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Bank Capital Adequacy versus Deposit Insurance

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Abstract

This paper re-evaluates the Diamond-Dybvig analysis of deposit insurance by constructing a model in which an agent not in need of liquidity sets up a financial intermediary to sell liquidity insurance to other agents who desire such insurance. This intermediary resembles a real-world bank in that it is financed by both demand deposits and equity. It also dominates the Diamond-Dybvig intermediary, which is funded only by demand deposits. Provided the intermediary has adequate capital, it also is perfectly safe. Deposit insurance then is both unnecessary and incapable of achieving a superior outcome to that which private agents could achieve on their own.

Key words: bank capital adequacy, deposit insurance

1. Introduction

Despite its major shortcomings as revealed in recent years, most economists still believe that government deposit insurance has a useful role to play in promoting the stability of the banking industry. This belief goes back to the view that banking is ''inherently'' unstable, so government support is needed to reassure depositors who otherwise would be prone to run on their banks. The seminal statement of this view is by Diamond and Dybvig (DD; 1983), who built a model that, with various modifications, has since become standard.[1] In their model, agents face individual liquidity risk, but aggregate liquidity needs (at least partially) are predictable. Agents therefore form an intermediary to pool their liquidity risks. However, this arrangement has a problem: The agents who do not need liquidity might ''panic'' and demand payment prematurely, in which case the intermediary would face a damaging run. DD suggest that this outcome could be avoided if the government provided those agents with a guarantee (which DD interpret as a form of deposit insurance) that they would be paid in full. Agents then would have no reason to run and the intermediary would be safe.

This paper presents a stylized version of the DD model that calls into question this conventional view of banking instability and deposit insurance.[2] The paper addresses a shortcoming of the DD analysis, which models intermediaries as having only one source of finance, making the DD intermediaries more like mutual funds than banks. Indeed, these DD intermediaries are odd even as mutual funds, since the nominal value of their liabilities is fixed, yet they have no capital to absorb any shocks to their portfolios and thus maintain their ability to honor their deposits in full.

There also is a serious problem with the analysis itself. The proportion of agents who face positive liquidity shocks, t, needs to be stochastic to make the analysis interesting.

However, if t is stochastic, the DD intermediary will not know the actual value of t until all the agents who want to withdraw early have already done so, in which case, presumably it is too late to make payments conditional on the realized value of t. The obvious alternative is to make payments conditional on *expected* t, but in this case, the DD intermediary would have total liabilities that exceed its total assets whenever the actual value of t exceeds its expected value. The mere possibility that this *might* occur then undermines the intermediary's ability to provide credible insurance. The problem is not so much that the DD intermediary faces instability, as DD themselves suggest, but that it has no clear reason to exist in the first place.

An alternative involves bringing some *other* agent(s) into the model to provide liquidity insurance. If the new agents know that they face no consumption risk, then under plausible circumstances they will offer the DD depositors insurance against their own individual liquidity risk in return for adequate premiums. They provide insurance by setting up their own financial intermediary. This intermediary would issue demand deposits to the other agents, while issuing a residual claim, equity, to the new agents. The intermediary therefore resembles a real-world bank financed by both deposits and equity. Furthermore, provided it has enough equity, it can guarantee all its deposits against default risk. My model thus formalizes the notion of bank capital adequacy, while also suggesting that banking without deposit insurance is more stable than the DD model would suggest.[3]

2. Diamond and Dybvig reconsidered

2.1. A stylized Diamond and Dybvig intermediary with no aggregate consumption risk

Suppose initially that we have a large number of identical individuals, each of whom lives for three periods, 0, 1, and 2. In period 0, each individual is endowed with a unit of a good and decides how to invest it. This person faces an investment technology that for each unit invested in period 0, yields 1 unit of output in period 1 or, if left till then, $R > 1$ units of output in period 2. When period 1 arrives, each agent receives a signal telling the period in which he or she wants (or will want) to consume, with some (the type I agents) wishing to consume only in period 1 and the others (the type II agents) wishing to consume only in period 2. The type Is therefore will liquidate and consume all the proceeds of their investment in period 1, but the type IIs have to decide whether to retain their initial investments until period 2 or liquidate their investments in period 1 and keep the proceeds until the next period. Storage from one period to another is costless and unobservable. An agent's type is not publicly observable, but the proportion of type I agents, t, initially is assumed to be fixed and known. I also follow Wallace (1988, p. 9) and assume that agents are isolated from each other in period 1, in the sense that those who collect their returns in period 1 do so at random instants during that period.[4]

