Modeling Bank Deposit Insurance

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Abstract

We consider a model in which a government insurer guarantees the deposit liabilities of banks. In the basic specification it is assumed that the agents pay for the insurance via a lump-sum tax. Banks respond to the opportunity, implied by the possibility of failure, to shift losses to the deposit insurer by holding higher levels of risky assets than they would in the absence of deposit insurance. Their doing so increases the equilibrium price of risky assets. Weak banks are more likely to benefit from an insurance transfer, so they purchase risky assets from strong banks. Thus deposit insurance creates a tendency for risky assets to end up in portfolios of weaker banks.

We also determine the equilibrium when the deposit insurance program is financed using premia that are based either on deposit levels or on the bank’s holding of risky assets, rather than financed using lump-sum taxes. In both cases, with actuarially fair insurance, agents either have an incentive to create banks and take on maximal risk or not create banks at all. Neither financing method eliminates the moral hazard distortion.

In the absence of deposit insurance, bank depositors must monitor banks to ensure that they will have enough cash to execute transfers of funds when called upon to do so. Such monitoring can be expensive. Additionally, adverse shocks to the banking system can result in bank runs. In order to relieve depositors of monitoring costs and eliminate the risk of bank runs, many countries have instituted deposit insurance. However, deposit insurance entails risks of its own: when losses are large enough to lead to bank failure the downside is transferred from bank owners, creditors and depositors to taxpayers. With bankers enjoying all gains on investment but bearing only part of investment losses, it appears that they have an incentive to take on more risk than they would otherwise. This implication of deposit insurance was pointed out in the classic paper of Kareken (1990); see also Pyle (1984). One expects that

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this distortion of bankers’ incentives increases the equilibrium prices of risky assets, resulting in turn in excessive allocation of resources to risky projects. This is, of course, the classic moral hazard problem that accompanies insurance programs in which the insurer cannot completely monitor the behavior of the insured party: the insured party has diminished incentive to take actions that decrease the value of the insurance or—as here—increased incentive to take actions that increase the value of the insurance.

That this problem exists is widely understood. There are a number of investigations of bank deposit insurance, but it is difficult to find studies that formally model the effects of deposit insurance in an equilibrium context (however, see Suarez (1993)). We do so here; specifically, we assume that individual banks are competitive but also that the banking sector as a whole comprises the entire financial market.\(^1\) The setting is highly stylized, but it seems to us to capture the essentials of the problem. It is assumed that all risky assets are held by banks which have access to deposit insurance. This specification is obviously inaccurate, but the qualitative results should carry over to settings in which there exist other significant participants in financial markets, as long as the banking system is not negligibly small.

Analysis of bailouts of financial institutions deals with issues similar to those involved with deposit insurance. The principal difference is that, as the name implies, deposit insurance applies only to deposits, not to non-deposit liabilities such as bonds, or to equity. In contrast, the goal of bailouts is to avoid bankruptcy. In practice this implies that bank obligations to most creditors are guaranteed, not just deposits. Also, in bailouts enough support is supplied to assure that bank equity continues to maintain some value. With the appropriate modifications, the model to be presented can be used to analyze “too big to fail” and other topics related to bailouts.

Having in hand a formal model, we can list several conjectures related to deposit insurance and ascertain the validity of these conjectures in the context of our model.

- “If the cost of deposit insurance is borne by the taxpayer, banks will overvalue risky assets (relative to the case where there is no deposit insurance) to the extent that they have strictly positive probability of failing.” Our model exhibits this property.

- “When deposits are insured, weak banks will have a comparative advantage in holding risky assets, implying that they will purchase risky assets from strong banks.” Our model bears out this property as well. This occurs because deposit insurance enables banks to offload the lower-end tail of the risk to the taxpayer in the event of failure. Weak banks attach higher value than strong banks to this option. Therefore risky assets have more attractive payoffs when held by weak banks than by strong banks. Accordingly, deposit insurance creates a tendency for risky assets to end up in the portfolios of weaker banks.

\(^1\)Thus our specification is the opposite of that of Kareken and Wallace (1978), who analyzed deposit insurance in a setting in which the banking sector consists of a single monopolistic bank.
• “The moral hazard distortion induced by deposit insurance can be mitigated only if deposit insurance premia are levied on risky assets rather than liabilities, with higher premia charged for high-risk assets than for low-risk assets.” This conjecture is incorrect. Under either regime agents have an incentive either not to create banks, or to create banks and take as much risk as possible.

• “If insurance premia are based on deposits, they eliminate banks’ incentive to select risky portfolios if and only if the premium is actuarially fair”. In the banking literature this proposition is often stated as if its validity is self-evident. Contrary to this, we display examples in which deposit insurance is actuarially fair but in which the equilibrium relative prices of risky and riskless capital depend on whether agents create banks that have access to deposit insurance.

1 No Deposit Insurance

In this section a simple model without deposit insurance is specified. This model—in particular, the equilibrium prices of capital—will serve as a benchmark against which to compare the equilibrium prices of capital when banks issue insured deposits.

There are three dates: 0, 1 and 2. Each member of a continuum of agents has a date-0 endowment consisting of one unit of a riskless capital good and one unit of a risky capital good. The riskless capital good is costlessly storable from date 0 to date 2, when it transforms into one unit of a consumption good. At date 1 each agent’s holding of risky capital is subject to a multiplicative productivity shock $\varepsilon_1$, different for different agents, so that it becomes $\varepsilon_1$ units of capital at date 1. At date 2 another multiplicative shock $\varepsilon_2$ occurs. Thus the risky capital good transforms into $\varepsilon_1 \varepsilon_2$ units of the consumption good at date 2. The shocks $\varepsilon_1$ and $\varepsilon_2$ are uniformly distributed on the interval $[\underline{\varepsilon}, \bar{\varepsilon}]$, independently of each other and of the shocks of other agents. Agents consume at date 2 and are risk neutral.

In this setting agents have no motivation to form banks, but we nevertheless assume that they do so in order to provide a standard for comparison for the analysis of deposit insurance in the following sections. To ensure that the banking sector comprises the entire financial market, we rule out exchange of risky for riskless capital between agents and banks at all dates. In this section it is assumed that there is no deposit insurance. Each agent turns over his endowment of risky and riskless capital to a bank, receiving in exchange deposits $d$ and bank equity $e_0$ (of course, without loss of generality the agent could be assumed to sell his endowment to other agents in exchange for deposits at other banks; the adopted specification should be seen as a simplifying convention rather than a substantive restriction).

