital), which gives him a joint technology for attracting deposits, providing payment services and selecting (or monitoring) loan applicants. Therefore banks make positive profits in the

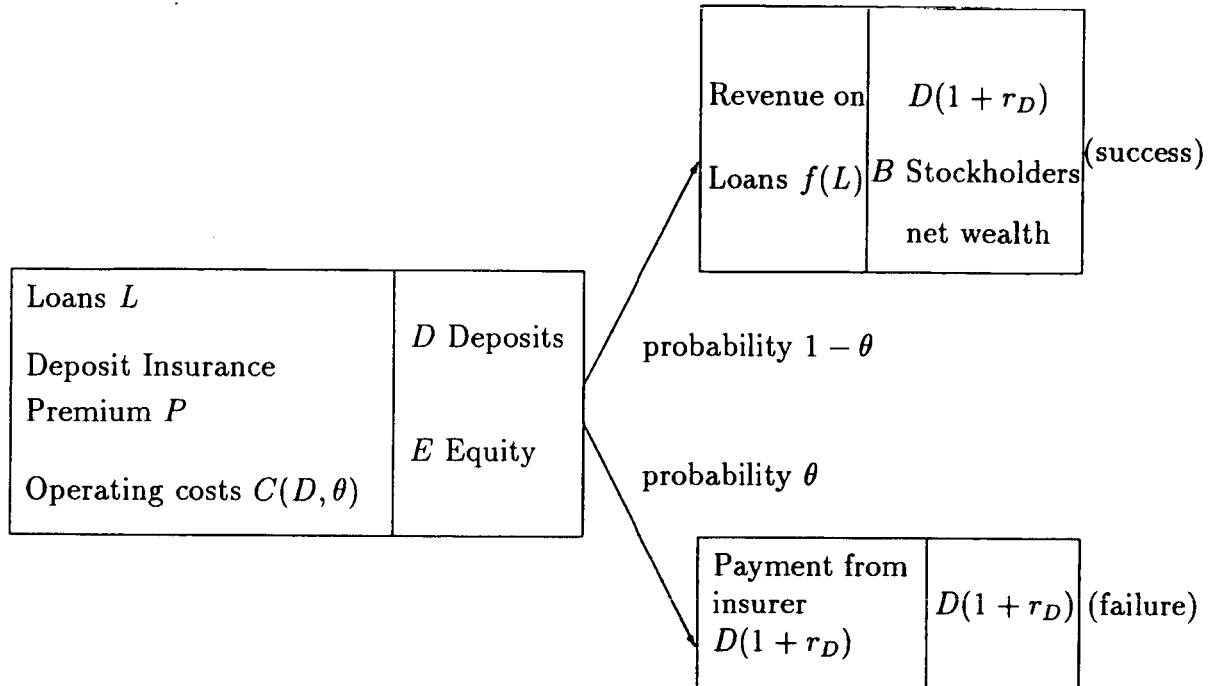
short run, not because of artificially imposed imperfect competition, but simply because there are costs of entry in the banking activity.

Our note is also motivated by the surprising, following remark : there is a classical argument in the economics of banking that subsidies to banks (either by entry barriers, underpriced deposit insurance, or ceilings on deposit rates) are good for limiting moral hazard. By granting a charter value (that banks lose in case of failure) regulators are able to counteract limited liability. Strangely enough, the also classical argument that cross subsidies are good for limiting the cost of adverse selection has not, apparently, penetrated the banking field. By subsidizing less efficient banks, the more efficient ones can prevent them from mimicking their behaviour, which would cause an unnecessary distortion in the allocation of deposits.

After presenting our model (section 2), we show that as soon as one introduces an explicit role of banks in the management of deposits, fairly priced deposit insurance becomes perfectly possible, even when adverse selection is present (section 3). In section 4 however we show that such a system is not efficient. The reason is that cross subsidies allow to decrease the cost of adverse selection. Of course these subsidies may lead to inefficient entry and exit decisions (“unfair competition”). In section 5 we compute the optimal deposit insurance schedule, which trades off the costs of adverse selection with the costs of unfair competition.