Each agent maximizes the expected utility function:

$$E\{tU(c_1) + (1-t)U(c_2)\} \tag{1}$$

where c_1 is consumption in the first period and c_2 is consumption in the second period. Since the type Is would consume only in period 1 and the type IIs would consume only in period 2, c_1 and c_2 also can be regarded as the consumption of type I and type II agents, respectively. To make the analysis explicit, $U(\cdot)$ is assumed to take the following form:

$$U(c_i) = c_i^{1-\gamma}/(1-\gamma) \tag{2}$$

where i equals 1 or 2, and $\gamma > 1$.[5] $U(\cdot)$ thus exhibits constant relative risk aversion and has a risk aversion coefficient greater than 1. Agents seek to maximize their utility subject to the resource constraint

$$tc_1 + (1-t)c_2/R = 1 \tag{3}$$

which tells us how total consumption is limited by agents' initial investments and returns in each of the two periods (see also DD, 1983, p. 407).

One option is for agents to live in autarky. If they do, our assumptions about endowments and investment technology imply that the type Is would consume 1 unit and have ex post utility $U(1) = 1/(1-\gamma)$ and the type IIs would consume R units and have ex post utility $U(R) = R^{1-\gamma}/(1-\gamma)$. Ex ante (i.e., in period 0), an agent living autarkically therefore would expect the utility

$$tU(1) + (1-t)U(R) = t/(1-\gamma) + (1-t)R^{1-\gamma}/(1-\gamma) \tag{4}$$

However, since agents are risk averse, they would value an opportunity to insure themselves in period 0 against the ''unlucky'' event of turning out to be type I. Given that the proportion of type Is, t, is known in advance, it ought to be possible for our agents to come to some arrangement to diversify this risk among themselves. Assuming it can be arranged costlessly, the optimal insurance arrangement is found by maximizing (1) subject to (2) and the resource constraint (3). The optimal consumption levels in periods 1 and 2 then can be found from (3) and the first-order condition

$$U'(c_1)/U'(c_2) = R \tag{5}$$

which tells us that, in any optimum, the marginal rate of substitution between consumption levels in the two periods should equal the marginal rate of transformation, R. The optimum consumption levels turn out to be

$$c_1 = R^{(\gamma-1)/\gamma}/(1-t+tR^{(\gamma-1)/\gamma}), \qquad c_2 = R/(1-t+tR^{(\gamma-1)/\gamma}) \tag{6}$$

where

$$1 < c_1 < c_2 < R \tag{7}$$

The optimal insurance arrangement thus leads type I agents to have higher consumption than they would have obtained under autarky, while the type II agents get less than they would have under autarky; however, the type Is still end up with less than the type IIs because period-1 consumption has a higher opportunity cost (see also DD, 1983, p. 407).

One way to provide this insurance is for agents to form a financial intermediary in period 0. Instead of investing their endowments in their backyards, agents would deposit them with the intermediary, and the intermediary would invest them on their behalf. When agents' types are revealed in period 1, the intermediary would pay out more to those withdrawing in period 1 than the one unit they would have received had they invested autarkically, with the remainder being paid out to those who withdraw in period 2, who would get less than the R they would have received under autarky. This solution also satisfies a self-selection constraint (i.e., it induces type Is to withdraw (only) in period 1, and type IIs to withdraw (only) in period 2). No type I agent would ever wish to keep a deposit until period 2, because he or she benefits only from consumption in period 1. At the same time, no type II agent would withdraw prematurely, because the return from premature withdrawal would be less than the return from withdrawing later.

This intermediary also operates in period 1 under a sequential service constraint (i.e., it deals with requests for redemption in period 1 in a random order, until it runs out of assets). This constraint arises because of agents' isolation in period 1: Since agents collect their returns at random times within period 1, the intermediary must deal with their requests for redemption ''separately, one after the other'' (Wallace, 1988, p. 4). It follows, naturally, that any suggested arrangements must be consistent with the sequential service constraint.

2.2. The stylized Diamond and Dybvig intermediary in the presence of aggregate consumption risk

Unfortunately, the DD arrangement is not robust to uncertainty about t. Suppose we now assume that t is, say, a uniform random variable that can take any value between 0 and 1 with equal probability. The uncertainty about t means that contractual payments cannot now be made conditional on the realized value of t because (a) the sequential service constraint requires that depositors must be dealt with sequentially, and (b) the realization of t cannot be known until all period 1 withdrawals have been completed. The intermediary does not know what to pay each depositor until they have all gone and it is too late to do anything about it. Consequently, it is not possible to condition any insurance arrangement on the realized value of t.

