Is Deposit Insurance a Good Thing, and If So, Who Should Pay for It?

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Abstract

Deposit insurance schemes are becoming increasingly popular around the world and yet there is little understanding of how they should be designed and what their consequences are. In this paper we provide a new rationale for the provision of deposit insurance. We analyse a model in which agents choose between depositing their funds with banks and placing them in a less productive self-managed project. Bankers have valuable but costly project management skills and the banking sector exhibits both adverse selection and moral hazard. Depositors do not fully account for the social benefits accruing from bank management of projects and so too few deposits are made in equilibrium. The regulator can correct this market failure by providing deposit insurance to encourage deposits. Contrary to received opinion, we find that deposit insurance should be funded not by bankers or depositors but through general taxation.

1. Introduction

Deposit insurance funds amount to $46 billion in the United States alone.[1] In the last twenty years, the number of deposit insurance schemes in operation around the world has almost tripled (Demirgüç-Kunt and Sobaci, 2001). A deposit insurance scheme was adopted as part of the 1994 single banking market legislation in the European Union, and now forms part of the IMF's best practice recommendations to developing countries. The level of consensus among policy makers is surprising given that the empirical evidence on the value of deposit insurance schemes is mixed, and seems to depend upon the details of scheme and how it is funded.[2] In this paper we provide a theoretical explanation. We develop a simple model of a banking system which shows deposit insurance schemes do increase social welfare, but only if they are funded through general taxation.

Much has been written on the topic of deposit insurance. Yet surprisingly few papers address the question of *why* deposit insurance schemes exist. Virtually the whole literature takes as given the existence and desirability of some form of deposit insurance and assesses its effects and implications. One strand, following Merton (1977), is concerned with the "correct" price of this insurance, observing that deposit insurance is essentially a put option held by bank shareholders for the value

[1] The Federal Deposit Insurance Corporation (FDIC) manages separate deposit insurance funds for thrift and bank depositors: the Savings Association Insurance Fund (SAIF) and the Bank Insurance Fund (BIC), whose respective sizes on December 31 were $33.8 billion and $12.2 billion. Assets in both funds must exceed 1.25% of estimated insured deposits. Fund contributions by insured institutions reflect the danger of a shortfall and are risk-sensitive. For the BIF and SAIF the total contributions in 2003 were $80 million and $15 million respectively (Federal Deposit Insurance Corporation, 2004).

[2] See Demirgüç-Kunt and Kane (2002) for a recent survey.

of the banks' debts and valuing it accordingly.[3] Another strand has been concerned with the perverse effects of deposit insurance schemes on banks' incentives to take on excessive risk - intuitively, the value of the put option is enhanced by greater volatility in the bank's assests.[4] In these latter models, deposit insurance has only negative effects on banking stability, which begs the question of why it should be introduced in the first place. Finally, more recent work has shown that in the presence of such moral hazard by or adverse selection of banks, fairly priced deposit insurance may be either impossible (Chan, Greenbaum and Thakor, 1992) or, possible but undesirable (Freixas and Rochet, 1998).[5] Our paper is related to this later work, since we argue that subsidised deposit insurance is preferable to "fairly-priced" deposit insurance from a welfare point of view. But we go further in that deposit insurance has a positive policy role to play in our model rather than being exogenously imposed. It not obvious that it makes sense to examine the pricing of deposit insurance in a framework which entirely abstracts from any of the reasons why its existence is considered desirable. Despite this, the small literature which does consider the desirability of deposit insurance per se (discussed below) has evolved almost entirely separately from the more policy-oriented literature considering how such schemes should be funded. In contrast our paper takes seriously the interrelation between these two.

In this model, we thus depart from the majority of the literature in examining how deposit insurance should be funded in a model in which deposit insurance does have a positive role to play. To make clear the source of the difference between our results and those in the existing literature, we use a stripped-down model where all agents are risk-neutral and there is no possibility of banking "panics" arising from sunspots and multiple equilibria. Whilst depositor risk aversion and the possibility of panics would no doubt provide a further rationale for deposit insurance, we focus instead on a need for deposit insurance which arises purely from information problems between banks and depositors. Thus unlike existing work, we are able to comment on how the level of deposit insurance provision ought to vary with the extent of such informational problems. In particular, we show that the worse the adverse selection problem is, the greater should be the extent of deposit insurance coverage (although in no case should deposit insurance be 100%). Thus lower quality banking systems should optimally introduce more generous deposit insurance, a result which may help reconcile explain the puzzling empirical finding that deposit insurance schemes are on the one hand associated with a higher probability of banking crisis and yet are at the same time being widely adopted across the world and promoted as part of good practice by institutions such as the IMF.

In common with the majority of existing models emphasising the problems which deposit insurance schemes create, we allow for moral hazard by banks. Banks have a socially useful role to play in receiving funds from depositors and transforming these funds into more productive investments through the use of their monitoring technology. However, if banks are not sufficiently rewarded for this costly monitoring activity, then they will have no incentive to undertake it. This yields

[3] Other theoretical contributions to this field include Merton (1978) and Pennacchi (1987).

[4] For theoretical contributions, see for example Kim and Santomero (1988), Nagarajan and Sealey (1995), Penati and Protopapadakis (1988).

[5] For a useful survey of the literature, see Freixas and Rochet (1997).

the moral hazard aspect of the model.[6] In contrast to much of the existing literature, we also allow for adverse selection in the banking system - in particular that there are some bankers who are simply unable to perform productivity-enhancing monitoring. The presence of moral hazard and adverse selection means that the gains from monitoring must be split between bankers and depositors. Since depositors are unable to extract all the social gains from placing their funds in a bank, they are too reluctant to deposit from a social point of view.

As a consequence of this under-depositing there is potentially a role for deposit insurance, which makes bank investment more attractive for depositors. Deposit insurance can improve social welfare when the adverse selection problem is sufficiently severe. We require the deposit insurance fund to balance its books in expectation, but allow it to be funded through payments by bankers, depositors, or through general taxation. In stark contrast to the existing literature, in our model with risk-neutral depositors, we find that *only if deposit insurance is funded through general taxation does it have any beneficial effect.* It is the tax levied on agents outside the banking system that provides a net subsidy to the system and thus encourages depositors to deposit therein. This result runs contrary to the majority of the existing literature which assumes that deposit insurance ought to be funded by bankers and then examines the pricing to individual banks.[7] We show, in contrast, that payments into the deposit insurance fund by bankers are completely welfare-neutral.[8] The reason is that forcing bank stockholders to make payments into a deposit insurance fund decreases the capital they have at stake in the bank and increases their incentives to undertake moral hazard. At the same time, the resulting increase in the deposit insurance payout allows bankers to attract deposits whilst offering lower deposit rates, increasing bankers' payoff from monitoring activity. These two effects exactly offset one another. Payments by depositors into the deposit insurance fund similarly take away with one hand what they give with the other. Payments by outsiders, however, contribute to the pie to be split between depositors and bankers. This is beneficial because it increases the rents available to banks, which when banks are subject to moral hazard is generally a good thing.[9]

Unlike many other models of deposit insurance which do not account for the existence of the scheme itself, in our model the presence of an optimally designed deposit insurance scheme does not cause moral hazard by banks. Quite the opposite is true - *deposit insurance reduces the tendency*

[6] Thus in our model, moral hazard takes the form that banks fail to monitor their investments. Our treatment follows Holmström and Tirole (1997). However, we could equally well allow moral hazard to involve NPV-reducing risk-enhancing investments, as is often done in the literature.

[7] But see *The Economist* ("Still Money in that Franchise", April 30, 1994):

> Give them half a chance and bankers in both Europe and America will complain ad nauseum about the iniquitous obligations that fall upon them as a result of possessing a bank charter. Ask them why they do not give their charter up and you will receive a funny look. [...] Ignore all this. The truth of the matter is that however much banks moan about the restrictions and obligations imposed by governments and regulators, they know that this is the price they pay in return for something hugely valuable. That something is a public subsidy, and the subsidy takes the form of deposit insurance.

[8] This holds when the proceeds are invested in a technology as productive as banking investments. Otherwise such payments are welfare-decreasing.

[9] In our model this arises because with lower deposit rates, bankers receive a higher return on monitoring when they are successful. In a more general multi-period model, the effect could also manifest itself through an increase in charter value. In this sense, a deposit insurance subsidy can be seen as an alternative to allowing banks to extract rents through excessive market power. See Bhattacharya (1982) and Keeley (1990).

to moral hazard. The reason for this difference is that in our model the *level* of deposit insurance protection is set optimally. It is true that if *too much* deposit insurance were provided, depositors would be unconcerned about whether banks had incentives to monitor or not (or might even prefer banks not to monitor), but clearly it is never optimal to set the level of deposit insurance so high. In this case, if banks do not monitor, they are contributing nothing to social welfare, so there is no reason to subsidise them. Subsidies should be cut until bankers' incentives improve. Thus our model has implications for the optimal level of deposit insurance. In particular, contrary to what one might expect, we show that the deposit insurance subsidy should be greater, the lower the expected quality of the banking system. Note further that if depositors cannot easily observe the level of deposits in each bank, the regulator should supplement deposit insurance schemes with a capital adequacy policy in order to prevent banks becoming too large and gambling with their funds. Interestingly, however, *as deposit insurance protection is increased from zero to the optimal level, capital requirements can be correspondingly eased*. This is simply because, as highlighted above, subsidised deposit insurance alleviates the moral hazard problem.[10]

The models most closely related to our own, at least in spirit, are Diamond and Dybvig (1983) and Matutes and Vives (1996). In common with ours, each of these models tackles the question of whether and how deposit insurance schemes affect social welfare, but from a very different perspective. Each paper starts with the premise that banks can make investments which are more productive than those available to households. In Diamond and Dybvig, bank investments are long-term, whereas households may suffer short-term liquidity shocks and wish to withdraw their funds early. Therefore it is optimal for banks to allow depositors to demand repayment of their deposits at an interim date, and they pay out at this date on a first-come-first served basis. A problem arises if too many depositors demand the return of their funds early. In this case the bank has to liquidate some of its long term investments, which is costly, and there will not be enough funds left at the later date to pay out patient depositors. This creates the potential for self-fulfilling expectations of a bank run. Thus the Diamond-Dybvig model provides a positive role for deposit insurance entirely different from that presented here: socially damaging bank runs can be eliminated if the government (or another body independent of the bank) provides a guarantee that deposits will be paid out in full at a later date. Thus providing deposit insurance eliminates the "bad" equilibrium where depositors run on a (solvent) bank. Although it has a totally different focus, the Diamond-Dybvig model has two features in common with the analysis presented in the present paper. Firstly, deposit insurance provided by the government may be more effective than private insurance, since the government has taxation powers which give it credibility in promising to meet the bank's liabilities. Secondly, when returns are certain, the deposit insurance fund never actually has to collect any taxation or pay out for this scheme to be effective.

