Bank Deposit Insurance: Implications for Portfolios and Equilibrium Valuation of Risky Assets

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Abstract

We consider a model in which a government insurer guarantees the deposit liabilities of commercial banks. In the basic specification it is assumed that agents pay for the insurance via a lump-sum tax. Banks respond to the opportunity 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 lump-sum taxes. In both cases, with revenue-neutral insurance, agents either have an incentive to create commercial banks and take on maximal risk or to create shadow banks and not participate in the deposit insurance program (creating commercial banks and taking on intermediate levels of risk is dominated). Neither financing method eliminates the moral hazard distortion implied by deposit insurance.

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.

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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 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 familiar moral hazard problem that accompanies insurance programs in which the insurer cannot completely monitor the behavior of the insured party: the insured party has an 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 under the assumption that banking is competitive.\footnote{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.} Agents have the option of creating banks and benefiting from deposit insurance or holding their assets in what we call shadow banks, which differ from banks in that they do not participate in the deposit insurance program. Because our model assumes away motives for trade other than those connected to the deposit insurance program, shadow banks do nothing other than hold assets until the maturity date.

We consider three regimes according to how deposit insurance is financed. In the first, insurance is financed using a lump-sum tax that is paid by all agents, including those who form shadow banks. In the second and third regimes deposit insurance is financed via premia that are proportional to deposits or proportional to holdings of the risky asset. Shadow banks do not pay these premia.

The setting is highly stylized, but it seems to us to capture the essentials of the problem. We expect that the qualitative results should carry over to settings in which there exist other significant participants in financial markets, and in which various restrictions that we impose are relaxed.

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.2

• “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, leading them to offer higher prices than strong banks.

• “The moral hazard distortion induced by deposit insurance can be mitigated if deposit insurance premia are levied on banks’ holdings of risky assets rather than deposit liabilities.” This conjecture is incorrect. A major conclusion of this paper is that in equilibrium under either deposit-based insurance premia or risky-asset-based premia agents are indifferent between creating shadow banks without deposit insurance or creating commercial banks with deposit insurance and taking as much risk as possible. (Hereafter we will take the term “commercial banks” as meaning banks that participate in deposit insurance, and “shadow banks” as meaning banks that do not.) Intermediate solutions—creating commercial banks that take moderate amounts of risk—are dominated under either deposit-based on risky-asset-based insurance premia. This conclusion applies even when insurance premia are such that the insurance program is revenue-neutral—no support from the taxpayer is involved—under optimal bank behavior.3

• “Deposit insurance that is not actuarially fair, bank-by-bank and period-by-period, distorts the equilibrium value of risky and riskless assets, relative to the no-deposit-insurance benchmark.” Contrary to the assertion, we find that the existence of the distortion depends on how deposit insurance is financed, and also on the detailed specification of what trades agents are able to implement.

2This finding shows that the asset-pricing implications of taxpayer-financed deposit insurance are similar the implications from models of agency problems between investors and portfolio managers: both induce risk-shifting behavior that leads to overvaluation of risky assets; see Allen and Gorton (1993) and Allen and Gale (2000) for a discussion of overvaluation due to agency problems.

3In studying revenue-neutral deposit insurance programs, we follow the typical approach taken by studies of deposit insurance: transfers between the insurance program and the taxpayer are undesirable. The typical approach, however, achieves this using actuarially fair deposit insurance. Boyd, Chang and Smith (2002) present an environment in which actuarially fair deposit insurance is undesirable. Revenue-neutral insurance, as studied here, need not be actuarially fair bank-by-bank or period-by-period, or for non-optimal portfolios.
Under lump-sum insurance premia equilibrium prices of both the risky and the riskless asset are higher than in the absence of deposit insurance. If instead deposit insurance is based on either deposits or holdings of the risky asset, and is revenue-neutral, then there always exists an equilibrium in which some or all agents form shadow banks, thus avoiding participation in deposit insurance. Depending on what trades agents can implement, there may or may not also exist an equilibrium in which asset values are distorted.

1 No Deposit Insurance

In this section a simple model without deposit insurance is specified. This model—in particular, the equilibrium prices of assets—will serve as a benchmark against which to compare the equilibrium prices of assets when commercial banks issue insured deposits. The equilibrium described in this section may be interpreted as that under shadow banking, meaning that agents transfer assets to banks that do not participate in the deposit insurance program.

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 asset and one unit of a risky asset. The riskless asset 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 the risky asset is subject to a multiplicative productivity shock $\varepsilon_1$, different for different agents, so that it becomes $\varepsilon_1$ units of the asset at date 1.

We identify the shocks with the holder of the risky asset rather than with the asset itself. For example, if one bank sells the risky asset to another, as will occur under deposit insurance, the newly acquired asset undergoes the shock of the buying bank, not that of the selling bank.

At date 2 another multiplicative shock $\varepsilon_2$ occurs, resulting in $\varepsilon_1\varepsilon_2$ 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; nevertheless we assume that they do so in order to provide a standard for comparison for the analysis of deposit insurance in the following sections. In this section it is assumed that there is no deposit insurance. Each agent turns over his endowment of the risky and the riskless asset 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).