2 The Model

It is a static model, with 2 dates : $t = 0, 1$. Each bank is characterized by a single parameter θ , which determines both the “risk” of its portfolio of loans (interpreted as a probability of failure) and the “efficiency” of its management of deposits. The balance sheets of a typical bank at $t = 0$ and $t = 1$ are given by :



where $f(L)$ has the usual properties of a neo-classical production function (differentiable, increasing, concave).

Notice that we have adopted several simplifying assumptions :

- The single parameter θ is at the same time the probability of failure and an index of efficiency in the management of deposits. Ideally, we should have adopted a two dimensional parametrization but would substantially increase the technical difficulties.
- In case of failure, banks lose everything on their investments and the insurer repays not only the principal D but also the interests on deposits $r_D D$.

The operating costs $C(D, \theta)$ (which we can interpret as the wages of the bank’s employees) are paid at $t = 0$. We assume that C is convex and twice continuously differentiable with respect to D . Our results would be similar, although more complicated, if the operating costs depended also on L .

- We treat loans as direct investments of the bank itself into industrial projects. Like CGT, we could have introduced a surplus sharing parameter $\alpha(\theta) \in [0, 1]$, to be interpreted

as the fraction of surplus accruing to the bank in the lender-borrower relationship. Here, we reason as if $\alpha(\theta) = 1$, but this is not essential for our results.

The owner-manager of each bank, who is the only one to observe θ , is risk neutral and has access to an inelastic source of funds at an interest rate r . His objective function is therefore the net present value of its investment in the bank's equity :

$$\Pi = \frac{(1 - \theta)B}{1 + r} - E \quad (1)$$

Using the balance sheets equalities, this can also be written as the sum of four terms :

$$\Pi = \Pi_1 + \Pi_2 + \Pi_3 - P$$

where :

$$\Pi_1 = \Pi_1(\theta, L) = \frac{1 - \theta}{1 + r} f(L) - L \quad (2)$$

is the expected profit realized on the credit activity,

$$\Pi_2 = \Pi_2(\theta, D) = \frac{r - r_D}{1 + r} D - C(D, \theta) \quad (3)$$

is the profit realized on the deposit activity, and

$$\Pi_3 = \Pi_3(\theta, D) = \frac{\theta}{1 + r} [D(1 + r_D)] \quad (4)$$

represents the expected present value of the payments received from deposit insurance.

Since we assume that depositors are fully insured, the interest rate r_D that they receive on their deposits is the same across banks, and determined by equality of supply and demand. For simplicity we will assume that the supply of deposit is infinitely elastic, so that r_D will be taken as exogenous. At equilibrium, the interest rate on equity r will be higher than r_D , which can be justified by a Baumol-Tobin type of model in which households have to use their bank deposits as a means of payment for their transactions needs or have an imperfect access to capital markets. These aspects are not explicitly modelled.

Notice that, so far, the only change we have introduced with respect to CGT is the management cost of deposits that depends on θ . An important consequence of this new feature is that it determines the optimal allocation of deposits to banks that would prevail in a competitive banking system under symmetric information when deposit insurance is fairly priced ($\Pi_3 = P$). This allocation is obtained by maximization of Π_2 with respect to D . It is characterized by the first order condition :

$$r - r_D = \frac{\partial C}{\partial D}(D^*(\theta), \theta). \quad (5)$$

For technical reasons, we will need the usual single crossing condition :

$$\text{Assumption 1 : } \forall(D, \theta) \frac{\partial^2 \Pi}{\partial \theta \partial D}(D, \theta) < 0.$$

Assumption 1 means that “good banks” (i.e. banks with a small probability of failure θ) are also more efficient in managing deposits . It is equivalent to the condition : $\frac{\partial^2 C}{\partial \theta \partial D} > \frac{1 + r_D}{1 + r}$ which implies in particular that $D^*(\theta)$, defined by (5), is decreasing in θ . We could have considered a symmetric situation in which, on the contrary, good banks (in terms of failure risk) are less efficient in managing deposits¹. Notice that in CGT (where $C(D, \theta) \equiv 0$) assumption 1 is not satisfied and equation (5) reduces to $r = r_D$, which leaves a complete indeterminacy on the optimal allocation of deposits.