Matutes and Vives (1996) study a model of Hotelling competition between two banks, augmented to allow for depositors to have different expectations (which must, in equilibrium, be self-fulfilling) about the banks' respective failure probabilities. They study the effects of intro-

[10]For a recent interesting contribution with contrasting results, see Hellman, Murdock and Stiglitz (2000). They impose full (100%) deposit insurance protection for depositors and show that this results in moral hazard by banks. They argue that capital requirements and deposit rate ceilings should be imposed, but do not tackle the question of the optimal level and design of deposit insurance schemes.

ducing deposit insurance into this model. Since differences in failure rates are effectively a form of endogenous vertical differentiation between banks, introducing deposit insurance lessens this differentiation and so increases competition between banks. Because (in common with Diamond and Dybvig and with our model) the supply of funds is perfectly elastic at the depositors' outside option, this increase in competition has no direct welfare implications and may in fact be harmful because in their model banks are more likely to fail when they compete more strongly on deposit rates. Deposit insurance does have some welfare benefits, however, apart from preventing "market collapse" due to depositors' pessimistic self-fulfilling expectations, as in Diamond and Dybvig. Larger banks are better able to diversify, and deposit insurance will extend the market coverage of local monopoly banks by increasing the attractiveness of depositing. It can also induce entry by a second bank where without insurance there would be monopoly - which reduces aggregate transport costs but also reduces diversification and raises failure rates. The authors find that deposit insurance is welfare-enhancing where banks would otherwise be in a monopoly position but harmful when there is competition, a conclusion that fits well with the recent literature blaming crises on financial liberalisation (e.g. Hellman et al, 2000, and Demirgüç-Kunt and Detragiache, 1998).

The paper is presented as follows. In the next section we describe a model of an unregulated economy in which bankers have a role in channelling funds from the household sector into productive investments, but in which adverse selection of and moral hazard by banks acts as an impediment to socially desirable depositing. In sections 3 and 4 we show how an appropriately designed deposit insurance scheme can address this problem and we investigate the appropriate way to fund such a scheme. In section 5 we show that our results are unaffected if our analysis is extended to multiple time periods. In section 6 we examine various schemes by which the regulator might attempt to resolve adverse selection problems by separating sound from unsound bankers and we show that none of these is effective. Section 7 examines some other extensions of our model and section 8 concludes.

2. The Model

We consider an economy consisting of $N + \mu$ agents. N of the agents, to whom we refer as *households*, are endowed with \$1 and with a project which has constant returns to scale. If it succeeds, the project will return $R > 0$ on each dollar invested in it; otherwise, it will fail and return 0. Households' projects succeed with probability p_L. The remaining μ agents in the economy also have an endowment of \$1 but they have no project of their own. These agents have two roles in our model: they collect and invest household funds, and they monitor households' projects so as to augment their returns. We will refer to these agents as *banks*. There are two types of banks. *Sound* banks are endowed with a costly monitoring technology which they can use to increase the probability of households' project success to $p_H = p_L + \Delta p > p_L$. The cost of monitoring a project in which $\$k$ has been invested is $\$Ck$. *Unsound* bankers have no monitoring ability. A banker's type is his private information.

Each of the N households must choose how to invest its own endowment. They can invest it in their own project, or they can deposit it with a bank. Depositors can then elect to borrow money from a bank and to run a project with the help of the bank. Bankers lend the funds which they collect from depositors to households whose projects they supervise. For simplicity, we analyse the case where each banker lends to only one agent (or equivalently, where the returns of the projects to which the banker lends are perfectly correlated).[11] For notational ease, we assume that the agent to whom the banker lends is drawn at random from amongst his depositors. We also assume that the banker has all of the negotiating power in his relationship with the agent to whom he lends his funds and hence that he extracts all of the returns from the project.[12] Households who elect to deposit their funds with a banker and then to compete for loans are therefore compensated only through the deposit contract which they write with the banker. Their role in running their projects is of no relevance to our model and we therefore refer to these households as *depositors*. Households who elect not to deposit are referred to as *self-managers*.

Self-managed funds earn an expected return of Rp_L. Deposited funds earn a return of Rp_L when managed by an unsound banker and net of costs earn $Rp_H - C$ when managed by a sound banker who chooses to monitor. We assume that monitoring is efficient:

$$R\Delta p > C. \tag{A1}$$

The social return on deposited funds depends on the type of banker with whom they are deposited, but is at least as high as the return on self-managed funds. It follows that the social optimum is for all agents to deposit their funds with bankers.[13]

The relationship between depositors and bankers is governed by a *deposit contract*, which stipulates the fee Q which the depositors will pay to the bankers in the event that their project succeeds. When bank size is k, a sound banker's payoff from monitoring is

$$(R + Q(k-1))\, p_H - Ck,$$

and the expected return to bankers who do not monitor is

$$(R + Q(k-1))\, p_L.$$

Monitoring is therefore incentive compatible for sound bankers if and only if:

$$Q \geq \frac{Ck - R\Delta p}{(k-1)\,\Delta p}. \tag{MIC}$$

[11] This assumption is not essential to our results. We require that bank returns be risky and that bankers cannot completely diversify by being sufficiently large, à la Diamond (1984). Modelling in this way allows us to abstract from any economies of scale in banking, which would complicate our anaylsis.

[12] These assumptions are not unreasonable since, in order to be induced to monitor, banks must invest their own capital in the project. Bank capital will be scarce in equilibrium, so that if agents were to bid for bank services, banks would be able to extract all the returns on their own funds and the incremental return on the agent's own investment, leaving agents with only Rp_L in expectation. This formulation is equivalent our assumption that the bank forces the borrower to deposit and gives him an expected return of Rp_L on his deposit and no return on his project (since we supress any entrepreneurial moral hazard), which turns out to be notationally simpler. If the borrowing agent had some negotiating power with the bank *ex post* (or there was entrepreneurial moral hazard), this would require a payment to be made to the entrepreneur in the case where the project succeeded. This would worsen the bank moral hazard problem without changing any qualitative results.

[13] We have normalised the return on unsound banks' project to be the same as that on self-managed projects. The idea is that unsound banks do not add any value to the projects in which they invest, yet they extract fees for intermediating the investment. Our results are robust to assuming that unsound banks' investments are worse than self-managers' provided that bank investments are on average more productive than self-managers' projects.

The deposit rate which the depositors receive if their bank succeeds is $R - Q$. We wish to examine the relationship between the quality of the banking sector and optimal deposit insurance policy. To this end, let $g \in [0, 1]$ be the probability that a randomly selected bank is sound.[14] The expected return to a bank depositor is then

$$(R - Q)(p_L + g\Delta p), \tag{1}$$

provided condition MIC is satisfied. Agents will be prepared to deposit provided this expression dominates the expected income Rp_L from self management, which is equivalent to the following:

$$Q < \frac{Rg\Delta p}{p_L + g\Delta p}. \tag{IRUnReg}$$

The monitoring incentive compatibility constraint, MIC, is monotonically increasing in bank size k: if banks are larger, bankers must receive higher fees to induce monitoring. Provided the limit $\frac{C}{\Delta p}$ of MIC exceeds $\frac{Rg\Delta p}{p_L+g\Delta p}$, equations MIC and IRUnReg cross at some $k^* < \infty$. This is equivalent to the following:

$$C(p_L + g\Delta p) - Rg\Delta p^2 > 0. \tag{A2}$$

If equation A2 is not satisfied then for every bank size k there is a fee to bankers Q such that monitoring is incentive compatible for sound banks *and* at the same time depositing is individually rational for all agents. This is sufficient for the social optimum of general bank investment to be achieved without regulatory interference. The interesting case therefore arises when A2 holds and we adopt it as an assumption. In this case there may be a need for banking sector regulation to achieve the social optimum. With assumption A2 the two constraints intersect at bank size k_B:

$$k_B = \frac{R\Delta p p_L}{C(p_L + g\Delta p) - Rg\Delta p^2}.$$

In the absence of regulation, k_B is the maximum size of a bank: if banks were larger, depositors would be unwilling to pay fees sufficient to prevent moral hazard by sound banks. The total volume of funds deposited in the unregulated banking sector is therefore μk_B: we can think of $\frac{1}{k_B}$ as the capital requirement for unregulated banks.[15] We assume that

$$\mu k_B < N + \mu; \tag{A3}$$

or equivalently, that

$$g < \frac{C(N + \mu)p_L - R\mu\Delta p}{(R\Delta p - C)(N + \mu)\Delta p}.$$

[14] For simplicity we treat g as exogenous. Morrison and White, 2002 show how g can be endogenised in a general equilibrium setting, when it is an increasing function of the quality of regulation.