\footnote{For example, “...there is general agreement that deposit institutions were subsidized by below-market deposit insurance, creating moral hazard”, p. 147 of Guaranteed to Fail, Acharya et al. (2011).}
Table 1: Bank Balance Sheet at Date 0, No Deposit Insurance

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_0$ (capital)</td>
<td>$d$ (deposits)</td>
</tr>
<tr>
<td>1 (reserves)</td>
<td>$e = p_0 + 1 - d$ (equity)</td>
</tr>
</tbody>
</table>

Table 2: Bank Balance Sheet at Date 2, No Deposit Insurance

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon_1\varepsilon_2$ (capital)</td>
<td>$\min(Rd, \varepsilon_1\varepsilon_2 + 1)$ (deposits)</td>
</tr>
<tr>
<td>1 (reserves)</td>
<td>$\max(0, \varepsilon_1\varepsilon_2 + 1 - Rd)$ (equity)</td>
</tr>
</tbody>
</table>

The value (in units of date-2 consumption) of the bank’s assets is $p_0 + 1$, where $p_0$ is the unit price of risky capital, to be determined as part of the equilibrium. The date-0 bank balance sheet identity is $d + e_0 = p_0 + 1$. Agents determine the breakdown of $p_0 + 1$ into $d$ and $e_0$; the Miller-Modigliani theorem implies that agents will be indifferent to the breakdown, so we can take it as exogenous.

Depositors are paid a return $R$ at date 2 if $\varepsilon_1$ and $\varepsilon_2$ are such that the assets of the bank are worth at least $Rd$. Equity holders receive $\varepsilon_1\varepsilon_2 + 1 - Rd$. If the value of bank assets is insufficient to pay off depositors fully, then all the assets are paid out to the depositors. In this representative agent environment agents have no motivation to trade capital at any date, so in equilibrium each is willing to consume his own endowment of capital. The unit price of risky capital at date 0 that supports the equilibrium is $\left[\varepsilon_1 + \varepsilon_2\right]/2 = E(\varepsilon_2)$. The equilibrium return on deposits from date 0 to date 2 is the value of $R$ that satisfies $d = E[\min(Rd, \varepsilon_1\varepsilon_2 + 1)]$. Equity holders receive $\varepsilon_1\varepsilon_2 + 1 - \min(Rd, \varepsilon_1\varepsilon_2 + 1) = \max(\varepsilon_1\varepsilon_2 + 1 - Rd, 0)$. Thus the expected gross return on equity is 1, and the same is true for deposits.

We utilize a version of the law of large numbers to characterize the sample distribution of the shocks, implying that the realizations of $\varepsilon_1$ and $\varepsilon_2$ are uniformly
distributed, like the population distribution of each bank’s $\varepsilon_1$ and $\varepsilon_2$.\footnote{In appealing to “a version of the law of large numbers” we follow a standard practice in applied macroeconomics of sidestepping without discussion a difficulty involved in modeling sample outcomes generated by a continuum of realizations of independent random variables: the difficulty is that for any $Y \in [\underline{\varepsilon}, \bar{\varepsilon}]$ the set of realizations for the event $\varepsilon_1 \leq Y$ is nonmeasurable with probability 1, implying that the usual characterization of the cumulative distribution function $P(y) = \text{prob}(Y \leq y)$ is not available. Thus the simplest justifications for the law of large numbers do not apply. This problem was first pointed out by Judd (1985) and Feldman and Gilles (1985). Several methods can be used to justify the law of large numbers; see Uhlig (1996). Most simply and intuitively, in this setting the sample distribution of a finite number of independent draws converges to the uniform distribution as the number of draws becomes large. Therefore the appeal to the law of large numbers can be justified informally using a limiting argument. Duffie and Sun (2007, 2012) followed Feldman and Gilles in applying nonstandard analysis to demonstrate the limiting result rigorously.}

The bank balance sheets at dates 0 and 2 are shown as Tables 1 and 2.

2 Informal Analysis: Lump-sum Premia

We now modify the model by assuming that the bank regulator insures all bank deposits. It does this by supplying funds at date 2 in an amount sufficient to enable banks with low realizations of $\varepsilon_1$ and $\varepsilon_2$ to pay depositors fully. As in the preceding section, the bank regulator makes no payment to equity holders of insolvent banks.

It is easiest to begin by assuming that deposit insurance is financed via a lump-sum tax $t$; doing so enables us to separate the effects of deposit insurance from the effects of how the insurance is financed. The tax is levied against the date-2 consumption of all agents. It is assumed throughout that consumption sets are unbounded below as well as above, ensuring that agents will always be able to pay the tax. The tax is applied whether or not the agents choose to create banks, whether or not the banks hold risky assets, and whether or not the banks turn out to be insolvent. For individual agents, investment decisions do not affect the amount of the tax they pay (although, of course, the choices all agents make collectively determine $t$). Thus $t$ plays no role in determining agents’ choices of the deposit level at date 0 or capital transaction at date 1. The regulator sets the tax so that the revenue it generates is just sufficient to fund the payments to failed banks. In later sections we will relax the assumption of lump-sum taxes and consider how things change when the insurance premium is proportional to deposits, and also when it is proportional to the holding of risky assets.

As above, at date 0 each agent is assumed to be able to allocate all or part of his endowments of both risky and riskless capital to his bank. Recall that the exchange of risky for riskless assets between agents and banks is ruled out at all dates. So capital that is not allocated to banks at date 0 remains outside the banking sector at dates 1 and 2. As we will see, under lump-sum taxes each agent strictly prefers allocating his entire endowment to his bank relative to holding it to date 2 and consuming it
Table 3: Bank Balance Sheet at Date 0

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_0$ (capital)</td>
<td>$d$ (deposits)</td>
</tr>
<tr>
<td>$q_0$ (reserves)</td>
<td>$e = p_0 + q_0 - d$ (equity)</td>
</tr>
</tbody>
</table>

then.\(^4\) Each agent has the option of designating part of the value of the assets he turns over to the bank as deposits (subject to deposit insurance), with the remaining value being the equity. At date 1 banks realize productivity shocks $\varepsilon_1$, which are generally different for each bank. Existence of this heterogeneity motivates banks to trade capital at date 1. Banks do so because the value of deposit insurance depends on the realizations of $\varepsilon_1$, implying that banks have differential comparative advantages of buying and selling capital. The banks are liquidated at date 2: deposits are paid out and consumption occurs.