The optimal allocation of credit (still in the full information case) is determined by the maximization of Π_1 with respect to L . It is characterized by the first order condition :

$$(1 - \theta)f'(L^*(\theta)) = 1 + r. \quad (6)$$

Notice that, like in CGT, $L^*(\theta)$ is the same as if the banks were 100% equity financed. The only dependence between deposit and credit activities comes in our model from the parameter θ , which jointly characterizes the bank’s profitability in both activities. This is consequence of our assumption of perfect capital markets. A more complete and satisfactory model would introduce explicit imperfections in capital markets and explain why depositors and investors cannot fully diversify. This would lead to a genuine theory of banks’ solvency and is outside the scope of this note².

An important difference between our approach and that of CGT is in the treatment of perfect competition in the banking sector. In CGT, perfect competition means that banks make zero profit both in their credit and deposit activities³. In our model, both activities have decreasing returns to scale, and banks make positive profits at the competitive equilibrium. The scare factor that is being remunerated by these profits is the banker’s “talent” or specific knowledge of a given population of depositors and borrowers. Our vision of banking is that some agents (the “bankers”) make specific fixed investments (both in physical capital and in reputation) for being able to select and monitor borrowers on the one hand, and provide payment services to depositors on the other hand. However simplistic this story may be (we already mentioned that it is a reduced form of a more satisfactory model that would incorporate explicit imperfections of capital markets) we

¹The only changes in our results would have been that D^* (and more generally any implementable deposit allocation) would be decreasing, and that in a signalling equilibrium, banks typically manage too few deposits.

²Recent contributions in this direction are Dewatripont-Tirole (1994), Giammarino-Lewis-Sappington(1993), Freixas-Gabillon (1994) and Bensaid-Pagès-Rochet (1995).

³Another way to put it is that, under the assumption of perfect capital markets, the Modigliani Miller theorem holds and implies that banks are redundant.

content that it provides a more accurate description than CGT of the role of banks in the economy. In particular, in the adverse selection context that we will study in the rest of this note, it is difficult to understand how banks can have private information on their “type” θ and simultaneously enjoy no rent from this private information. In our story, banks pay a set-up cost in exchange for some monopoly power on a population of borrowers (the profit they make on their credit activity is in fact completely independent and could be suppressed without changing our results).

3 Yes, Fairly Priced Deposit Insurance is Possible

We proceed to the case of adverse selection by assuming from now on that θ is private information of each bank. We show that, contrarily to CGT’s result, fairly priced deposit insurance is possible. In fact, we are in a particular form of Spence’s (1974) signalling model in which the principal is the deposit insurer who offers a premium schedule $P(D)$ to a population of agents (the banks) whose types θ belong to some interval $[\underline{\theta}, \bar{\theta}]$. A fair pricing schedule corresponds to nothing but a signalling equilibrium in Spence’s terminology, i.e. satisfies :

$$\forall \theta \in [\underline{\theta}, \bar{\theta}] \quad P(D(\theta)) = \frac{\theta}{1+r} [D(\theta)(1+r_D)] \quad (7)$$

where $D(\theta)$, the amount of deposits chosen by the bank of type θ solves :

$$\max_D [\Pi_2(\theta, D) + \Pi_3(\theta, D) - P(D)]. \quad (8)$$

Since equations (3) and (4), and the convexity of $C(., \theta)$ guarantee the concavity of the objective function, this is equivalent to the first order condition :

$$\frac{\partial \Pi_2}{\partial D}(\theta, D(\theta)) + \frac{\partial \Pi_3}{\partial D}(\theta, D(\theta)) = P'(D(\theta)). \quad (9)$$