[15] There are two interpretations of how exactly the enforcement of capital requirements occurs. These are essentially equivalent from a modelling point of view, though very different in spirit. It can be assumed that banks state their anticipated deposit-to-capital ratio; depositors observe the level of deposits banks collect and before banks invest they have an opportunity to withdraw without penalty if banks exceed their promised ratios. This can be termed *market monitoring* of capital adequacy. Alternatively if one supposes that depositors do not observe the level of deposits but that the regulator does, one can assume that there is *regulatory monitoring* of capital requirements. The regulator should immediately close any bank which accepts more deposits than would be compatible with monitoring by sound banks.

Since $N + \mu$ is total size of the economy's endowment, assumption A3 states that the volume of funds under bank management in the pure market equilibrium is less than the total available: in other words, that the level of deposits is sub-optimal. It is in this situation, where the adverse selection problem is more serious, that deposit insurance can play a useful role. If, on the other hand, the proportion of sound banks g is sufficiently large that A3 is violated, there will be no need for deposit insurance.

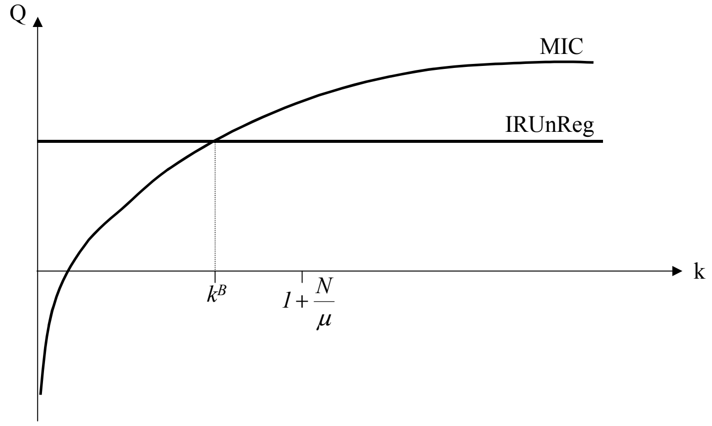

Figure 1: Constraints in the unregulated economy.

The situation is illustrated in figure 1. Sound bankers will decide to monitor only when they are compensated for doing so, which is when (k, Q) lies above MIC. Households will elect to deposit only when the deposit rate is sufficiently high: in other words, below the IRUnReg constraint. Bankers earn the highest income from their activities at the point where the two constraints cross and they will therefore offer this contract to the household sector. When the intersection point k_B is below $1 + \frac{N}{\mu}$ as illustrated, assumption A3 holds and there is under-depositing.

This completes our description of the economy. Our model deliberately avoids introducing various features of banking models such as depositor risk aversion and self-fulfilling panics which have been used to justify deposit insurance in the past in order to show that deposit insurance may be desirable even if, as may be the case in many developed economies, panics are thought to be unlikely. Our model captures two important aspects of the banking literature which we believe are common to virtually all modern economies. Firstly, banks have an allocational role: they take funds from unproductive agents and place them where they can be most profitably used. Secondly, banks have monitoring and project management skills which tend to augment the return which entrepreneurs achieve on their projects.

Two features of the model are essential for our conclusions. Firstly, the non verifiable monitoring activities of the sound bankers give rise to moral hazard which must be countered by a monitoring fee. Secondly, there is an adverse selection problem in the banking sector. Depositors will with probability $(1 - g)$ place their funds with an unsound banker who will take the fee Q but who will not perform any monitoring. Depositing is at worst welfare-neutral, but because they pay the monitoring fee Q to both sound and unsound bankers, depositors will fail to value the social benefits of bank management when g is sufficiently low. There is therefore a wedge between the objective function of the depositors and that of society and this drives our results. We demonstrate below that judicious use of deposit insurance contracts can counter this problem and ensure that the optimum is attained.

3. The Impact of Deposit Insurance on the Banking Sector

We now introduce a benevolent regulator with a utilitarian welfare function. The regulator aims to maximise production levels in the economy, and hence the size of the banking sector, and is unconcerned with questions of distribution. The only tool at her disposal is a deposit insurance scheme, which must be paid for out of taxes levied on the bankers, depositors and self-managers who comprise the economy.[16]

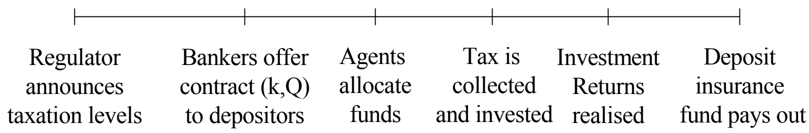

Figure 2: Time line for the regulatory game.

The timing of the game which the regulator plays with the depositors is illustrated in figure 2. Firstly, the regulator announces lump sum taxes τ_S, τ_B and $\tau_D \in [0,1]$ which will apply to self-managers, bankers and depositors respectively. Each banker then offers a contract (k, Q) to depositors. As in section 2, $\frac{1}{k}$ is the bank's capital adequacy requirement. With a tax rate τ_B upon bankers this implies that each bank will have size $k(1-\tau_B)$. The fee Q which bankers receive per dollar for managing depositor funds is defined in section 2. After bank contracts have been announced, agents decide how to allocate their funds. The regulator then collects tax and invests the tax revenue either in the banking sector or in the storage technology used by self-managers (in which case it will return in expectation Rp_L). After investment returns are realised and distributed, the proceeds from the deposit insurance fund will be distributed to depositors in failed institutions in proportion to the amount of their deposit. We assume that the deposit insurance fund must balance its budget: it cannot pay out more than it has collected in tax. In this simple one-period model there will be no benefit to the fund in holding over surpluses, so it will always pay out all the taxes it has collected.

3.1. Deposit Rationing

When there is no taxation, assumption A3 implies that there will be rationing of deposits. This occurs because with a bank size k_B and a deposit rate $\frac{Ck_B - R\Delta p}{(k_B-1)\Delta p}$ all (non-bank) agents will wish to be depositors, but the banking sector will not be big enough to absorb all of their funds. The banking

[16] In practice banking regulators often have other tools at their disposal, including the ability to set capital requirements and to close banks which violate these. We largely abstract from this issue here in the interests of simplicity (but see footnote 15 and also section 6.1 where we discuss the use of capital requirements as a screening device). For a general equilibrium model where capital requirements may be used for screening purposes and banks can be audited ex post, see Morrison and White (2002).

sector cannot expand to absorb the excess funds without either reducing capital requirements (and so violating the monitoring incentive compatibility constraint (MIC)) or reducing deposit rates (so violating depositors' individual rationality constraint (IRUnReg)).

Deposits could still be rationed when the regulator levies taxes. We assume that if rationing occurs, all agents who attempt to deposit succeed in placing a fraction ρ of their pre-tax endowment with a bank.[17] Notice that as the total revenue T from taxation is the sum of taxes from banks, depositors and self-managers, it depends on the extent to which deposits are rationed:

$$T \equiv \mu\tau_B + N\rho\tau_D + N(1-\rho)\tau_S \tag{2}$$

The expression for ρ depends upon whether the revenue T is invested in the banking sector or in the (inefficient) storage technology. In both cases the size of the banking sector will be $k\mu(1-\tau_B)$, of which $\mu(1-\tau_B)$ will be bank capital.

If T is invested in the storage technology, all of the remaining $(k-1)\mu(1-\tau_B)$ in the banking sector will be depositor funds. This corresponds to a pre-tax figure of $\frac{(k-1)\mu(1-\tau_B)}{(1-\tau_D)}$ and there are a total of N potential depositors in the economy, each of whom is endowed with a single pre-tax dollar. If all the non-bank agents wish to deposit each will therefore succeed in depositing the following pre-tax quantity:

$$\rho_{st} \equiv \frac{(k-1)\mu(1-\tau_B)}{N(1-\tau_D)} \tag{3}$$

whenever this expression is less than 1, and 1 otherwise.

If T is invested in the banking sector, of the $(k-1)\mu(1-\tau_B)$ dollars in the banking sector which are not banker endowment, $\max\{(k-1)\mu(1-\tau_B)-T, 0\}$ will be depositor funds. In practice the regulator has nothing to gain from collecting a tax revenue greater than the banking system can absorb, so we can assume that $T \leq (k-1)\mu(1-\tau_B)$. It follows that if all non-bank agents were to deposit, rationing would be given by:

$$\rho_{bk} \equiv \frac{(k-1)\mu(1-\tau_B)-T}{N(1-\tau_D)}. \tag{4}$$

3.2. Deposit Insurance Fund Invested in Banks

In this section we examine the optimal level of deposit insurance when the regulator invests the deposit insurance fund in the more productive banking technology. In this case we can substitute equation 2 into equation 4 and rearrange to obtain the extent of deposit rationing as a function of the taxes imposed by the regulator to fund the deposit insurance scheme:

$$\rho_{bk} = \frac{\mu[k(1-\tau_B)-1]}{N(1-\tau_S)} - \frac{\tau_S}{1-\tau_S}. \tag{5}$$

Since the gross return on bank deposits is $(R-Q)(p_L+g\Delta p)$ (see equation 1), the expected total return from the deposit insurance scheme in this case is $T(R-Q)(p_L+g\Delta p)$. Since all agents are *ex ante* equally likely to invest in a failed institution and all invest the same amount, they each

[17] One could equivalently assume that a fraction ρ of agents who wish to deposit succeed in depositing all of their funds, and the remainder are forced to self-manage.

expect an equal *ex post* payment from the fund of $\frac{T}{N}(R-Q)(p_L+g\Delta p)$. Note that the extent of rationing of deposits ρ_{bk} does not appear in this expression, because we have assumed that the deposit insurance fund must balance its budget.