Banks that are unable at date 2 to pay their depositors from their own assets receive a transfer from the insurance fund. The total tax collected $t$ is nonrandom by virtue of “a version of the law of large numbers”, as discussed above. In the context of the model to be presented the assumption that each agent operates his own bank is innocuous, again as in the preceding section. This is so because agents, being risk neutral, have no incentive to pool risks.\(^5\) Agents in their roles as both individuals and banks act to maximize expected date-2 consumption, which equals the sum of deposits and expected equity, and also equals the date-0 value of the endowments of risky and riskless capital.

Bank balance sheets are shown in Tables 3-5.

3 Outline of the Model

We begin with a partial equilibrium analysis in which we assume that in setting up banks all agents choose the same level $d$ of deposits at date 0, and we take $d$ as given.

\(^4\)The fact that agents pay the tax $t$ even if they do not create banks justifies the assumption that all agents will in fact create banks. If they do not do so they pay the tax but do not benefit from payments from the insurer in the event that their banks fail.

\(^5\)It can be shown (using the fact that $\max(a + b, 0) \leq \max(a, 0) + \max(b, 0)$, with strict inequality if $a$ and $b$ are random variables that take different signs with positive probability) that pooling risks would strictly diminish the value of deposit insurance. Thus even (slightly) risk averse agents would prefer not to pool their risks in the presence of deposit insurance.
Table 4: Bank Balance Sheet at Date 1 After Capital Transactions

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>((\varepsilon_1 + x)v(\varepsilon_1 + x)) (capital)</td>
<td>(d) (deposits)</td>
</tr>
<tr>
<td>(1 - p_1x) (reserves)</td>
<td>(e_1 = (\varepsilon_1 + x)v(\varepsilon_1 + x) + 1 - p_1x - d) (equity)</td>
</tr>
</tbody>
</table>

Table 5: Bank Balance Sheet at Date 2

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>((\varepsilon_1 + x)\varepsilon_2) (capital)</td>
<td>(d) (deposits)</td>
</tr>
<tr>
<td>(1 - p_1x) (reserves)</td>
<td>(e_2 = \max[(\varepsilon_1 + x)\varepsilon_2 + 1 - p_1x - d, 0]) (equity)</td>
</tr>
<tr>
<td>(\max[-{(\varepsilon_1 + x)\varepsilon_2 + 1 - p_1x - d}, 0]) (insurance payment)</td>
<td></td>
</tr>
</tbody>
</table>
In the latter part of this section we will broaden the analysis to include determination of the equilibrium under optimal choice of \( d \). The description in this section is informal and incomplete; details are presented in Section 5.

We assume that banks cannot issue, retire or transfer deposits at date 1, implying that the bankers cannot use deposits to pay for capital purchases. Instead, banks that buy or sell risky capital—all banks except those on a boundary—draw down or augment their holdings of riskless capital, indicated in the bank balance sheets as reserves, according to whether they are buyers or sellers. This device, although artificial, serves to ensure that capital transactions lie in a bounded interval. This fact, plus continuity, assures existence of optimal capital transactions. At date 2 the deposits are withdrawn in the form of the physical good, which the agents then consume. As in Section 1, bank-held risky capital is subject to random productivity shocks \( \varepsilon_1 \) at date 1 and \( \varepsilon_2 \) at date 2.

To begin the characterization of the equilibrium for different values of deposits \( d \), consider first the case where \( d \) is so low that all banks will be able to pay off their depositors regardless of their draws of \( \varepsilon_1 \) and \( \varepsilon_2 \). The worst possible outcome for a bank is to experience productivity shock \( \varepsilon \) at date 1, exchange its endowment of riskless capital for risky capital at the equilibrium price \( E(\varepsilon_2) = (\varepsilon + \varepsilon)/2 \) and experience another draw of \( \varepsilon \) at date 2. If this bank is able to honor its obligation to depositors, then all banks can do so. We denote the no-default region as Region I, and label the maximum value of \( d \) consistent with this bank honoring deposit obligations as \( d_{\text{II}}^I \). We have

\[
d \leq d_{\text{II}}^I = (\varepsilon + 2/(\varepsilon + \varepsilon))\varepsilon
\]

in Region I. The equilibrium values of the risky asset are \([\varepsilon + \varepsilon] / 4 = E(\varepsilon_1 \varepsilon_2)\) at date 0 and \([\varepsilon + \varepsilon] / 2 = E(\varepsilon_2)\) at date 1, as when there is no insurance. The riskless asset has value 1 at both dates. In Region I banks will not have comparative advantages or disadvantages in holding risky capital, so we can neglect trade in risky capital at date 1. Banks will pay off depositors at date 2 and pay whatever remains to equity holders. With no bank failures, the deposit insurer will set \( t \) equal to zero. The prices of risky and riskless capital at date 0 and date 1 will be the same as in the case of no deposit insurance.

Now suppose that \( d \) is slightly higher than \( d_{\text{II}}^I \), so that banks with low \( \varepsilon \) will fail if \( \varepsilon_2 \) is also low (note that here we are deferring to the following section discussion of how optimal trading in risky capital connects with \( d \)). However, assume that \( d \) is still low enough so that banks with high realizations of \( \varepsilon_1 \) have no risk of failure. Denote these values of \( d \) as Region II. We conjecture that the price \( p_1 = (\varepsilon + \varepsilon)/2 \) clears the market for the risky asset under the higher value for \( d \), as in Region I. Define \( \bar{\varepsilon}(\varepsilon_1) \) as the value of \( \varepsilon_2 \) such that banks with given \( \varepsilon_1 \) and \( \varepsilon_2 < \bar{\varepsilon}(\varepsilon_1) \) will fail and banks with \( \varepsilon_2 > \bar{\varepsilon}(\varepsilon_1) \) will not. If \( \varepsilon_1 \) is high enough so that the bank cannot fail, set \( \bar{\varepsilon}(\varepsilon_1) \) equal to \( \varepsilon \). Finally, define \( \tilde{\varepsilon} \) as the lowest value of \( \varepsilon_1 \) such that \( \bar{\varepsilon}(\varepsilon_1) = \varepsilon \). Then banks with \( \varepsilon_1 > \tilde{\varepsilon} \) do not face the possibility of failure if they draw a low value.
of $\varepsilon_2$, whereas banks with $\varepsilon_1 < \hat{\varepsilon}$ do face this possibility. In the event of failure these banks will benefit from a transfer from the insurance fund. Existence of this transfer implies that the lower tail of the distribution of $\varepsilon_1$ and $\varepsilon_2$ is shifted to the insurance fund, thus rendering risky capital more attractive as an asset to the bank. Because the equilibrium price of risky capital is equal to its expected payoff, making no allowance for the effect of risky capital purchases on the future transfer from the deposit insurer, banks which face the possibility of failure will strictly prefer to buy rather than sell risky capital at the equilibrium price.