Now equation (7) is equivalent to :

$$\forall \theta \in [\underline{\theta}, \bar{\theta}], \Pi_3(\theta, D(\theta)) = P(D(\theta)).$$

Assuming that $D(.)$ is differentiable, we can differentiate this equation with respect to θ :

$$\forall \theta \in [\underline{\theta}, \bar{\theta}] \quad \frac{\partial \Pi_3}{\partial \theta} + \left[\frac{\partial \Pi_3}{\partial D} - P'(D) \right] D'(\theta) = 0.$$

Using equation (9), this is equivalent to :

$$\forall \theta \in [\underline{\theta}, \bar{\theta}] \quad \frac{\partial \Pi_3}{\partial \theta}(\theta, D(\theta)) = \frac{\partial \Pi_2}{\partial D}(\theta, D(\theta)) D'(\theta). \quad (10)$$

The interpretation of this equation is easy : in a signalling equilibrium, the marginal rent received by agent θ (left hand side of (10)) equals the marginal surplus generated by the deposit allocation $\theta \rightarrow D(\theta)$ (right hand side). Because of assumption 1, any solution to (10) is indeed a signalling equilibrium (i.e. satisfies (7) and (8)), provided that it is implementable by some premium schedule, which is equivalent to saying (because of our single crossing assumption) that $\theta \rightarrow D(\theta)$ is decreasing. Since $\frac{\partial \Pi_3}{\partial \theta} > 0$, equation (10) implies that $\frac{\partial \Pi_2}{\partial D} < 0$, or equivalently that $D(\theta)$ is greater than $D^*(\theta)$ ⁴. Deposits being used as a signal on the bank's quality, we obtain the usual result of overinvestment in the signal. Finally, as usual, there is a continuum of signalling equilibria, that can be ranked by the Pareto criterion. The Pareto dominating signalling equilibrium is characterized by the differential equation (10) and the initial condition :

$$D(\bar{\theta}) = D^*(\bar{\theta}), \quad (11)$$

which means that deposits are efficiently allocated the less efficient bank (which is the usual no "distortion at the top" condition).

Now, why is it that fairly priced deposit insurance was impossible in CGT ? The explanation is simple : in CGT's model the deposit activity generated a zero net surplus (i.e. $\Pi_2(\theta, D) \equiv 0$). Therefore equation (10) reduced to :

$$-\frac{1}{1+r} [D(\theta)(1+r_D)] = \frac{\partial \Pi_3}{\partial \theta}(\theta, D(\theta)) = 0,$$

which is only possible when $D(\theta) \equiv 0$. This corresponds to the very peculiar case of a "zero sum signalling model" in which the agent's signalling cost equals exactly the profit made by the principal. As soon as we introduce, as a motivation for the deposit activity, that it generates a positive net surplus, this peculiarity disappears and there are an infinity of fairly priced deposit insurance schedules. We now present our second result : even though fairly priced deposit insurance is possible, it is not desirable.

4 Fairly Priced Deposit Insurance is Not Desirable

In our adverse selection set up, we can define an optimal deposit insurance pricing schedule as the one which maximizes the aggregate profit of the banking sector under the break-even constraint of the insurance company. Assuming a continuous distribution of types on $[\underline{\theta}, \bar{\theta}]$ (with a density $f(\theta)$) and neglecting for the moment the participation constraints, we have to maximize aggregate surplus :

$$\phi = \int_{\underline{\theta}}^{\bar{\theta}} \Pi_2(\theta, D(\theta)) f(\theta) d\theta,$$

⁴Since $D' < 0$, and Π_2 is concave in D .