As in the unregulated economy, the maximum possible bank size with deposit insurance occurs at the intersection of the monitoring incentive compatibility constraint MIC and the depositors' participation constraint. The MIC constraint is unaffected by deposit insurance.[18] The IR constraint is affected by the deposit insurance scheme and becomes:

$$\left[\frac{T}{N}+\rho_{bk}(1-\tau_D)\right](R-Q)(p_L+g\Delta p)+(1-\rho_{bk})(1-\tau_S)Rp_L \geq Rp_L(1-\tau_S),$$

or, rearranging,

$$Q \leq R - Rp_L\frac{\mu(k(1-\tau_B)-1)-N\tau_S}{(p_L+g\Delta p)[\mu(k(1-\tau_B)-1)+\mu\tau_B]}. \tag{IRBankInv}$$

This expression is decreasing in k and has limiting value $\frac{Rg\Delta p}{p_L+g\Delta p}$, which is equal to IRUnReg. The situation is illustrated in figure 3, from which the following result is immediate.

PROPOSITION 1 *Let k_B and k_{bk} be the respective intersections of MIC with IRUnReg and IRBankInv. Then $k_B < k_{bk}$. When a deposit insurance fund is created using* ex ante *taxation and invested in the banking sector, bank capital requirements may be loosened from $\frac{1}{k_B}$ to $\frac{1}{k_{bk}}$.*

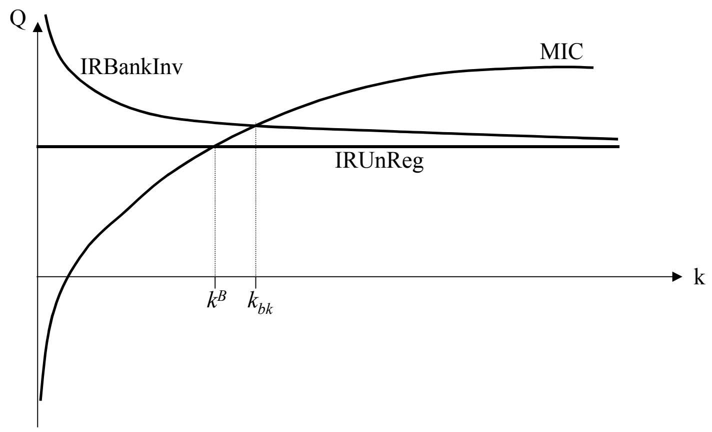

Figure 3: Constraints when the deposit insurance fund is invested in the banking sector.

The intuition for proposition 1 is straightforward. Tax is levied *ex ante* to create a deposit insurance fund which is invested in the banking sector. The returns on the deposit insurance fund are in expectation divided equally amongst depositors and so create an additional incentive for households to deposit their endowment. All else equal, households are therefore prepared to

[18] The monitoring requirement becomes $(1-\tau_B)\{(R+(k-1)Q)p_H - Ck\} \geq (1-\tau_B)\{(R+(k-1)Q)p_L\}$ from which the taxation terms cancel. Since much of the literature has emphasised that deposit insurance causes moral hazard by banks, this might appear paradoxical. The result follows because in our model, the return to depositors depends upon the bank's monitoring effort even with deposit insurance so that banks will be charged *ex ante* for slacking. This is not true when deposit insurance renders depositor return insensitive to banker behaviour.

accept a lower deposit rate, shifting up (IRBankInv) relative to (IRUnReg). Bankers can thus earn a correspondingly higher return on their monitoring activities for a given bank size. This reduces their temptation to moral hazard and so reduces the amount of capital required to induce them to monitor a dollar of depositor funds.

Note that we have not yet proved that deposit insurance will increase bank size, however. The *ex ante* taxes which bankers pay reduce their capital base, as well as increasing the leverage of their banks: bank size is $k(1-\tau_B)$. Social welfare $\mathcal{W}_{bk}$ is proportional to the volume $\mu k(1-\tau_B)$ of funds managed by banks. Proposition 2 provides an expression for $\mathcal{W}_{bk}$ and gives its maximal value.

Proposition 2 *When the proceeds of the* ex ante *taxation scheme* (τ_S, τ_B, τ_D) *are invested in the banking sector, the following social welfare level is achieved:*

$$\mathcal{W}_{bk} = \frac{(\mu + N\tau_S) R\Delta p p_L}{C(p_L + g\Delta p) - Rg\Delta p^2}. \tag{6}$$

This has maximal value

$$\mathcal{W}_{bk}^* = \mu + N,$$

which is attained when τ_S *assumes the following value:*

$$\tau_S^* = \left(1 + \frac{\mu}{N}\right) \frac{C(p_L + g\Delta p) - Rg\Delta p^2}{Rp_L\Delta p} - \frac{\mu}{N}. \tag{7}$$

Proof. Setting the IRBankInv constraint equal to the MIC constraint yields the following equation for bank capital:

$$k_{bk}(1-\tau_B)\frac{\mu}{N}\left[C(p_L + g\Delta p) - Rg\Delta p^2\right] = \left(\frac{\mu}{N} + \tau_S\right) Rp_L\Delta p. \tag{8}$$

Social welfare $\mathcal{W}_{bk}$ is proportional to the volume of funds managed by banks, $\mu k_{bk}(1-\tau_B)$. Rearranging equation 8 yields equation 6.

Welfare is increasing in τ_S.[19] Our discussion so far has assumed that $\rho_{bk} \leq 1$: welfare is therefore maximised when τ_S is at its maximum value subject to this constraint. Substituting from equation 8 for $k(1-\tau_B)$ into the bank rationing equation (4) we obtain equation 7, as required. □

Proposition 2 has several interesting consequences. Firstly, note that neither τ_B nor τ_D appears in the social welfare function (equation 6). In other words, taxing bankers and depositors is welfare-neutral. When depositors are risk-neutral, taxing them *ex ante* and using the proceeds to make *ex post* payouts has no effect upon their incentives. Deposit insurance paid for by depositors does nothing to improve welfare in this model. Moreover, the negative effects of bank taxation upon bankers' capital levels are precisely offset by the positive effects which follow from the relaxation of capital requirements highlighted in proposition 1. Thus the common prescription that deposit insurance schemes ought to be paid for by banks does not hold in this model. A deposit insurance scheme funded only by banks would not improve welfare because of the adverse effects which it would have upon bank capital.[20]

[19] Note that, in the light of A2, the denominator of expression 6 is positive.

[20] Although bank capital is fixed in our model this insight would be unaffected if bank capital could be raised externally by issuing equity or subordinated debt. Bank taxation would then affect external capital in the same way as it does banker capital in our model and hence would have the same incentive consequences.

The only tax rate which has an effect upon welfare is the rate τ_S which is levied upon self-managers. Taxation of self-managers increases the expected returns from depositing, and it renders self-managing less attractive. It thus slackens the depositors' participation constraint. As we discuss above (proposition 1), this loosens optimal capital requirements by allowing bankers to extract higher fees from depositors. It has no effect upon bank capital and so increases bank size and hence welfare.

At the optimum taxation level τ_S^* the first best level of welfare is achieved, in which all agents deposit their endowments in banks which then invest in projects and monitor them. In equilibrium there is no deposit rationing and no taxes are gathered from self-managers since all non-bank agents opt to deposit. One possible optimal taxation arrangement which achieves this has $\tau_B = \tau_D = 0$ and $\tau_S = \tau_S^*$. In this case the no taxes will be collected and the deposit insurance fund will be empty. The deposit insurance scheme then functions more as a "stick" than as a "carrot": it threatens agents with penal taxation if they do not allow banks to reallocate their funds to socially more productive uses.

The socially optimal allocation can also be achieved by flat rate taxation of τ_S^* upon all agents: banks, depositors and self-managers. This alternative is likely to be politically more palatable. Although all agents are taxed at the same rate, only the taxes on self-managers have any real effect. The deposit insurance scheme in this case collects general taxation and then re-allocates it only to those who deposit in the banking system. Since those who invest elsewhere will not benefit from the scheme, it creates a strong incentive to invest in the banking system. This does not seem a bad approximation to the way that (government funded) deposit insurance schemes operate in practice. Such schemes will produce social benefits if (as in our model) the average productivity of the funds invested by the banking sector is higher than the average productivity of the funds which it attracts from other uses (i.e., "self-management"). This is likely in practice if deposit insurance mostly attracts funds which would otherwise be held unproductively by agents "under the mattress", rather than funds which would otherwise be invested in projects with a higher yield than that earned by banks. Given that most real-world deposit insurance schemes are designed to reassure the small investor (most schemes have caps on the amount which is insured), this assumption does not seem too unrealistic.[21]

3.3. Deposit Insurance Fund Invested in the Storage Technology

In the previous section we assumed that the deposit insurance fund was invested in the banking sector. Intuitively, one might expect this to yield higher welfare for society than investing the fund in the relatively unproductive storage technology. However, this policy might not always be very realistic in practice.[22] For example, in a world where investors are risk-averse, one might obtain diversification benefits from investing the deposit insurance fund less productively outside the banking sector. Therefore in this section, we analyse the case where the deposit insurance fund

[21] This intutition would not be affected by the introduction of alternative, high-yielding projects for self-managers. In this case τ_S would be optimally set so as to discourage unproductive self-management, whilst not discouraging self-management by households with very productive projects.