Banks with $\varepsilon_1 > \hat{\varepsilon}$, on the other hand, will not fail under any value of $\varepsilon_2$. They will be indifferent as to whether or not to trade risky capital. This is so because the value of the deposit insurance guarantee is zero for these banks, and the conjectured equilibrium price of risky capital makes no allowance for the value of a transfer from the insurance fund. If the aggregate risky-capital demanded by buying banks is less than the maximum aggregate risky-capital selling banks are willing to supply, as it will be if $d$ is only slightly higher than $d^{III}$, the assumed price of risky capital $p_1 = (\bar{\varepsilon} + \bar{\varepsilon})/2$ will clear markets. This fact validates the conjecture that the date-1 equilibrium price of risky capital is the same for $d > d^{III}$ as for $d \leq d^{III}$ (as in Region I).

Even though the equilibrium prices of risky and riskless capital at date 1 are the same in Regions I and II, the same is not true of the equilibrium date-0 prices. At date 0 banks know that they run the risk of drawing low values of $\varepsilon_1$ and $\varepsilon_2$ at dates 1 and 2, in which case they will value risky capital highly because, in addition to its direct date-2 payoff, risky capital entitles its owner to the insurance transfer in the event of failure. The equilibrium date-0 price of risky capital equals the expectation of its date-1 value, so this price strictly exceeds that which occurs in Region I. A similar analysis applies to the date-0 price of riskless capital, which we denote $q_0$. Its date-0 value equals the expectation of its date-1 payoff, and therefore will exceed 1 because banks with low $\varepsilon_1$ will use it to buy risky capital, which generates a surplus (because risky capital has imputed value greater than its purchase price to buyers).

At higher values of $d$ more banks run the risk of failure. Thus more banks strictly prefer to buy risky capital at its equilibrium price, and fewer banks are indifferent as to whether to sell or not. For $d$ above a borderline value $d^{III}$ banks buying risky capital demand more capital than is available at price $p_1 = (\hat{\varepsilon} + \bar{\varepsilon})/2$ from the selling banks. In that case the date-1 equilibrium price of risky capital must increase above $(\hat{\varepsilon} + \hat{\varepsilon})/2$. At the higher price all banks with high $\varepsilon_1$ now strictly prefer to sell capital rather than hold it. Having sold all their risky capital, the date-2 equity values of these banks do not depend on the date-2 capital shocks. Banks buying risky capital each purchase less capital at the equilibrium price than they would at the lower price $p_1 = (\hat{\varepsilon} + \bar{\varepsilon})/2$, making market clearing possible. The borderline value of $\varepsilon_1$ that separates the buyers of risky capital from the sellers, as above, is designated $\hat{\varepsilon}$. As will be made clear in Section 5, for each $d$ there exists a single pair $(p_1, \hat{\varepsilon})$ that is consistent with market clearing. This is Region III.
In Region III, as in Region II, banks with low values of $\varepsilon_1$ impute values to risky capital strictly higher than its transaction price $p_1$. The lower is $\varepsilon_1$, the higher is the imputed value of risky capital. This is so because at low values of of $\varepsilon_1$ the conditionally expected payment from the insurance fund is high. Banks with values of $\varepsilon_1$ greater than $\hat{\varepsilon}$, on the other hand, impute value $p_1$ to risky capital because they sell all their risky capital at that price. Because the date-0 price of risky capital equals the expectation of its date-1 value, the date-0 price rises with $d$. The same analysis applies to the riskless asset: banks with low values of $\varepsilon_1$ realize a surplus when they buy the risky asset, and existence of this surplus increases the date-0 value of the riskless asset.

In Region III it is assumed that $d$ is such that all banks buying risky capital can avoid failure with a sufficiently high realization of $\varepsilon_2$. Thus each bank that is buying risky capital will fail for low values of $\varepsilon_2$ and will not fail for high values of $\varepsilon_2$. The upper bound of Region III is the maximum level of $d$ such that this is true. We denote this upper bound for Region III by $d^\ast$.

For $d > d^\ast$ banks with low values of $\varepsilon_1$ would be certain to fail at date 2. This causes problems. Banks that are certain to fail have no stake in the returns on their investments. They would be indifferent as to whether to buy or sell risky capital at date 1, or do nothing: the date-2 value of equity is zero under any of these courses of action. This indeterminacy in banks’ investment decisions would result in an indeterminacy in equilibrium prices. Rather than complicate the analysis of the model by incorporating this case we rule out indeterminacy by assuming that the regulator enforces the restriction $d \leq d^\ast$, so that all banks have positive probability at date 1 of remaining solvent at date 2. This restriction is empirically realistic: bank regulators, at least in theory, shut down banks when failure is a foregone conclusion.\(^6\)

The final step of the analysis consists of replacing the assumption that $d$ is specified to equal some arbitrary number in the interval $[0,d^\ast]$ with the specification that agents set $d$ to maximize expected date-2 consumption, equal to the sum of deposits plus date-0 equity. This is equivalent to setting $d$ to maximize the date-0 value of agents’ endowment of risky and riskless capital. The equilibrium date-0 value of both types of capital increase with $d$, and strictly increase in Regions II and III. Therefore the equilibrium level of $d$ is $d^\ast$: banks set deposits at the highest level permitted by the regulator.

\(^6\)It would seem that one could avoid the indeterminacy problem by specifying that banks that are certain to fail cannot trade capital. This restriction in fact does not resolve the problem. Even if banks that are certain to fail are prohibited from trading, the imputed date-1 values of risky capital for banks that are prohibited from trading capital are not well defined, implying that the equilibrium date-0 values of risky and riskless capital are indeterminate.