under the incentive compatibility constraint (8) and the break-even condition :

$$\int_{\underline{\theta}}^{\bar{\theta}} \{ \Pi_3(\theta, D(\theta)) - P(D(\theta)) \} f(\theta) d\theta = 0. \quad (12)$$

It is easy to see that the solution to this problem corresponds to the first best allocation of deposits $\theta \rightarrow D^*(\theta)$. Indeed by the single crossing condition, the optimal allocation $D^*(\theta)$ is decreasing and therefore, implementable by a premium schedule $P(\cdot)$ satisfying condition (9) :

$$\forall \theta \in [\underline{\theta}, \bar{\theta}], P'(D^*(\theta)) = \frac{\partial \Pi_2}{\partial D}(\theta, D^*(\theta)) + \frac{\partial \Pi_3}{\partial D}(\theta, D^*(\theta)).$$

By definition of $D^*(\theta)$ the first term on the right hand side is zero and this equation reduces to :

$$\forall \theta \in [\underline{\theta}, \bar{\theta}], P'(D^*(\theta)) = \frac{\theta}{1+r} [1+r_D]. \quad (13)$$

Since $\theta \rightarrow D^*(\theta)$ is increasing, we can define its inverse $\theta^*(D)$. Then equation (13) can be written :

$$P'(D) = \frac{1+r_D}{1+r} \theta^*(D).$$

This determines $P(D)$ up to an additive constant. Finally this constant is uniquely determined by the break-even condition (12).

Let us study the net subsidy received by a bank of type θ :

$$S(\theta) = \Pi_3(\theta, D^*(\theta)) - P[D^*(\theta)].$$

By differentiating this equation, and using equation (13) we get :

$$S'(\theta) = \frac{\partial \Pi_3}{\partial \theta}(\theta, D^*(\theta)) > 0.$$

Since by assumption (condition (12)) we have

$$\int_{\underline{\theta}}^{\bar{\theta}} S(\theta) f(\theta) d\theta = 0,$$

it is clear that the most efficient banks (θ small) will be taxed ($S(\theta) < 0$) where as the less efficient ones (θ large) will receive a positive subsidy ($S(\theta) > 0$).

5 The Cost of Unfair Competition

Although cross-subsidiation may seem “unfair”, it has no efficiency cost, unless we introduce dynamical aspects, like for instance possible entry or exit in the banking industry. So

far, we have assumed that all banks were profitable and were willing to operate. In view of our description of pure competition in the banking sector already presented above, we now introduce a set-up cost K for banks, and study the impact of deposit insurance pricing on banks' participation decisions. In the case of symmetric information, we already saw that efficiency of deposits allocation could be obtained independently of any consideration about cross subsidiation between different banks (the usual separation between equity and efficiency). However cross subsidiation can have adverse effects on banks' participation decisions. To see this, let us denote as before by $\Pi_1^*(\theta)$ and $\Pi_2^*(\theta)$ the full-information (optimal) surplus obtained by bank θ on the credit and deposit activities (respectively) and by $S(\theta)$ the net subsidy received by the deposit insurer. Optimality requires that θ participates if and only if :

$$\Pi_1^*(\theta) + \Pi_2^*(\theta) \geq K.$$

Since both functions on the left hand side of this inequality are decreasing, this is equivalent to :

$$\theta \leq \theta^*,$$

with θ^* defined by :

$$\Pi_1^*(\theta^*) + \Pi_2^*(\theta^*) = K.$$

Now if cross subsidies $S(\theta)$ are introduced, bank θ participates if and only if :

$$\Pi_1^*(\theta) + \Pi_2^*(\theta) + S(\theta) \geq K$$

or :

$$S(\theta) \geq [K - \Pi_1^*(\theta) - \Pi_2^*(\theta)].$$

This has to be satisfied for all $\theta \leq \theta^*$ (otherwise some "efficient" banks would be unduly discouraged to participate) and symmetrically the reverse inequality has to be true for all $\theta > \theta^*$. This implies in particular that the subsidy to the marginal bank $S(\theta^*)$ is necessarily 0. Of course one still can find an infinity of subsidy functions $S(\theta)$ which satisfy these constraints (and therefore do not perturb the efficient participation decision) but since nothing is gained (in efficiency terms) from these cross subsidiations, it seems reasonable to recommend that in the full information case $S(\theta)$ is set to be identically zero. This is, we believe, the main argument for "fairly priced deposit insurance", as a way to avoid useless distortions in interbank competition.