[22] For example, the FDIC is required by statute to invest its funds in U.S. Treasury obligations.

is invested in the unproductive storage technology. We demonstrate that in fact the social first best can still be attained, provided the regulator's taxation policy is unconstrained. When the regulator is constrained to use a flat rate taxation scheme the first best cannot be achieved, although the deposit insurance scheme is still welfare increasing. Proposition 3 summarises our results.

PROPOSITION 3 *When the proceeds of the* ex ante *taxation scheme* (τ_S, τ_B, τ_D) *are invested in the storage technology, social welfare* $\mathcal{W}_{st}$ *is achieved, provided the rationing fraction* ρ_{st} *of equation 3 satisfies the constraint* $\rho_{st} \leq 1$ *:*

$$\mathcal{W}_{st} = \frac{(\mu + N\tau_S)\, R\Delta p p_L}{C\,(p_L + g\Delta p) - Rg\Delta p^2}. \tag{9}$$

The maximal welfare level $\mathcal{W}^*_{st}$ *is*

$$\mathcal{W}^*_{st} = \mu\,(1-\tau_B) + N\,(1-\tau_D)\,. \tag{10}$$

Proof. The MIC constraint is unchanged from section 3.2, but the depositors' IR constraint now takes the following form:

$$\frac{TRp_L}{N} + \rho_{st}\,(1-\tau_D)\,(R-Q)\,(p_L + g\Delta p) + (1-\rho_{st})\,(1-\tau_S) \geq Rp_L\,(1-\tau_S)\,. \tag{IRStoreInv}$$

Assume for now that $\frac{(k-1)\mu(1-\tau_B)}{N(1-\tau_D)} \leq 1$, so that ρ_{st} is given by equation 3. Rearranging and substituting in equation IRStoreInv for ρ_{st} yields the following expression for bankers' fees Q:

$$Q \leq R\frac{g\Delta p\,(k-1) + \frac{\frac{N}{\mu}\tau_S + \tau_B}{1-\tau_B} p_L}{(k-1)\,(p_L + g\Delta p)}. \tag{11}$$

Solving equation 11 simultaneously with the monitoring incentive compatibility constraint MIC yields an expression for $k\,(1-\tau_B)$ as in section 3.2. Multiplying this expression by μ immediately yields equation 9 for welfare when $\rho_{st} \leq 1$.

Note that, since taxes are invested in the unproductive storage technology, it will never pay the regulator to raise more taxes than are required to remove deposit rationing. In other words, the limiting value for $\mathcal{W}_{st}$ will occur when $\frac{(k-1)\mu(1-\tau_B)}{N(1-\tau_D)} = 1$. This expression can be solved for $k\mu\,(1-\tau_B)$ to yield equation 10. □

Note that $\mathcal{W}_{st} = \mathcal{W}_{bk}$. In other words, provided $\frac{(k-1)\mu(1-\tau_B)}{N(1-\tau_D)} \leq 1$, the welfare effects of deposit insurance are the same, irrespective of the way in which the deposit insurance fund is invested. The conclusions of section 3.2 above are unchanged.

At the maximal welfare level $\mathcal{W}^*_{st}$, there is no rationing and all after tax household funds are invested in the banking sector. As in section 3.2, the taxation scheme increases welfare by discouraging households from unproductive self-management. When $\tau_B = \tau_D = 0$, $\mathcal{W}^*_{st} = \mathcal{W}^*_{bk} = N + \mu$ and the social first best is achieved by levying taxes upon self-managers at τ^*_S, as in equation 7. However, taxes on bankers and depositors are no longer welfare-neutral, but welfare-decreasing. This is because any tax raised from these sources is diverted from the banking sector to be invested into the unproductive storage technology, which is inefficient. Thus it is positively damaging to ask bankers or depositors to contribute to the deposit insurance fund in this case: ideally they should not be taxed. Notwithstanding this observation, we are able to prove that there should still be a deposit insurance scheme:

LEMMA 4 *Deposit insurance funded via a flat rate* ex ante *tax which is invested in the storage technology is welfare increasing. The optimal tax rate is* τ^**:*

$$\tau^* = \frac{(N+\mu)\left[C(p_L + g\Delta p) - Rg\Delta p^2\right] - \mu R\Delta p p_L}{(N+\mu)\left[C(p_L + g\Delta p) - Rg\Delta p^2\right] + NR\Delta p p_L} > 0. \tag{12}$$

Proof. With a flat tax rate of τ, the maximal welfare (equation 10) is $\mathcal{W}^*_{st(general\ taxation)} = (1-\tau)(\mu+N)$. Setting this equal to equation 9 allows us to solve for the optimal flat rate tax τ^*, which is given by equation 12.

To see that $\tau^* > 0$ and hence that flat rate taxation is welfare increasing, note that assumption A3 implies that $\left(Rg\Delta p^2 - Cg\Delta p\right)(N+\mu) < C(N+\mu)p_L - R\mu\Delta p$, from which it follows that

$$(N+\mu)\left[C(p_L + g\Delta p) - Rg\Delta p^2\right] > R\mu\Delta p - C(N+\mu)p_L + C(N+\mu)p_L > R\mu\Delta p p_L.$$

□

4. *Ex post* Taxation

So far, we have assumed that deposit insurance schemes are funded through *ex ante* taxation. In this section we investigate schemes which are paid for through *ex post* taxation of agents. Perhaps surprisingly, we derive the same welfare levels as those of section 3.2, so that it is unimportant for welfare whether taxes are levied ex post or ex ante.

The game which we study in this section is differs from that illustrated in figure 2 in the following way. Although the regulator announces the taxation schedule (τ_S, τ_B, τ_D) at the start of the game, taxes are collected *after* projects end and are then distributed as deposit insurance payments. As in section 3, we assume that the regulator's budget must balance so that all taxes are distributed to depositors in failed institutions.

With taxation levied in this way the banker's *ex ante* capital level is \$1 and, excluding monitoring costs and taxes, his return from running a successful bank is therefore $[R + Q(k-1)]$. This quantity is taxed at τ_B so the monitoring incentive compatibility condition in this case is the following:

$$Q \geq \frac{Ck - R(1-\tau_B)\Delta p}{(k-1)(1-\tau_B)\Delta p}. \tag{MIC$_{\text{ep}}$}$$

Without *ex ante* taxes, the rationing equations 3 and 4 when all households wish to deposit both reduce to

$$\rho_{ep} = \frac{\mu(k-1)}{N}.$$

Since all depositors are equally likely to invest in both successful and unsuccessful banks, the expected return per dollar invested in the banking system is

$$r_{ep} \equiv \frac{(1-\tau_D)(R-Q)(k-1)\mu(p_L + g\Delta p)}{\mu(k-1)} + \frac{T_{ep}}{\mu(k-1)}.$$

The first term in this expression is the total after tax return on bank deposits divided by the dollar amount $\mu(k-1)$ invested in the banking system. T_{ep} is the amount raised by the *ex post* taxation scheme:

$$T_{ep} = \mu(p_L + g\Delta p)\left[\tau_B(R + Q(k-1)) + \tau_D(R-Q)(k-1)\right] + \left[N - \mu(k-1)\right]\tau_S R p_L. \tag{13}$$

The second term in the expression for r_{ep} is T_{ep} divided by amount invested in the banking system. The depositors' participation constraint is as follows:

$$\rho r_{ep} + (1 - \rho) R p_L (1 - \tau_S) \geq R p_L (1 - \tau_S).$$

This reduces after some manipulation to the following:

$$Q \leq R \frac{\mu [(k-1) g\Delta p + \tau_B (p_L + g\Delta p)] + \tau_S N p_L}{\mu (1 - \tau_B)(k-1)(p_L + g\Delta p)}. \tag{IR$_{\mathrm{ep}}$}$$

Equations $\mathrm{MIC_{ep}}$ and $\mathrm{IR_{ep}}$ can be used to determine social welfare with this taxation scheme. Proposition 5 summarises our findings:

PROPOSITION 5 *Social welfare $\mathcal{W}_{ep}$ with* ex post *taxation is equal to the welfare level $\mathcal{W}_{bk}$ attained when deposit insurance is funded* ex ante *taxes which are invested in the banking sector.*

Proof. Social welfare is given by the amount invested in the banking system. Without *ex ante* taxes, this is equal to k. Simultaneous solution of equations $\mathrm{MIC_{ep}}$ and $\mathrm{IR_{ep}}$ yields $k = \mathcal{W}_{bk}$, as required. □

This result is somewhat surprising: the received wisdom on *ex post* taxation is that it is bad for bankers' incentives as it takes away from successful bankers some of the fruits of their labours to give these away to the unlucky depositors in failed institutions. Thus it reduces the effort which sound bankers will devote to monitoring. In fact, as proposition 5 demonstrates, this is not the whole story: this intuition holds only for a given bank size. If bankers do not have to pay taxes *ex ante*, their starting capital will be larger and this will improve their incentive to monitor in a way which exactly offsets the reduction due to taxation *ex post*. Another way to think about this is that taxation which occurs *ex post* may be regarded as simply the retrieval of *ex ante* taxes which have been deposited in the banking system. When *ex post* taxation is levied at levels determined *ex ante*, it has the same welfare effects as the *ex ante* taxes investigated in section 3.2.

5. Deposit Insurance with Inter-Generational Transfers

In practice, deposit insurance schemes typically guarantee a specific payment to depositors if their bank fails. In the model which we have so far considered the deposit insurance fund's budget balance constraint precludes such a scheme, since (even with a stochastic *ex post* taxation rate) it would be impossible for the fund to meet its obligations in the unlikely event that every bank failed. In this section we allow for inter-generational transfers via the deposit insurance fund. This allows us to examine guaranteed payout deposit insurance funds. For simplicity (and without loss of generality when intertemporal transfers are allowed), we consider *ex post* taxation schemes. It transpires that the welfare conclusions of section 4 are unaffected.