We choose to rule out these indeterminacies because they are consequences of the details of our model specification, and do not seem to correspond to real-world phenomena.
4 An Example

We now present an example of the equilibrium under deposit insurance. Our example will set $\varepsilon$ equal to 2 and $\xi$ equal to .5, implying that risky projects are equally likely to experience any outcome between a doubling of value and a halving, at both date 1 and date 2. Consider first the setting in which there is no deposit insurance, discussed in Section 1. In that case the value of risky capital at date 0 is 1.56 at date 0 and 1.25 at date 1, regardless of the division of bank value into debt and equity. The riskless capital good has price 1 at both dates. Thus the date-0 value of each agent’s endowment is 2.56. If deposits $d$ are set below $1 + \varepsilon^2 = 1.25$ deposits are risk-free, implying that their return $R$ equals 1. For $d = 1.5, 1.7, 1.9, 2.1, 2.3$ and 2.5 the equilibrium values of $R$ are $1.02, 1.08, 1.22, 1.35, 1.48$ and 1.69.

Now impose deposit insurance, so that $R$ is guaranteed at 1 regardless of bank solvency. The equilibrium level $d^*$ of $d$ equals 2.47. Figure 1 plots $p_0$ and $p_1$ as functions of $d$ for values of $d$ between 0 and 2.47. The boundaries for the equilibrium regions discussed in Section 3 are as follows: $d^{I-II} = 0.65$ and $d^{II-III} = 1.66$.

The existence of deposit insurance increases the date-0 equilibrium price of the risky capital good from 1.56 to 1.82, and it increases that of the riskless capital good from 1 to 1.11. This increase in the value of capital endowments is exactly offset by the lump-sum tax $t$.

5 Formal Analysis: Lump-sum Premia

In this section the Region III equilibrium is discussed in detail. The derivation of the equilibrium in the other regions is similar, and need not be discussed separately.

For $d$ equal to 2, a value near the center of the Region III values of $d$, we have $p_1 = 1.29$. The boundary between sellers and buyers of risky capital occurs at $\bar{\varepsilon} = 1.54$. The date-1 value of risky capital ranges between 1.63 and $p_1$ as $\varepsilon_1$ ranges between $\varepsilon$ and $\bar{\varepsilon}$, and equals $p_1$ for $\varepsilon_1 \geq \bar{\varepsilon}$. For a bank with date-1 shock $\varepsilon_1$ that buys capital ($\varepsilon_1 < \bar{\varepsilon}$) there exists a value of $\varepsilon_2$, denoted $\tilde{\varepsilon}(\varepsilon_1)$, such that banks will fail if $\varepsilon_2 < \tilde{\varepsilon}(\varepsilon_1)$ and will not fail if $\varepsilon_2 > \tilde{\varepsilon}(\varepsilon_1)$. In Region III the equilibrium value $\overline{\varepsilon}(\varepsilon_1)$ lies in the interior of $[\varepsilon, \bar{\varepsilon}]$. 7 Thus $\overline{\varepsilon}(\varepsilon_1)$ is the level of $\varepsilon_2$ at which banks generate income just sufficient to pay off the depositors, with nothing left for the equity holders. Thus the borderline point $\overline{\varepsilon}(\varepsilon_1)$ equals the value of $\varepsilon_2$ that solves

$$\varepsilon_1 + x^*(\varepsilon_1)\varepsilon_2 + 1 - p_1x^*(\varepsilon_1) = d.$$  

Here $x^*(\varepsilon_1)$ is the amount of risky capital optimally purchased, or sold, if negative.

7If we had $\overline{\varepsilon}(\varepsilon_1) = \varepsilon$ for some level of $\varepsilon_1$ some banks buying risky capital would have no risk of failure. But these banks would find risky capital overpriced in Region III because they do not benefit from deposit insurance. Therefore they would prefer to sell rather than buy risky capital. All banks selling capital is inconsistent with market clearing.
Figure 1: Equilibrium price of capital as a function of deposits.

by a bank with shock $\varepsilon_1$. The higher the value of $\varepsilon_1$ the lower the failure threshold $\tilde{\varepsilon}(\varepsilon_1)$. Solving for $\varepsilon_2$, we have

$$\tilde{\varepsilon}(\varepsilon_1) = (p_1 x^*(\varepsilon_1) + d - 1)/(\varepsilon_1 + x^*(\varepsilon_1)).$$

For reference below, we have

$$\text{probability of non-failure} = \frac{\varepsilon - \tilde{\varepsilon}(\varepsilon_1)}{\varepsilon - \tilde{\varepsilon}},$$

which is strictly between 0 and 1. The expectation of date-2 bank equity conditional on non-failure is

$$\text{expected equity} = (\varepsilon_1 + x^*(\varepsilon_1))((\varepsilon + \tilde{\varepsilon}(\varepsilon_1))/2) + 1 - p_1 x^*(\varepsilon_1) - d.$$
Banks choose $x$ to maximize date-1 bank equity, equal to the probability of nonfailure, (3), multiplied by the expectation of date-2 bank equity conditional on nonfailure, (4). We have

$$e_1(\varepsilon_1) = \max_{x \in [-\varepsilon_1, 1/p_1]} E\{\max[(\varepsilon_1 + x)\varepsilon_2 + 1 - p_1 x - d, 0]|\varepsilon_1\}$$

(5)

$$= \max_{x \in [-\varepsilon_1, 1/p_1]} \left(\frac{\varepsilon - \tilde{\varepsilon}(\varepsilon_1)}{\varepsilon - \tilde{\varepsilon}}\right) \left[(\varepsilon_1 + x) \left(\frac{\varepsilon + \tilde{\varepsilon}(\varepsilon_1)}{2}\right) + 1 - p_1 x - d\right],$$

(6)

and

$$x^*(\varepsilon_1) = \arg\max_{x \in [-\varepsilon_1, 1/p_1]} e_1(\varepsilon_1).$$

(7)

From the bank balance sheets, assuming that banks maximize $e_1$ at date 1 implies that they take into account the effect of $x$ not only on the date-2 direct payoff on risky capital above cost, $(\varepsilon_1 + x)\varepsilon_2 - p_1 x$, but also on the expectation of the next-period insurance payment, because the latter is capitalized into the date-1 value of risky capital. (Recall that, from Table 4, date-1 bank equity equals the expected date-2 direct payoff on risky capital plus the expected date-2 insurance payout, plus the holding of the riskless capital good (for banks selling capital), less deposits).\(^8\)