Suppose, then, that our intermediary were to offer agents insurance contracts along earlier lines, but with payments now conditional on t^e (which is equal to 0.5) rather than t:

$$c_1 = R^{(\gamma-1)/\gamma}/(1 - t^e + t^e R^{(\gamma-1)/\gamma}), \qquad c_2 = R/(1 - t^e + t^e R^{(\gamma-1)/\gamma}) \tag{8}$$

Using (8) rather than (6) to determine payouts, the intermediary would pay out tc_1 to agents withdrawing in period 1, leaving $(1 - tc_1)$ at the end of the period. It then would make a gross return of $(1 - tc_1)R$ in period 2, from which it would have to pay out $(1 - t)c_2$ to those withdrawing that period. A little manipulation then shows that its net profit is

$$\Pi = R(t - t^e)(1 - R^{(\gamma-1)/\gamma})/(1 - t^e + t^e R^{(\gamma-1)/\gamma}) \tag{9}$$

Since $R^{(\gamma-1)/\gamma} > 1$, the net profit is positive if $t < t^e$ and negative if $t > t^e$.

But a new problem now becomes apparent: If $t > t^e$, the intermediary's promised payments exceed the return on its investments, and the intermediary cannot make its contractual payments—and this means that it cannot offer credible insurance. (By contrast, the intermediary *could* offer credible insurance before, precisely because t was deterministic: The deterministic t meant that the intermediary knew its future payments and knew that it could make them.) A type II depositor cannot now be confident of the promised return from waiting until period 2 to redeem the deposit and so may rationally decide to ''play it safe'' by redeeming the deposit in period 1 and keeping it under the mattress until he or she consumes it in period 2. In other words, the self-selection constraint no longer holds, and type II investors may rationally decide to run on the intermediary in period 1. Indeed, if agents expect the type II agents to run in period 1, they would have no reason to leave deposits with the intermediary in the first place.[6]

The DD solution is for an outside party, the government, to guarantee the intermediary's payments to those withdrawing in period 2 (DD, 1983, pp. 413–416). Type II agents then would have no reason to run, the self-selection constraint would be satisfied, and the intermediary could provide optimal insurance. However, this ''solution'' is not feasible if we take investors' isolation seriously: If the deposit insurance guarantee is to work, the government must credibly promise that depositors who keep their deposits till period 2 will get repaid in full. Yet, the only available resources are those the intermediary has already paid out to agents who have withdrawn in period 1, and the government can get access to these resources only if it has some means of overcoming the sequential service constraint, which in turn implies that the government has the means to overcome the period-1 isolation that gives rise to this constraint in the first place. If we take the isolation assumption seriously, the government has no way of providing credible deposit insurance—and the DD solution is not feasible (see also, e.g., Wallace, 1988).[7]

3. A ''real-world'' bank

A more fruitful approach is to consider another way for investors to obtain the insurance they want. If depositors cannot provide such insurance themselves, the obvious alternative is for some *other* agents to provide it. Suppose, then, that we add a third type of agent to our model, a type III agent. This new agent is endowed with an amount K for each depositor and differs from them by already knowing in period 0 that he or she will want to consume (only) in period 2. (This latter condition makes it easier for the type III agent to commit to postponing consumption until period 2.) This person, too, has the option of investing in the backyard and, by doing so, knows that he or she would get a return of KR (per depositor) in period 2. The issues involved are seen most easily if we initially suppose that the type III agent is risk neutral, but I relax this assumption later.

The question is whether a type III agent would wish to use the endowment to provide aggregate consumption insurance to the other agents. To answer this question, we need to establish whether the agent could charge an insurance premium p for these services that would be high enough to induce that person to sell insurance, but low enough to make it worth their while for the other agents to buy insurance from him or her.

3.1. A risk-neutral type III agent

The analysis is very straightforward if our type III agent is risk neutral. Suppose the agent sets up a bank and offers investors the same optimum returns as earlier, minus a charge p.

(We assume for convenience that this charge is deducted from the deposit repayment.) The agent's return in period 2 would be the sum of the return on his or her own capital, KR, the same net profit Π we had earlier, and the charge p. Given that (9) implies that the expected value of Π is 0, a risk-neutral banker would choose to set up a bank—that is, choose the uncertain return $(KR + \Pi + p)$ over the certain return KR—for any positive value of p. Any inducement, however small, will lead our type III agent to set up a bank.