In this section we make assumptions in addition to those of previous sections. Firstly, we assume that the deposit insurance fund, which is infinitely lived, is able to borrow and to lend unlimited quantities from an external capital market. Secondly, we assume that the interest rate on the associated borrowing and lending is 0%. This is equivalent to assuming that, in real terms, the economy, and hence taxation revenues, grows at the same rate as the interest rate to which the fund is subject. Thirdly, we assume that banking licences are reassigned in every period, so that in each period the depositors use the same value for the quality parameter g.[23]

The possibility of intertemporal wealth transfers via the deposit insurance fund will not affect the incentives of bankers and so the monitoring incentive compatibility constraint is given by equation $\mathrm{MIC}_{\mathrm{ep}}$.

To understand the depositors' participation constraint, note that with inter-generational transfers funded at an interest rate of 0%, we only require the budget to balance *in expectation*. In other words,

$$T_{ep} = \mu (k-1)(1-(p_L + g\Delta p))P, \tag{14}$$

where T_{ep} is the total revenue from taxation, given by equation 13, and P is the payment which depositors in failed institutions receive. The depositors' IR constraint is then

$$\rho \left\{ \frac{(1-\tau_D)(R-Q)(k-1)\mu(p_L + g\Delta p)}{\mu(k-1)} + (1-(p_L+g\Delta p))P \right\} + (1-\rho) R p_L (1-\tau_S) \geq R p_L (1-\tau_S).$$

Substituting for P from the budget balance constraint 14 we obtain $\mathrm{IR}_{\mathrm{ep}}$. The constraints of this section are therefore the same as those of section 4. We have therefore proved the following result:

Proposition 6 *Social welfare $\mathcal{W}_{ig}$ with fixed deposit insurance payouts and inter generational wealth transfers allowed is equal to the welfare level $\mathcal{W}_{bk} = \mathcal{W}_{ep}$ attained when the deposit insurance fund must balance its budget in each period*

Of course, proposition 6 requires agents to be risk-neutral. If intertemporal transfers can smooth expected payouts from the deposit insurance fund then they will increase the welfare of risk-averse agents.

6. Sorting Bank Types: Privately Funded Deposit Insurance and Coinsurance

In the foregoing we assumed that welfare was maximised when all funds were invested in the banking sector, since all banks do at least as well as self-managers. Yet since some banks are better than others at investing deposits, one might wonder whether the regulator can do better by trying to select out the unsound banks and channel more funds to the good banks. Certainly if the regulator can employ any policy such as periodic inspections or audits to deter unsound banks and reduce the severity of the adverse selection problem by raising the value of g, then, all other things being equal, this will improve welfare. So far we have implicitly assumed that the regulator is already employing such complementary policies to the full extent of his ability, so that the parameter g can be considered a function of the regulator's ability (for further discussion, see section 7.1 below). In this section we ask whether, given the tools available, one might expect either the regulator or the

[23] Without this assumption, depositors would become increasingly certain that long-lived banks were sound. In such a situation, new banks would be squeezed out of the market, or older banks would earn equilibrium reputational rents. Either scenario would introduce complications which are outside the scope of this paper.

good bankers collectively to attempt to find a separating mechanism to resolve the adverse selection problem. We examine the use of capital requirements imposed upon bankers by the regulator; cross-subsidisation schemes operated by the regulator to bribe unsound bankers to leave the market; and bankers' clubs ("co-insurance") set up by bankers in an attempt to screen out poor bankers. None of these approaches succeeds in our setting where bankers' types are pure private information.

6.1. Capital Requirements

The regulator could impose severe capital requirements on the banking industry in an attempt to select out the bad bankers. Note however that the unsound bankers' outside option is to run their own project. This is equivalent to running a bank with a capital requirement of 100%. The regulator must set a lower capital requirement to avoid autarky for the sound bankers and such a requirement will always be accepted by the unsound bankers. The reason is that they can extract fees Q on any deposits which they manage, and for unsound bankers, managing deposits is costless. Thus capital requirements alone cannot resolve the adverse selection problem in this model, because unsound bankers will always mimic sound bankers.[24] The argument here is similar to the reason Chan, Greenbaum and Thakor (1992) find that is impossible to induce depository instititions to reveal their risk levels by choosing a revealing capital requirement deposit insurance premium pair. However, their result holds only for unsubsidised schemes. In our analysis we allow for a net subsidy to the deposit insurance system.

6.2. Cross-Subsidisation Schemes

We now consider schemes which may involve some kind of subsidy to unsound bankers to induce them not to participate in the banking sector. Consider in particular a scheme under which the regulator selects μ volunteers from the pool of potential bankers, imposes an *ex ante* tax of τ_B upon those who elect to run banks and then, instead of using the proceeds to fund a deposit insurance scheme, pays them to those agents from this pool who elect not to bank.[25] These agents can use this sum to augment their initial endowment for investment, but they cannot collect deposits. We call such a scheme "cross subsidisation."

Cross subsidisation schemes will only be effective if the non-deposit-taking option is more attractive to the unsound bankers than to the sound ones. This is difficult to achieve since monitoring is efficient, so the sound bankers generate greater profits from subsidies than unsound ones. Moreover, if the monitoring incentive compatibility constraint binds, sound and unsound bankers will earn the same profits from running a bank, so that separation will be impossible. Below we demonstrate

[24] Morrison and White (2002) demonstrate in a general equilibrium model that the regulator can use capital requirements to resolve the adverse selection problem when banker entry is endogenous and the regulator is able to screen potential bankers. Unsound bankers then have depositing as an outside option. But they show that only regulators with poor screening technology will resolve the adverse selection problem: better regulators prefer not to separate good from bad bankers as this would involve shrink the banking sector more than is desirable. Thus our assumption that screening using capital requirements does not occur is robust to the use of a more general setting for appropriate parameter ranges.

[25] Without loss of generality we consider the case where all the proceeds from this tax are paid out to the non-participating banks, since this allows the largest possible "bribe" and thus the greatest chance of separation.

that this intuition extends even to the case where capital requirements are tightened so that the MIC is slack: if a sound agent is willing to run a bank, an unsound agent will also wish to do so. The single crossing condition runs in the wrong direction. Intuitively, the only way to support an equilibrium where only sound agents run banks is if the number of the number $(1-g)\,\mu$ of unsound bankers receiving subsidies is sufficiently low, so that if one agent elects to stop taking deposits he will significantly reduces the per agent subsidy for not banking and thus prefers not to do so. This is obviously impossible if the number of banks is large enough. Lemma 7 provides a sufficient condition for cross subsidisation schemes to be ineffective.

LEMMA 7 *Cross subsidisation schemes cannot separate sound from unsound bankers when condition 15 is satisfied.*

$$(1-g)\,\mu > \frac{(R\Delta p - C)\,p_H}{Cp_L}. \tag{15}$$

Proof. A cross subsidisation scheme which resolves the adverse selection problem must render deposit taking incentive compatible for sound bankers. Suppose that all sound bankers elect to take deposits. If one sound banker deviates then the total tax subsidy per non deposit taking banker is $\frac{g\mu-1}{(1-g)\mu+1}\tau_B$. The deposit taking IC constraint for sound bankers is therefore given by equation 16:

$$\{[R+(k-1)\,Q]\,p_H - Ck\}\,(1-\tau_B) \geq \left(1+\frac{g\mu-1}{(1-g)\,\mu+1}\tau_B\right)(Rp_H - C). \tag{16}$$

A successful cross subsidisation scheme must in addition render non-deposit-taking incentive compatible for unsound bankers:

$$[R+(k-1)\,Q]\,p_L\,(1-\tau_B) \leq \left(1+\frac{g}{1-g}\tau_B\right)Rp_L. \tag{17}$$

Rearranging these equations yields the following constraint upon τ_B:

$$\frac{(k-1)\,(Qp_H - C)}{[R+(k-1)\,Q]\,p_H - Ck + \frac{g\mu-1}{(1-g)\mu+1}\,(Rp_H - C)} \geq \tau_B \geq \frac{(k-1)\,Qp_L}{[R+(k-1)\,Q]\,p_L + \frac{g}{1-g}Rp_L}.$$

Cross multiplying the outside terms in this expression and rearranging yields the following necessary condition for a suitable tax rate τ_B to exist:

$$-CR\,[(1-g)\,\mu+1] + CQ\mu\,(1-g) + QRp_H \geq 0. \tag{18}$$

Note that, if separation occurs, the depositors' IT constraint reduces to $Q \leq R\Delta p/p_H$. So a sufficient condition for a separating equilibrium not to exist is for condition 18 to be violated when $Q = R\Delta p/p_H$. In other words, for condition 19 to be satisfied:

$$-Cp_H\,[(1-g)\,\mu+1] + C\mu\,(1-g)\,\Delta p + R\Delta p p_H < 0. \tag{19}$$

Rearranging this expression yields equation 15. □

In fact, even if an equilibrium exists in which sound agents run banks and unsound agents do not, it may be only one of many:

LEMMA 8 *In a neighbourhood of the MIC constraint, if a cross-subsidisation equilibrium exists in which each of the $g\mu$ banks is sound, then provided depositors' IR constraints are satisfied, any number of sound banks is sustainable through a cross-subsidisation equilibrium.*

Proof. In the appendix □

Lemma 8 indicates that, even when a good equilibrium can be supported by cross-subsidisation, there is no particular reason to suppose that this is the equilbrium which will arise. The results of this section suggest that attempting to separate out bank types by combining capital requirements and cross-subsidisation schemes is not likely to form the basis of effective policy. Given the adverse selection problem, the regulator cannot separate bank types and rather than subsidising non-entrants is best off providing a deposit insurance subsidy to all banks which choose to enter, as we have assumed in deriving the results of previous sections. For similar reasons we conjecture that it cannot be optimal to charge a licence fee to those wishing to run a bank.