The maximand in (5) is a convex function of $x$. Convexity follows from (6), where (2), with $x^*(\varepsilon_1)$ replaced by $x$, is used to substitute out $\tilde{\varepsilon}(\varepsilon_1)$. Convexity implies that $x^*(\varepsilon_1)$ always equals either $-\varepsilon_1$ or $1/p_1$, the boundary points for $x$. Banks with low values of $\varepsilon_1$ will be buyers of risky capital. This is so because they take account of the expected value of the insurance transfer. The insurance transfer is lower (for optimal $x$, zero) for banks with higher $\varepsilon_1$, inducing banks with low $\varepsilon_1$ to value risky capital more highly than banks with higher $\varepsilon_1$. There exists a boundary point $\hat{\varepsilon}$ such that $x^*(\varepsilon_1) = 1/p_1$ for $\varepsilon_1 \leq \hat{\varepsilon}$ and $x^*(\varepsilon_1) = -\varepsilon_1$ for $\varepsilon_1 > \hat{\varepsilon}$.\(^9\)

We can define a function $v(\varepsilon_1 + x^*(\varepsilon_1))$ giving the unit value of post-purchase or -sale risky capital at date 1 associated with each value of $\varepsilon_1$. For banks buying risky capital this valuation is defined from the date-1 bank balance sheet, reflecting the capitalization of the expected date-2 transfer from the insurance fund. For banks with $\varepsilon_1 < \hat{\varepsilon}$ the function $v$ satisfies $v(\varepsilon_1 + 1/p_1) > p_1$; these banks buy as much risky capital as possible because they value it more highly than its price indicates. This effect is stronger the lower is $\varepsilon_1$. Hence $v(\varepsilon_1 + 1/p_1)$ is a decreasing function of $\varepsilon_1$.

\(^8\)Note that because banks’ choices of $x$ affect the value of the insurance payout as well as the date-2 payoff on risky capital, the value of risky capital at date 1 does not necessarily equal the conditional expectation of its payoff at date 2.

\(^9\)The observation that levered banks value deposit insurance more highly than unlevered banks, with the corollary that banks’ motivation for adopting highly levered capital structures is precisely to maximize the value of deposit insurance, has been made before. See Keeley and Furlong (1990), for example.
reaching \( p_1 \) at \( \varepsilon_1 = \hat{\varepsilon} \).

For banks with \( \varepsilon_1 > \hat{\varepsilon} \) risky capital is valued at \( p_1 \) since these banks will sell their risky capital at that price.\(^{11}\) Therefore we can extend \( v(\varepsilon_1 + x^*(\varepsilon_1)) \) to \( \varepsilon_1 > \hat{\varepsilon} \):

\[
v(\varepsilon_1 + x^*(\varepsilon_1)) \equiv p_1 \text{ for } \varepsilon_1 > \hat{\varepsilon}
\] (9)

(this extension is necessary as a separate specification because the date-1 bank balance sheet cannot be used to define \( v \) for \( \varepsilon_1 > \hat{\varepsilon} \) due the the fact that \( v(\varepsilon_1 + x^*(\varepsilon_1)) \) is multiplied by \( \varepsilon_1 + x^*(\varepsilon_1) = 0 \) in the bank balance sheet). Having the extension (9) is convenient (for example, in (12) below).

Given that \( \hat{\varepsilon} \) constitutes the boundary between the buyers of risky capital, who each buy \( \frac{1}{p_1} \) units, and the sellers, who sell \( \varepsilon_1 \) units, it is determined by the equilibrium of supply and demand for risky capital:

\[
(\hat{\varepsilon} - \varepsilon)/p_1 = E(\varepsilon_1|\varepsilon_1 \geq \hat{\varepsilon})(\varepsilon - \hat{\varepsilon}).
\] (10)

We thus have two variables that determine the date-1 equilibrium: \( p_1 \) and \( \hat{\varepsilon} \). The market-clearing condition (10) gives one relation between these two variables. From (10), an increase in \( p_1 \) decreases the amount of risky capital that selling banks are able to sell, implying that the market can clear only at a higher level of \( \hat{\varepsilon} \).

The second equation relating \( p_1 \) and \( \hat{\varepsilon} \) comes from the fact that the payoffs from buying and selling risky capital can be written as functions of \( \varepsilon_1 \). These payoffs are equal at \( \varepsilon_1 = \hat{\varepsilon} \). Equating the relevant expressions gives \( \hat{\varepsilon} \) as a function of \( p_1 \). We have

\[
E[\max\{ (\hat{\varepsilon} + 1/p_1)\varepsilon_2 - d, 0 \}] = p_1 \hat{\varepsilon} + 1 - d,
\] (11)

which defines \( \hat{\varepsilon} \) as a decreasing function of \( p_1 \). We thus have two functions giving \( \hat{\varepsilon} \) as a function of \( p_1 \), one increasing and one decreasing. Equilibrium occurs at the intersection of these functions.

The date-0 price of risky capital equals the expected date-1 value of risky capital, with the expectation taken over the distribution of \( \varepsilon_1 \):

\[
p_0 = E[\varepsilon_1 v(\varepsilon_1 + x^*(\varepsilon_1))].
\] (12)

\(^{10}\)To see that \( v \) is continuous at \( \hat{\varepsilon} \), note that we have

\[
v(\varepsilon_1 + 1/p_1)[\varepsilon_1 + 1/p_1] = [1 + p_1\varepsilon_1]
\] (8)

at \( \varepsilon_1 = \hat{\varepsilon} \). The two terms in brackets are continuous in \( \varepsilon_1 \), so \( v(\varepsilon_1 + 1/p_1) \) must be continuous as well.

\(^{11}\)As the notation implies, the valuations of risky capital apply only for optimal \( x \). For example, the valuation of risky capital for banks selling capital does not equal \( p_1 \) for \( x \neq -\varepsilon_1 \). To see this, note that for any bank with \( \varepsilon_1 < \hat{\varepsilon} \) continuity implies that the fact that the bank will be solvent with certainty for \( x = -\varepsilon_1 \) implies that there exists \( x \) small enough (that is, close enough to \( -\varepsilon_1 \)) \( x \) that the bank will remain solvent with certainty for that \( x \). In that case the bank’s risky capital \( \varepsilon_1 + x \) has unit value \((\varepsilon + \hat{\varepsilon})/2\). This is strictly less than \( p_1 \), reflecting the suboptimality of \( x > -\varepsilon_1 \).
Similarly, the date-0 value of agents’ endowment of riskless capital is the expectation of its date-1 value:

\[ q_0 = E[v_1 + x^*(\varepsilon_1)]/p_1 > 1. \] (13)

The expression on the right-hand side results from the fact that a unit of riskless capital at date 1 has value \( v(\varepsilon_1 + x^*(\varepsilon_1))/p_1 > 1 \) if the bank turns out to be a buyer of risky capital, and has value 1 if it is a seller.