As soon as adverse selection is introduced, things become more complicated. However, as we saw in section 3 the optimal allocation of deposits $\theta \rightarrow D^*(\theta)$ can be implemented by choosing a premium schedule $P(D)$ such that

$$P'(D^*(\theta)) = \frac{\partial \Pi_3}{\partial D}(\theta, D^*(\theta)) = \frac{1 + r_D}{1 + r} \theta. \quad (14)$$

The net subsidy received by bank θ is :

$$S(\theta) = \Pi_3(\theta, D^*(\theta)) - P(D^*(\theta))$$

As already observed, if we differentiate this equation and use condition (14) we obtain :

$$S'(\theta) = \frac{\partial \Pi_3}{\partial \theta}(\theta, D^*(\theta)) > 0. \quad (15)$$

The break-even constraint of the deposit insurer means that the mean value of $S(\theta)$ is zero. However, this mean value has to be restricted to the set of participating banks $[\underline{\theta}, \hat{\theta}]$, where $\hat{\theta}$ is defined by :

$$\Pi_1^*(\hat{\theta}) + \Pi_2^*(\hat{\theta}) + S(\hat{\theta}) = K.$$

Since S is increasing, we necessarily have net subsidies ($S(\theta) > 0$) for high risk banks, which implies in particular :

$$S(\hat{\theta}) > 0.$$

Therefore optimal participation decisions cannot be implemented (there will be inefficient entry) and the second best will optimally trade off between the costs of adverse selection and the costs of unfair competition.

The optimal premium schedule for deposit insurance is then more complex to obtain. We show in the appendix that, under certain assumptions, it is characterized by the following conditions :

$$\forall \theta \in [\underline{\theta}, \hat{\theta}] : \frac{\partial C}{\partial D}(\theta, D(\theta)) = \frac{r - r_D}{1 + r} + \frac{\lambda - 1}{\lambda} \frac{\partial^2 \Pi}{\partial \theta \partial D}(\theta, D(\theta)) \frac{F(\theta)}{f(\theta)}, \quad (16)$$

and :

$$S(\hat{\theta}) = \Pi_3(\hat{\theta}, D(\hat{\theta})) - P(D(\hat{\theta})) = -\frac{\lambda - 1}{\lambda} \frac{\partial \Pi}{\partial \theta}(\hat{\theta}, D(\hat{\theta})) \frac{F(\hat{\theta})}{f(\hat{\theta})}, \quad (17)$$

where $\lambda > 1$ is the lagrange multiplier associated to the break-even constraint. Since $\frac{\partial^2 \Pi}{\partial \theta \partial D} < 0$ and $\frac{\partial \Pi}{\partial \theta} < 0$ by assumption, these conditions imply :

$$D(\theta) \leq D^*(\theta) \text{ (with equality when } \theta = \underline{\theta} \text{)}$$

and

$$S(\hat{\theta}) > 0.$$

Since $S'(\theta) = \frac{\partial \Pi_3}{\partial \theta}(\theta, D(\theta)) > 0$, there will still be subsidiation of some risky banks ($\theta \in [\theta_1, \hat{\theta}]$) at the expense of the less risky ($\theta \in [\underline{\theta}, \theta_1]$), but it will be limited and the more risky banks $]\hat{\theta}, \bar{\theta}]$ will be inactive. Banks will have less deposits than in the first best,

which corresponds to an optimal trade-off between relaxing the incentive compatibility constraint and allowing less efficient banks to participate (unfair competition). Another way to see this is to compute the marginal insurance premium :

$$P'(D(\theta)) = \frac{\partial \Pi}{\partial D}(\theta, D(\theta)) = \frac{r - r_D}{1 + r} - \frac{\partial C}{\partial D}(\theta, D(\theta)) + \theta \frac{1 + r_D}{1 + r}.$$