6.3. Voluntary Deposit Insurance Schemes and Coinsurance

Coinsurance schemes between banks have operated in the past with varying degrees of success (see for example Calomiris (1990), Calomiris and Schweikart (1991), Kumbhakar and Wheelock (1995)). Under such schemes bankers form clubs to insure their members, with strict entry requirements designed to ensure quality of membership. Such clubs are ineffective in a model such as ours where agents are asymmetrically informed. Since unsound bankers are less likely than sound ones to be required to pay out under such schemes, they have stronger incentives to enter them than sound bankers.[26] Screening of members through the imposition of capital requirements cannot succeed for the reasons outlined in section 6.1. Similarly, willingness to enter a voluntary deposit insurance schemes cannot itself serve as a separation device. (We assume that a voluntary scheme does not receive any net subsidy from outside the scheme; we considered schemes involving cross-subsidisation in the previous subsection). In our model, the general public would never wish to deposit in an unsound bank if they knew its type, so unsound banks will simply mimic the decision of sound banks in entering a voluntary scheme or not. Since this is a signalling game, whether any bank joins a voluntary deposit scheme depends on the general public's off-the-equilibrium-path beliefs about the type which is most likely to join. An equilibrium where all join would be sustained by beliefs that any bank outside the scheme is an unsound bank; an equilibrium where no one joins would be supported by beliefs that joiners are unsound types. In our model of risk-neutral agents, voluntary deposit insurance schemes, since they cannot function as screening devices, do not serve any useful purpose. Having banks pay a fee to enter the scheme which is then paid out to depositors of the failing institutions in the scheme is equivalent to taxing bankers to pay for deposit insurance in our earlier model, and is thus welfare-neutral.

More generally, one might expect coinsurance schemes to arise when bankers are better able to learn about one another than is the regulator (see Rochet and Tirole (1996) for a model where banks monitor one another). Our model indicates a possible reason why private schemes have in the

[26] For evidence that this was indeed the case for the deposit insurance scheme which operated in Kansas 1909-1929, see Kumbhakar and Wheelock (1995).

last half century or so been replaced by schemes funded through public taxation. We have argued that deposit insurance is most effective when it is not funded by bankers: that deposit insurance should instead be funded through general taxation. One would therefore expect a state-operated deposit insurance scheme to crowd out less efficient private schemes.

7. Other Extensions and Discussion of Related Literature

7.1. Deposit Insurance and Banking Crises

Examination of propositions 2 and 3 and lemma 4 shows that independently of how deposit insurance funds are invested and when taxes are levied, the optimal level of deposit insurance will be decreasing in the quality of the banking system:

Corollary 9 *The tax rate τ and hence the optimal size of the deposit insurance fund is decreasing in banking sector quality g.*

This result may help us reconcile the increasing popularity of deposit insurance schemes with recent findings in the empirical literature that deposit insurance schemes seem to be associated with reduced banking sector stability (see for example Demirgüç-Kunt and Detragiache (1998), Demirgüç-Kunt and Kane (2002) and Barth, Caprio and Levine (2002)). In our model, a system with a lower fraction of sound banks g is more likely to experience widespread failures (which in most empirical models would be classified as a banking crisis). But it is precisely in such systems that depositors are most reluctant to invest their funds in banks. Therefore optimal policy calls for larger deposit insurance subsidies in countries where the banking system is weaker.[27] So one would expect to see a positive association between the generosity of deposit insurance and the occurence of banking crises in the data, without this necessarily implying that one is causing the other. Rather, a lack of regulatory resources for screening and monitoring banks and enforcing capital regulations, or a weak regulatory environment, may cause banking sector instability and at the same time make a generous deposit insurance scheme optimal.[28] For example (Cargill, 2002), the Japanese government responded to financial sector fragility by announcing in 1996 an explicit 100% government guarantee on all deposits, which was withdrawn in stages between April 2002 and April 2003.

7.2. Recapitalisations

An alternative to using the money raised though the deposit insurance fund to pay out depositors would be to use it to augment banks' capital through an ex ante subsidy. One could consider such a policy to be a 'recapitalisation' of banks. Given the irrelevance of the timing of the deposit insurance

[27] Of corse, our model assumes that regulators can be relied upon to act in the public interest. Demirgüç-Kunt and Kane (2002) argue that generous deposit insurance schemes may be problematic where corruption is rife and the rule of law is erratic, so that legal reform should accompany deposit insurance reform.

[28] To be more explicit, let the average quality of banks $g(a)$, be a function of the regulator's ability a to prevent unsound banks from getting licences. Then if countries with worse regulators (low a) have both worse quality banks and more banking crises, but deposit insurance is more likely to be adopted where it is most beneficial, then our model would predict a positive correlation between banking crises and deposit insurance, although deposit insurance would not be causing crises.

subsidy to banks (*ex post* versus *ex ante*) already proved, it should be clear that such a policy can be welfare-enhancing and substitute for the imposition of deposit insurance. General taxation could be used to collect funds to augment banks' capital and allow them to expand to absorb remaining funds without violating their monitoring incentive compatibility constraints. (Note that for the usual reasons, recapitalisations using funds drawn from the banking sector itself will be ineffective, at least in our model where all banks are symmetrically placed.) In our stripped down model of risk-neutral depositors, recapitalisations and deposit insurance serve exactly the same purpose, and so the choice between them must be one of political expediency. It would be interesting to see in a richer model which factors should lead a government to choose recapitalisation over deposit insurance[29] - we leave this question to further research.

7.3. Deposit Insurance, Banking Competition and Capital Requirements

In our model, the presence of binding capital requirements means that there is no competition between banks for deposits.[30] A bank cannot attract too many deposits relative to its own start up capital because if it were to do so, it would violate its monitoring incentive compatibility constraint. It could not credibly commit to monitoring and earning a high expected return, and so would be shunned by depositors and/or closed or forced to reduce its borrowing by the regulator. Because banks cannot expand deposits beyond this threshold, if there is not enough banking capital μ relative to potential depositors N, deposits will be rationed - depositors have more funds available to deposit than banks are able to accept.[31] In this environment, which is precisely the environment where deposit insurance is useful in our model, there is no reason for banks to compete for deposits.[32] The effect of subsidised deposit insurance is then benign. It would be interesting to extend the model to examine to what extent this would hold true if banks did compete for deposits. Interestingly, Keeley (1990) argues that an important factor behind the US Savings and Loan debacle of the 1980s was an increase in competition between banks and thrifts. He argues that, as in our model, the deposit insurance scheme worked very well during the decades when competition was limited, and shows empirically that a proxy for increased competition is associated with a higher probability of bank failure. Hellman et al. (2000) argue similarly that financial liberalisation was a major culprit in the banking crises of the 1990s. Their model assumes that depositors are 100% insured, and so do not care about the fact that banks offering higher returns are also more risky.[33] They show in this environment that capital requirements are insufficient to prevent excessive risk-taking without also implementing deposit rate ceilings to limit banking competition. We conjecture that it may be socially preferable in their environment simply to reduce the level of deposit insurance protection

[29] Sweden, for example, had no explicit system of deposit insurance, but rather recapitalised its banks after the banking crisis of the early 90s. Following EU guidelines, it then introduced a system of explicit deposit insurance in 1996 (see e.g. "Cleaning up", *The Economist*, June 28, 1997).

[30] Acharya (2002) also has this feature. Essentially, the flipside of banks' capital requirements binding is that depositors would like to deposit more than banks are able to accept, so there is no reason for banks to compete for deposits.

[31] The deposit rate does not fall because this would violate depositors' individual rationality constraint.

[32] As mentioned in section 2 above, if $\frac{\mu}{N}$ were large enough that there were no deposit rationing, deposit insurance would have no impact in our model.

[33] For evidence that depositors do in fact care about the level of risk taken by banks, and that the market discipline they exert is reduced by the introduction of deposit insurance, see Demirgüç-Kunt and Huizinga (2004).

from a super-optimal level.

8. Concluding Remarks

We have developed a model in which bankers play a socially useful role in monitoring investments to improve their productivity, but where these banking services are subject to both adverse selection and moral hazard. We have shown that in this set-up, deposit insurance is welfare enhancing *to the extent that it constitutes a net subsidy to the banking system.* This result runs contrary to the received wisdom that deposit insurance should be financed through the contributions of banks, and that the objective of the deposit insurance fund should be to minimise losses to the taxpayer.[34] The reason the result arises is that in the presence of moral hazard, banks must earn rents if they are to perform monitoring. Depositors do not value the rents which accrue when they deposit, so as a consequence the banking system will be socially too small unless the regulator can provide some additional incentive to deposit. Taxing bankers and then paying this back to depositors in the case of ex post failure - as has traditionally been advocated - is at best a welfare-neutral policy brecause it has the adverse effect of reducing the banks' capital base, making moral hazard more likely. Similarly, a tax upon depositors acts to reduce their investable funds and to deter them from investing. When the proceeds of the *ex ante* taxation are invested productively, we have demonstrated that each of these negative effects exactly balances the positive incentive effects of deposit insurance. Taxation of those agents who choose to remain outside the banking system ('self managers') has neither of these adverse side-effects however, and hence increases welfare. Funding the deposit insurance scheme through *general* taxation is therefore welfare-enhancing since its net impact is on taxpayers who are neither depositors nor bankers.