The last stage of the analysis consists of calculating the tax \( t \) that is just sufficient to finance the payments to depositors at failed banks. Since \( t \) is a lump-sum tax, calculation of \( t \) does not interact with the determination of the equilibrium discussed above, which is why we have been able to ignore \( t \) up to now. Therefore \( t \) can be evaluated by calculating the total payments to failed banks, which in turn equals the sum of the date-0 values of risky and riskless capital less the sum of the values of their direct payoffs.

6 Deposit-Based Premia

Up to now it has been assumed that deposit insurance is financed by lump-sum taxes paid by the agents to the deposit insurer. This specification has the convenient implication that the financing scheme plays no role in determining the equilibrium, implying that it could be ignored in determining the equilibrium. However, it does not correspond to the real-world situation. In the United States banks pay insurance premia to the Federal Deposit Insurance Corporation based primarily on the amount of deposits that are insured (but also on such variables as the bank’s capital and the adequacy of the FDIC’s insurance fund).

It turns out to be easy to modify the model to allow for deposit-based insurance premia. We redefine the date-2 transfer from the bank insurer as net of the insurance premium, where the latter is defined as \( \delta d \). Thus the net transfer will be the negative of the insurance premium for banks that remain solvent, while for insolvent banks the transfer may be positive or negative depending on whether the asset shortfall exceeds or falls short of the insurance premium. The insurance premium per unit of deposits \( \delta \) is taken as given. To close the model with deposit-based premia, we assume that the bank insurer settles any shortfalls (surpluses) in the insurance fund via lump-sum taxes (transfers). The insurance scheme is actuarially fair when the lump-sum payments equal zero.

\^{12}A shortcut for calculating the value of \( t \) is available. We know that in the absence of deposit insurance the expected value of consumption is just \( \{\varepsilon + \bar{\varepsilon}\}^2/4 + 1 \), equal to the endowment of the riskless capital good plus the expected date-2 value of the risky capital good. The insurance program involves nothing more than a redistribution of the endowment, so the sum of the initial value of risky and riskless capital must exceed the value in the absence of deposit insurance by exactly the amount of the tax. Therefore the latter can be calculated directly.
When deposit insurance was financed entirely using lump-sum taxes the tax was not capitalized into the values of risky and riskless capital. This being so, capital values were an increasing function of \( d \). The unique equilibrium involved agents forming banks and operating these banks so as to take maximal risk; bankers benefit from the insurance transfer only if they do so, and they ignore the tax in their decision-making because they pay it regardless of the amount of risk they take. In contrast, under deposit-based insurance premia, agents can avoid paying the premium if they do not form banks, and can benefit from low payments for deposit insurance if they form banks but issue low levels of deposits.

Derivation of date-0 capital values as a function of deposit levels under deposit-based insurance premia involves only a minor modification of the calculations described in Section 5. We omit the details. Figure 2 shows the equilibrium value \( p_0 + q_0 \) of each agent’s date-0 endowment of risky and riskless capital, as a function of \( d \). It is assumed that the insurance rate \( \delta \) is set so that deposit insurance is actuarially fair when deposits are set equal to the maximal value consistent with all banks having a strictly positive probability of remaining solvent at date 2 regardless of their draw of \( \varepsilon_1 \) at date 1 (we motivated this specification in Section 2).

The fact that insurance is actuarially fair for \( d = 0 \) and \( d = d^* \) implies that the summed values of risky and riskless capital are equal. Agents are indifferent between not creating banks and creating banks and taking maximal risk. The fact that \( p_0 + q_0 \) is a convex function of \( d \) implies that the value of capital—and therefore also the equilibrium value of expected consumption for each agent—is lower at intermediate \( d \) than at the endpoints \( d = 0 \) and \( d = d^* \). The fact that the insurance premium is proportional to \( d \) implies that at intermediate \( d \) the expectation of the insurance transfer to failed banks is lower than the premium that would be collected. The fact that deposit insurance is overpriced at intermediate values of \( d \) implies that agents will never set \( d \) at these levels. Thus \( d = 0 \) and \( d = d^* \) are the only optima.

Figure 2 also shows \( p_0 \) and \( q_0 \) separately. For low levels of \( d \) the value of risky capital \( p_0 \) decreases with \( d \). The decrease reflects the expectation of the insurance transfer relative to the payment for insurance. For example, consider the case in which \( d \) is so low that all banks stay solvent with probability one. In this case, a small increase in \( d \) raises the payment for deposit insurance without raising the expected insurance transfer, implying that the price of capital declines. As \( d \) increases further the value of the insurance transfer increases more than in proportion to \( \delta d \), so the effect of increasing \( d \) on \( p_0 \) is reversed. The effect of increasing \( d \) on the price \( q_0 \) of riskless capital shows the same pattern. This occurs because the excess of \( q_0 \) over 1 is based on the exchange value of riskless capital in obtaining the surplus \( v(\varepsilon_1 + 1/p_1) - p_1 \) available to low \( \varepsilon_1 \)-banks from buying risky capital. The fact that increasing \( d \) raises \( v(\varepsilon_1 + 1/p_1) \) more than in proportion to \( p_1 \) implies that \( q_0 \) will increase just as \( p_0 \) does.

For \( d = d^* \) the price of risky (riskless) capital is higher (lower) than for \( d = 0 \). Thus existence of deposit insurance with deposit-based premia increases the price of risky
capital and decreases the price of riskless capital even if the insurance is actuarially fair (of course, actuarial fairness implies that the summed effect is zero). So the link between actuarial fairness of deposit insurance and non-distortion that is presumed in much discussion of deposit insurance is in error, at least in the model discussed here. Here deposit insurance is actuarially fair, but its existence results in an equilibrium in which the price of risky capital is increased relative to riskless capital.

Agents are indifferent between the two optimal courses of action: do not create banks versus create banks and issue the maximal level of deposits. These equilibria can coexist with some agents opting for one and some for the other. The fact that the equilibria have different relative capital prices does not cause a problem because we ruled out trade of risky for riskless capital between agents and banks at all dates; agents start banks and determine the initial capital structure of these banks (between deposits and equity), but they do not trade risky and riskless capital for one another. Allowing such trade would invalidate the equilibria just described due to the failure of the law of one price.