Using equation (18), we obtain :

$$P'(D(\theta)) = \theta \frac{1 + r_D}{1 + r} - \frac{\lambda - 1}{\lambda} \frac{\partial^2 \Pi}{\partial \theta \partial D}(\theta, D(\theta)) \frac{F(\theta)}{f(\theta)}. \quad (18)$$

Now the second term on the right hand side of equation (20) is negative (since $\lambda > 1$ and $\frac{\partial^2 \Pi}{\partial \theta \partial D} < 0$). Therefore the marginal premium $P'(D)$ is greater than its actuarial counterpart $\theta \frac{1+r_D}{1+r}$. Since $P(D)$ is actuarial on average, this means that banks with a small volume of deposits will receive a subsidy, while those with a high volume of deposits will be taxed, which is an alternative way of establishing the result.

6 Conclusion

The objective of this note is twofold :

- first, to pursue the line of research initiated by Chan-Greenbaum-Thakor (1992). We show that as soon as one introduces an explicit role of banks in the management of deposits, fairly priced deposit insurance is perfectly possible even when adverse selection is present.
- Second, we show that, from an efficiency viewpoint, fairly priced deposit insurance is never desirable : even when participation constraints are active, some degree of cross subsidiation is desirable.

Of course, our analysis here is limited for at least two reasons :

- deposit insurance pricing should not be studied independently of banks' solvency regulations, which necessitates an explanation of why bank capital matters.
- In connection with the previous point, the crucial problem involved in banks' prudential regulation is moral hazard, which is absent here. However, this problem cannot be separated from adverse selection, which implies that the type of analysis performed here is necessarily relevant.

Finally, we have developed here a simple model which captures the notion of “unfair competition”. Cross subsidies between banks, which are justified by adverse selection considerations, are also costly because they encourage less efficient banks to participate, and conversely penalize more efficient banks. The optimum deposit insurance schedule trades off between the cost of adverse selection and the cost of unfair competition. The fact that it involves cross subsidies gives a further argument for public provision of deposit insurance.

APPENDIX : Determination of optimal pricing of deposit insurance when participation constraints are binding.

If a premium schedule $D \rightarrow P(D)$ is offered, a bank of type θ will solve :

$$\max_D \left\{ \Pi_1^*(\theta) + \Pi_2(\theta, D) + \Pi_3(\theta, D) - P(D) \right\}. \quad (19)$$

Where $\Pi_1^*(\theta) = \Pi_1(\theta, L^*(\theta))$.

Let us denote by $D(\theta)$ the solution to this problem and by $\pi(\theta)$ its value. The single crossing assumption implies that the couple of functions (D, π) is implementable by a premium schedule P if and only if :

$$\begin{cases} \dot{\pi}(\theta) = \frac{\partial \Pi}{\partial \theta}(\theta, D(\theta)) & (20) \\ \theta \rightarrow D(\theta) \text{ non increasing} & (21) \end{cases}$$

where, as before,

$$\Pi(\theta, D) = \Pi_1^*(\theta) + \Pi_2(\theta, D) + \Pi_3(\theta, D).$$

The second best optimum is obtained by maximizing the total net surplus under the incentive compatibility constraints (20), (21), the (global) break-even constraint for the insurer and the participation constraint for the banks. Assuming that (21) is not bunding, and using $D(\theta)$ and $\pi(\theta)$ as choice variables, we obtain a variation calculus problem :