We have used a stripped down model in which the need for deposit insurance arises not from depositor risk aversion or the possibility of banking panics, but purely from the existence of informational problems - adverse selection and moral hazard - within the banking sector. Thus in contrast to much of the previous literature, we are able to derive comparative statics as to optimal policy with respect to deposit insurance. We show that as the level of public confidence in the banking sector falls, so that depositors are more inclined to withdraw their funds from the banking sector, the regulator should counter this tendency with a more generous deposit insurance scheme. This was what happened in Japan. Worse regulators should provide more generous deposit insurance, a result which may go some way towards an understanding of why on the one hand deposit insurance seems to be associated with banking crises (see Demirgüç-Kunt and Detragiache (1998) and Demirgüç-Kunt and Detragiache (2002)), yet on the other such schemes are being widely adopted across the world and increasingly recommended as part of good practice (see for example Garcia (1999) and references therein).

[34] See e.g. Mishkin's (2001, p301) description of the goals of the Federal Deposit Insurance Corporation Improvement Act.

Appendix

Proof of Lemma 8

Note that a cross-subsidisation equilibrium exists with $g\mu$ banks of which any number are sound provided depositors wish to deposit, monitoring is incentive compatible, and the following conditions are satisifed:

$$\begin{aligned}\left(1+\frac{g\mu-1}{(1-g)\,\mu+1}\tau_B\right)(Rp_H-C) &\leq \{[R+(k-1)\,Q]\,p_H-Ck\}\,(1-\tau_B)\\ &\leq \left(1+\frac{g}{1-g}\tau_B\right)(Rp_H-C)\,; \end{aligned} \tag{20}$$

$$\left(1+\frac{g\mu-1}{(1-g)\,\mu+1}\tau_B\right)Rp_L \leq [R+(k-1)\,Q]\,p_L\,(1-\tau_B) \leq \left(1+\frac{g}{1-g}\tau_B\right)Rp_L. \tag{21}$$

The first inequality in equation 20 and the second in 21 state that a sound bankers and unsound non-bankers do not choose to change their roles. To prove the lemma, we need to demonstrate that they imply the second inequality in equation 20 and the first in 21: these state respectively that sound non-bankers and unsound bankers do not choose to deviate, either.

The sound banker non-deviation condition reduces to

$$(k-1)\,(Qp_H-C)\,(1-\tau_B) \geq (Rp_H-C)\,\tau_B\frac{\mu}{(1-g)\,\mu+1};$$

the unsound banker non-deviation condition is

$$(k-1)\,Qp_L 1-\tau_B \geq Rp_L\tau_B\frac{\mu}{(1-g\mu+1)}.$$

Given the former condition, a sufficient condition for the latter is

$$(k-1)\,(1-\tau_B)\,(Q\Delta p-C) \leq \tau_B\,(R\Delta p-C)\,\frac{\mu}{(1-g)\,\mu+1}. \tag{22}$$

Similarly, a sufficient condition given non-deviation by unsound non-bankers for non-deviation by sound non-bankers is

$$(k-1)\,(1-\tau_B)\,(Q\Delta p-C) \leq \frac{\tau_B}{1-g}\,(R\Delta p-C)\,. \tag{23}$$

We know from the MIC constraint that $(k-1)\,(1-\tau_B)\,(Q\Delta p-C) \geq -(R\Delta p-C)\,(1-\tau_B)$. So in a close enough region to the MIC line (where this expression holds with equality), conditions 22 and 23 are satisfied.

References

Acharya, V. V. (2002), 'Is the International Convergence of Capital Adequacy Regulation Desirable?', *Journal of Finance,* Forthcoming.

Barth, J. R., G. Caprio and R. Levine (2002), Bank Regulation and Supervision: What Works Best?, Working Paper w9323, National Bureau of Economic Research, Cambridge, Mass.

Bhattacharya, S. (1982), 'Aspects of Monetary and Banking Theory and Moral Hazard', *Journal of Finance*, Vol. 37, No. 2 (May), pp. 371 – 84.

Calomiris, C. W. (1990), 'Is Deposit Insurance Necessary? A Historical Perspective', *Journal of Economic History*, Vol. 50, No. 2 (June), pp. 283 – 295.

——— and L. Schweikart (1991), 'The Panic of 1857: Origins, Transmission, and Containment', *Journal of Economic History*, Vol. 51, No. 4 (December), pp. 807 – 834.

Cargill, T. (2002), Japan Passes Again on Fundamental Financial Reform, Economic Letter 2002-28, Federal Reserve Bank of San Fransisco, San Fransisco, CA.

Chan, Y., S. Greenbaum and A. Thakor (1992), 'Is fairly priced deposit insurance possible?', *Journal of Finance*, Vol. 47, pp. 227–45.

Demirgüç-Kunt, A. and E. Detragiache (1998), The Determinants of Banking Crises: Evidence from Developed and Developing Countries, IMF Staff Papers 45, I.M.F., Washington, D.C.

——— and ——— (2002), 'Does Deposit Insurance Increase Banking System Stability? An Empirical Investigation.', *Journal of Monetary Economics*, Vol. 49, No. 7 (October), pp. 1337 – 1371.

——— and E. J. Kane (2002), 'Deposit Insurance Around the Globe: Where Does It Work?', *Journal of Economic Perspectives*, Vol. 16, No. 2 (Spring), pp. 175 – 195.

——— and H. Huizinga (2004), 'Market Discipline and Deposit Insurance', *Journal of Monetary Economics*, Vol. 41, No. 2 (March), pp. 375 – 399.

——— and T. Sobaci (2001), 'Deposit Insurance Around the World: A Database', *World Bank Economic Review*, Vol. 15, No. 3, pp. 481 – 490.

Diamond, D. W. (1984), 'Financial Intermediation and Delegated Monitoring', *Review of Economic Studies*, Vol. 51, pp. 393–414.

——— and P. Dybvig (1983), 'Bank Runs, Deposit Insurance and Liquidity', *Journal of Political Economy*, Vol. 91, pp. 401–19.

Federal Deposit Insurance Corporation (2004), *Annual Report*, FDIC, Washington DC.

Freixas, X. and J.-C. Rochet (1997), *Microeconomics of Banking*, MIT, Cambridge, Mass.

Freixas, X. and J.-C. Rochet (1998), 'Fair Pricing of Deposit Insurance. Is It Possible? Yes. Is It Desirable? No.', *Research in Economics*, Vol. 52, No. 3 (September), pp. 217 – 32.

Garcia, G. G. H. (1999), Deposit Insurance: A Survey of Actual and Best Practices, Working Paper WP/99/54, International Monetary Fund, Washington, D.C.

Hellman, T. F., K. C. Murdock and J. E. Stiglitz (2000), 'Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough?', *American Economic Review*, Vol. 90, No. 1 (March), pp. 147 – 165.

Holmström, B. and J. Tirole (1997), 'Financial Intermediation, Loanable Funds and the Real Sector', *Quarterly Journal of Economics*, Vol. 112, No. 3 (August), pp. 663 – 691.

Keeley, M. (1990), 'Deposit Insurance, Risk, and Market Power in Banking', *The American Economic Review*, Vol. 80, No. 5, pp. 1183 – 1200.

Kim, D. and A. Santomero (1988), 'Risk in Banking and Capital Regulation', *Journal of Finance*, Vol. 43, No. 5, pp. 1219–1233.

Kumbhakar, S. C. and D. C. Wheelock (1995), 'Which Banks Choose Deposit Insurance? Evidence of Adverse Selection and Moral Hazard in a Voluntary Insurance System.', *Journal of Money, Credit, and Banking*, Vol. 27, No. 1 (February), pp. 186 – 201.

Matutes, C. and X. Vives (1996), 'Competition for Deposits, Fragility, and Insurance', *Journal of Financial Intermediation*, Vol. 5, pp. 184 – 216.

Merton, R. C. (1977), 'An Analytic Derivation of the Cost of Deposit Insurance and Loan Guarantees: An Application of Modern Option Pricing Theory', *Journal of Banking and Finance*, Vol. 1, No. 1 (June), pp. 3 – 11.

——— (1978), 'On the Cost of Deposit Insurance When There are Surveillance Costs', *Journal of Business*, Vol. 51, No. 3, pp. 439 – 452.

Mishkin, F. S. (2001), *The Economics of Money, Banking, and Financial Markets*, 6th edn, Addison-Wesley, New York.

Morrison, A. D. and L. White (2002), Crises and Capital Requirements in Banking, Working Paper 2002-FE-05, Oxford Financial Research Center, University of Oxford.

Nagarajan, S. and C. W. Sealey (1995), 'Forebearance, Deposit Insurance Pricing, and Incentive Compatible Bank Regulation', *Journal of Banking and Finance*, Vol. 19, No. 6 (September), pp. 1109 – 1130.

Penati, A. and A. Protopapadakis (1988), 'The Effect of Implicit Deposit Insurance on Banks' Portfolio Choices with an Application to International 'Overexposure'', *Journal of Monetary Economics*, Vol. 21, No. 1 (January), pp. 107 – 126.

Pennacchi, G. G. (1987), 'A Reexamination of the Over- (or Under-) Pricing of Deposit Insurance', *Journal of Money, Credit, and Banking*, Vol. 19, No. 3 (August), pp. 340 – 360.

Rochet, J.-C. and J. Tirole (1996), 'Interbank Lending and Systemic Risk', *Journal of Money, Credit and Banking*, Vol. 28, No. 4, pp. 733–762.