7 Risk-Based Premia

Many analysts of banking recommend replacing deposit insurance premia based on deposit levels with premia based on asset risk: banks would be required to pay higher
insurance premia to the extent that they hold riskier assets. To ascertain how this change affects the equilibrium pricing of risky and riskless assets, we modify the model by specifying that banks pay premia that are proportional to their holdings of risky assets, with factor of proportionality $\lambda$. As with the deposit-based premia of the preceding section, it is assumed that $\lambda$ is set so that insurance is actuarially fair under optimal behavior by banks.

Asset-based insurance premia have the opposite effect on equilibrium capital prices as deposit-based premia: for intermediate values of $d$ asset-based premia decrease equilibrium $p_0$ relative to the equilibrium without deposit insurance (Figure 3). This is hardly surprising inasmuch as the insurance premium is levied on risky capital. The value of riskless capital increases with $d$; in fact, its behavior for different values of $d$ is nearly the same under risk-based premia as under lump-sum premia.

Under risk-based premia bank value $p_0 + q_0$ is lowest at $d = 0$. This contrasts with deposit-based premia, as we have seen, under which $p_0 + q_0$ takes on the same value at $d = 0$ as in the case of no deposit insurance. This difference reflects the fact that by setting $d = 0$ banks can avoid a deposit-based premium altogether, but they have to pay an asset-based premium, which decreases the value of risky capital. Total bank value rises with $d$, reaching a maximum at $d^*$. With risk-based premia there are two equilibria: one involves not creating banks at all, and the other involves creating banks and operating them at the maximum riskiness permitted by the regulators. As

Figure 3: Equilibrium price of capital with risk-based premia.
with deposit-based premia, setting \( d \) at an intermediate value is dominated because deposit insurance is overpriced. Thus, as expected, deposit insurance with risk-based insurance premia decreases the equilibrium price of risky assets and increases the equilibrium price of riskless assets relative to the case without deposit insurance, in contrast to the case with deposit-based premia, under which the opposite happens. However, risk-based insurance premia do not have the expected effect of inducing banks to decrease their holdings of risky assets: instead, it induces them to either shut down their banks or hold the maximum amount of risky assets.

### 8 Conclusion

We have shown that, if one abstracts away from how deposit insurance is financed (we did so in Sections 2 - 5 by assuming that it was financed by lump-sum taxes), the existence of deposit insurance induces banks to choose maximally levered—and therefore maximally risky—portfolios. This conclusion reflects a basic fact about deposit insurance: the expected payoff on deposit insurance rises more than in proportion to bank leverage. The conclusion appears to be robust to how the deposit insurance is financed: we showed that if insurance premia are levied in proportion to deposits or holdings of risky capital the model has the same proclivity for corner solutions as is the case with lump-sum taxes. Thus the result of this paper is that the existence of deposit insurance induces banks to avoid interior solutions in which banks take moderately risky positions, which are optima in the absence of deposit insurance, in favor of corner solutions in which banks take no risk at all or maximal risk.

If bank deposit insurance is financed using actuarially fair deposit-based insurance premia, or if there is no deposit insurance, then agents are indifferent between creating and not creating banks, provided that banks invest optimally if they are created. Despite this indifference, we find that the distortion induced by actuarially fair deposit-based insurance increases the price of risky capital and decreases the price of riskless capital by an equal amount. In contrast, risk-based deposit insurance has the opposite effect on capital prices.

We recognize that the clean conclusions of this paper do not extend in any simple way to the real world. Our model incorporated several major simplifications:

- The riskiness of various bank investments can be unambiguously evaluated. This presumption is not remotely accurate; consider the senior tranches of US mortgage-backed securities, which were treated by many investors, including the rating agencies and bank regulators, as virtually equivalent in riskiness to US Treasury bonds. The recent financial crisis, of course, showed otherwise.

- It was presumed that there exists a well-defined optimal bank response to deposit insurance; i.e., that it is possible to determine exactly what banks would do in order to game the deposit insurance system to the extent implied by equity
value maximization. Our model was structured to make this calculation possible, but in the real world situation it is hard to determine what “the maximum extent” means. In many theoretical settings deposit insurance would motivate banks to hold an infinite long position in risky assets and an infinite short position in riskless assets, which is inconsistent with existence of a well-defined equilibrium.

- We assumed that agents are risk neutral. Under universal risk-neutrality all feasible allocations are welfare-equivalent assuming, as we have, that deposit insurance that is not actuarially fair is accompanied by the appropriate lump-sum transfers. If agents are risk averse this conclusion would fail, resulting in welfare effects according to whether deposit insurance exists and how it is financed.

There are other problems with our specification. There is no reason even to have deposit insurance in our environment. Further, banks do not serve any purpose in the setting that we hypothesize: as we noted, the equilibrium welfare of agents is the same with and without banks. This fact that there is no motivation for deposit insurance in our model invites comparison with Diamond and Dybvig (1983). The Diamond-Dybvig model is predicated on the presumption that banks play an essential role as financial intermediaries. However, Diamond and Dybvig provided no explanation of why there do not exist the securities markets that could bring about an allocation that, being efficient, would Pareto-dominate the allocation achieved under a banking system. In their setting agents have no incentive to misrepresent their type, so setting up the relevant markets is straightforward. Given the existence of the relevant markets, however, banks would be redundant (see Allen and Gale (2007) for a clear treatment of this issue). Thus the absence in our setting of an explicit rationale for the existence of financial intermediaries, if it is a problem, has an exact parallel in the Diamond-Dybvig model (and, for that matter, most other banking models, which justify the existence of banks in a setting where there exist no other financial markets).

We believe that the exercise reported in this paper provides a useful guide in thinking about real-world regulation of the banking system. The most important result here is our finding that deposit insurance predisposes banks to all-or-nothing solutions in terms of risk-bearing. We relied on risk neutrality to demonstrate this result, but it seems likely that it carries over to more general specifications. If so, there is reason to expect that the substance of our analysis, if not its details, carries over to less restrictive settings. Making the transition from toy models to reality involves replacing the stylized model of this paper with a more general model that connects more closely with the real world. Such a model could in principle be calibrated, leading to conclusions that can be taken seriously empirically. We have just enumerated reasons why providing such a model will be difficult, but we still think that attempting to do so is an appropriate direction for future work.
References