3.2. A risk-averse type III agent

What happens if the type III agent has the same aversion to risk as the other agents? In this case, it is easy to show that, by setting up the bank, the type III agent accepts a gamble on the realization of t, the expected utility from which is

$$EU = \int_{t=0}^{t=1} p(t)U(KR + \Pi_t + p)\mathrm{d}t \tag{10}$$

Assuming that t is distributed uniformly over the interval $[0, 1]$, we substitute (9) into (10) and rearrange to obtain

$$EU = [1/(1-\gamma)] \int_{t=0}^{t=1} (\alpha + \beta t)^{1-\gamma}\mathrm{d}t \tag{11}$$

where:

$$\alpha = KR + p - t^e R(1 - R^{(\gamma-1)/\gamma})/(1 - t^e + t^e R^{(\gamma-1)/\gamma}) \tag{12a}$$

$$\beta = R(1 - R^{(\gamma-1)/\gamma})/(1 - t^e + t^e R^{(\gamma-1)/\gamma}) \tag{12b}$$

We then integrate (11) and obtain

$$EU = [(\alpha + \beta)^{2-\gamma} - \alpha^{2-\gamma}]/[\beta(1-\gamma)(2-\gamma)] \tag{13}$$

For the agent to accept the gamble and establish the bank, the expected utility in (13) must exceed the person's autarky utility level $(KR)^{1-\gamma}/(1-\gamma)$. Some numerical simulations then suggest that, provided the type III agent has sufficient capital,[8] there always exist values of p that would make the depositors and the type III agent better off with a bank than under autarky.[9] A bank always would be in everyone's interest, provided the type III agent has enough capital.

3.3. Capital adequacy

The analysis thus far presupposes that the bank is able to guarantee its promised payments, and we need to check that this is the case. To guarantee its payments, the bank must have enough capital to cover its losses in the worst-case scenario. The worst-case scenario in our model is where every depositor decides to redeem in period 1. Given that the bank would have to pay out c_1 to each depositor who withdraws in period 1, but would make a return of only 1 on each such deposit, the worst possible loss the bank could face is $c_1 - 1$ per depositor. The bank therefore can guarantee all its commitments only if the type III agent's capital per depositor, K, is at least as great as this maximum possible loss:

$$K \geq c_1 - 1 = [R^{(\gamma-1)/\gamma}/(1 - t^e + t^e R^{(\gamma-1)/\gamma})] - 1$$
$$= (R^{(\gamma-1)/\gamma} - 1)(1 - t^e)/(1 - t^e + t^e R^{(\gamma-1)/\gamma}) \quad (14)$$

Equation (14) gives us a capital adequacy condition (see also Dowd, 1993, p. 366) or Eichberger and Milne, 1990, p. 19). Provided the bank's capital satisfies (14), the bank always can meet its commitments and depositors can be fully confident of being repaid.[10] The bank's contracts then are fully credible and there is no reason for a type II agent ever to run. Even if a type II agent expected all other agents to redeem in period 1, it still would be rational to wait until period 2 because the return would be higher. He would therefore wait. Other type IIs are just like this one, so they would wait as well. A run therefore would never occur, and the only agents who would redeem in period 1 are the type I agents who should redeem in that period anyway.

4. Conclusions

An intermediated arrangement is feasible in a DD-like environment, provided one or more additional agents are able and willing to commit the resources needed to ensure that the intermediary can honor its obligations. This intermediary would be similar to a real-world bank and would issue demand deposits, which would be redeemable on demand and fixed in nominal value, and a residual claim, held by the type III agent(s), which would be similar to real-world bank equity. By contrast, the DD model predicts the existence of a peculiar type of mutual organization that we seldom observe in the real world but does *not* predict the existence of banks as such. It therefore cannot provide a rationale for real-world banking regulation or government deposit insurance.[11]

My model also explains the function of bank capital—bank capital is a device to give depositors rational confidence in the bank. This explains why bankers traditionally have placed so much emphasis on bank capital, an emphasis that makes no sense in traditional DD models, which deal only with mutual institutions. My model also suggests that there need be no bank stability problem provided a bank has sufficient capital. It therefore is not surprising that banks are the dominant form of intermediary and that intermediaries like the DD one rarely, if ever, arise.