$$\begin{cases} \max_{\hat{\theta}, D(\cdot), \pi(\cdot)} \int_{\underline{\theta}}^{\hat{\theta}} (\pi(\theta) - K) f(\theta) d\theta \\ \text{under the constraints :} \\ \dot{\pi}(\theta) = \frac{\partial \Pi}{\partial \theta}(\theta, D(\theta)) & (22) \\ \pi(\hat{\theta}) = K & (23) \\ \int_{\underline{\theta}}^{\hat{\theta}} (\pi(\theta) - \Pi_1^*(\theta) - \Pi_2(\theta, D(\theta))) f(\theta) d\theta \leq 0 & (24) \end{cases}$$

This can be simplified further by integrating by parts in constraint (24) (which is clearly binding as an equality) :

$$\int_{\underline{\theta}}^{\hat{\theta}} \pi(\theta) f(\theta) d\theta = \pi(\hat{\theta}) F(\hat{\theta}) - \int_{\underline{\theta}}^{\hat{\theta}} \dot{\pi}(\theta) F(\theta) d\theta.$$

Therefore, constraints (22) and (23) can be incorporated into (24), yielding :

$$KF(\hat{\theta}) \leq \int_{\underline{\theta}}^{\hat{\theta}} \left[\frac{\partial \Pi}{\partial \theta}(\theta, D(\theta)) F(\theta) + (\Pi_1^*(\theta) + \Pi_2(\theta, D(\theta))) f(\theta) \right] d\theta.$$

Similarly the objective function can be written :

$$\int_{\underline{\theta}}^{\hat{\theta}} (\pi(\theta) - K) f(\theta) d\theta = - \int_{\underline{\theta}}^{\hat{\theta}} \frac{\partial \Pi}{\partial \theta}(\theta, D(\theta)) F(\theta) d\theta.$$

Denoting by λ the Lagrange multiplier associated to the budget constraint, we have to maximize :

$$\mathcal{L}(\hat{\theta}, D(\cdot)) = \int_{\underline{\theta}}^{\hat{\theta}} \left\{ (\lambda - 1) \frac{\partial \Pi}{\partial \theta}(\theta, D(\theta)) F(\theta) + \lambda (\Pi_1^*(\theta) + \Pi_2(\theta, D(\theta))) f(\theta) \right\} d\theta - \lambda K F(\hat{\theta}).$$

The first order conditions with respect to $\hat{\theta}$ and $D(\cdot)$ give :

$$\begin{cases} (\lambda - 1) \frac{\partial \Pi}{\partial \theta}(\hat{\theta}, D(\hat{\theta})) F(\hat{\theta}) + \lambda f(\hat{\theta}) (\Pi_1^*(\hat{\theta}) + \Pi_2(\hat{\theta}, D(\hat{\theta})) - K) = 0, \\ \forall \theta \in [\underline{\theta}, \hat{\theta}] (\lambda - 1) \frac{\partial^2 \Pi}{\partial \theta \partial D}(\theta, D(\theta)) F(\theta) + \lambda \frac{\partial \Pi_2}{\partial D}(\theta, D(\theta)) f(\theta) = 0. \end{cases}$$

After simplifications, these relations becomes :

$$\frac{\partial C}{\partial D}(\theta, D(\theta)) = \frac{r - r_D}{1 + r} + \frac{\lambda - 1}{\lambda} \frac{\partial^2 \Pi}{\partial \theta \partial D}(\theta, D(\theta)) \frac{F(\theta)}{f(\theta)}, \quad (25)$$

and :

$$S(\hat{\theta}) = \Pi_3(\hat{\theta}, D(\hat{\theta})) - P(D(\hat{\theta})) = \frac{\lambda - 1}{\lambda} \frac{\partial \Pi}{\partial \theta}(\hat{\theta}, D(\hat{\theta})) \frac{F(\hat{\theta})}{f(\hat{\theta})}, \quad (26)$$

which was to be proven.

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