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Notes

1. For some perspectives on the Diamond-Dybvig literature, see, e.g., Chant (1992), Selgin (1993), or the survey in Dowd (1992).
2. The model is a stylized version of the DD model. It is based on theirs to facilitate comparison but differs in two significant ways: It assumes a more explicit utility function to derive clearer results and it invokes Wallace's ''isolation'' assumption to provide an underpinning for the sequential service constraint on which the existence of financial intermediation depends in this sort of environment. See also note 4.
3. This paper is not the first to question the DD rationale for deposit insurance, but previous papers, I believe, are less satisfactory. The first of these, Dowd (1988, 1993) is somewhat informal, and the other, Eichberger and Milne (1990), has a less desirable motivation for the existence of financial intermediaries than the present paper—it motivates them by assuming that small agents lack access to the investment technology—as well as a less complete treatment of the banker's optimization problem. It also has very little to say about the internal consistency of the DD model or deposit insurance, both of which are major themes of this paper.
4. This ''isolation assumption'' serves two functions: (1) It provides a ''friction'' in the economic environment that gives an intermediary an advantage over a credit market in period 1 (see, e.g., Jacklin, 1987; Wallace, 1988, p. 9). Without it, or something similar, the outcome obtainable by an intermediary also can be obtained by the credit market. There then would be no reason for agents to prefer an intermediary and therefore no reason to suppose that one would arise. (2) The isolation assumption provides a motivation for the sequential service constraint that plays an important role in the DD analysis but that DD assume rather than derive (DD, 1983, p. 408; see also Wallace, 1988, p. 3). This is important because the sequential service constraint turns out to be inconsistent with DD government deposit guarantee (see Wallace, 1988, pp. 3–4: and pp. 11 in this paper).
5. It also is necessary to impose the condition that $\gamma \neq 2$ to ensure that (13) later is determinate.
6. If investors leave deposits with the intermediary and the type IIs run, the average depositor will get an uncertain return of mean 1: Those who get there first get more than one unit each, and those who get there later get nothing. The average investor's implied expected utility then is less than the expected utility under autarky. If agents expect the type IIs to run, they would be better off investing autarkically and the intermediary would attract no depositors.
7. An alternative discussed in the DD literature is for the intermediary to suspend payments in certain circumstances (see, e.g., Jacklin, 1987, or Selgin, 1993). The knowledge that the intermediary can or would suspend payments then might reassure depositors that it was not about to run out of resources and so discourage a run from starting. I prefer to focus only on the way in which equity capital can discourage runs, in order to keep the paper as simple as possible, but exploring the relative merits of suspension clauses and equity capital as reassurance devices would be an interesting extension.
8. The explanation is that, as the capital rises, the type III agent becomes less absolutely risk averse and therefore more willing to take the risk; consequently, if capital is high enough, the type III agent always can be induced to become a banker at a price (i.e., premium) that the other agents are willing to pay.
9. Spreadsheet results also suggest that the amount of capital required can be high and usually is considerably more than is required to guarantee that the bank always can pay its depositors in full. To give an example, if $R = 2$ and $\gamma = 1.5$, then a premium of $p = 0.01$ is sufficient to make a bank worthwhile for everyone, but only provided the type III agent has around 0.7 units of capital for each depositor (i.e., provided the bank can satisfy a 70% capital-assets ratio).
10. The minimum adequate level of capital varies with the input parameters, but spreadsheet simulations suggest it usually is well under half of the amount the type III agent needs to be induced to become a banker. For example, if $R = 2$ and $\gamma = 1.5$, as in the last note, the minimum adequate capital ratio is 11.5%.
11. There is no room for welfare-improving government intervention in this model. There are three possible cases to consider, depending on the amount of capital the type III agent has. (a) If the capital is high enough to induce our type III agent to become a banker and make that bank capital-adequate, then our economic problem is solved and there is nothing the government can do to improve social welfare. (b) If the agent's capital is insufficient to induce that person to become a banker but more than enough to meet our capital adequacy condition (14), then the government can set up its own bank and use the type III agent's resources to capitalize it and guarantee deposit repayments. However, this makes the type III agent worse off than

under autarky, so this arrangement is not Pareto-superior to autarky. (c) Finally, if the type III agent lacks enough capital to satisfy (14), there is not enough capital for anyone to establish a capital-adequate (i.e., safe) bank, and a guarantee—governmental or otherwise—is impossible. Government intervention is redundant in the first case, fails the Pareto efficiency test in the second case, and is not feasible in the third.

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