The value (in units of date-2 consumption) of the bank’s assets is $p_0 + q_0$, where $p_0$ is the unit price of the risky asset and $q_0$ is the unit price of the riskless asset, both to be determined as part of the equilibrium. The date-0 bank balance sheet identity is $d + e_0 = p_0 + q_0$. Agents determine the breakdown of $p_0 + q_0$ 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 $\varepsilon_1\varepsilon_2 + 1 - R$. 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 assets at any date, so in equilibrium each is willing to consume his own endowment of assets. The unit price of the risky asset at date 0 that supports the equilibrium is $p_0 = \frac{[\varepsilon + \bar{\varepsilon}]^2}{4}$, equal to the expectation of $\varepsilon_1\varepsilon_2$. The equilibrium date-0 price of the riskless asset is $q_0 = 1$. The corresponding date-1 unit price of the risky asset is $p_1 = \frac{[\varepsilon + \bar{\varepsilon}]}{2} = E(\varepsilon_2)$. 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 $\varepsilon_1\varepsilon_2 + 1 - \min(Rd, \varepsilon_1\varepsilon_2 + 1) = \max(\varepsilon_1\varepsilon_2 + 1 - R, 0)$. 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 $\varepsilon_2$.4

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4In appealing to “a version of the law of large numbers” we follow a standard practice in applied...
The bank balance sheets at dates 0 and 2 are shown as Tables 1 and 2.

2 Informal Description: Lump-sum Premia

We now modify the model by assuming that the bank regulator insures all commercial 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. The bank regulator makes no payment to equity holders of insolvent banks, who therefore experience a 100 per cent loss. Agents can also turn over their assets to shadow banks in exchange for deposits; if they do so their deposits are not insured.

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 commercial banks or shadow 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 the choices all agents make collectively determine $t$). Thus $t$ plays no role in determining agents’ choices of whether to start a commercial bank or shadow bank, what level of deposits to issue or the asset transactions at date 1. The regulator sets the tax so that the revenue it generates is just sufficient to fund the payments to failed commercial 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 the level of deposits at commercial banks, and also when it is proportional to the holdings of risky assets by commercial banks.

As above, at date 0 each agent is assumed to be able to allocate all or part of his endowments of both the risky and the riskless asset to his bank. Trade between owners of commercial banks and shadow banks is ruled out at all dates, so that assets that are allocated to shadow banks at date 0 remain outside the commercial banking system at dates 1 and 2.

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This difficulty involved in modeling sample outcomes generated by a continuum of realizations of independent random variables: the difficulty is that for any $Y \in [\varepsilon, \bar{\varepsilon}]$ 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.
Table 3: 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)) (risky asset)</td>
<td>(d) (deposits)</td>
</tr>
<tr>
<td>(1 - p_1x) (riskless asset)</td>
<td>(e_1 = (\varepsilon_1 + x)v(\varepsilon_1 + x) + 1 - p_1x - d) (equity)</td>
</tr>
</tbody>
</table>

Each agent has the option of designating part of the value of the assets he turns over to the commercial bank as deposits (subject to deposit insurance), with the remaining value being equity. At date 1 banks realize productivity shocks \(\varepsilon_1\), which are generally different for each bank. Existence of this heterogeneity motivates commercial banks to trade the risky asset among themselves at date 1. Commercial 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 the risky asset. The banks are liquidated at date 2: deposits are paid out and consumption occurs.

Commercial banks that are unable at date 2 to pay their depositors from their own assets receive a transfer from the insurance fund. The total amount paid out, and therefore also 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 the risky and the riskless asset.

Bank balance sheets are shown in Tables 1, 3 and 4.

3 Outline of the Model

We begin with a partial equilibrium analysis in which we assume that in setting up commercial banks all agents choose the same level \(d\) of deposits at date 0, and we take \(d\) as given. In the latter part of this section we will broaden the analysis to include

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\(^5\)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 2

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>((\varepsilon_1 + x)\varepsilon_2) (risky asset)</td>
<td>(d) (deposits)</td>
</tr>
<tr>
<td>(1 - p_1x) (riskless asset)</td>
<td>(d) (deposits)</td>
</tr>
<tr>
<td>(\max[-((\varepsilon_1 + x)\varepsilon_2 + 1 - p_1x - d), 0]) (insurance payment)</td>
<td>(\varepsilon_2 = \max[(\varepsilon_1 + x)\varepsilon_2 + 1 - p_1x - d, 0]) (equity)</td>
</tr>
</tbody>
</table>

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 commercial banks cannot issue, retire or transfer deposits at date 1, implying that bankers cannot use deposits to pay for asset purchases. Instead, banks that buy or sell the risky asset—all banks except those on a boundary—draw down or augment their holdings of the riskless asset according to whether they are buyers or sellers. This device, although artificial, serves to ensure that asset transactions lie in a bounded interval. This fact, plus continuity, assures existence of optimal asset transactions. At date 2 the deposits are withdrawn in the form of the physical good, which the agents then consume. As in Section 1, the bank-held risky asset 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 commercial 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 the productivity shock \(\varepsilon\) at date 1, exchange its endowment of the riskless asset for the risky asset at the equilibrium price \(p_1\) 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. In this region commercial banks will not have comparative advantages or disadvantages in holding the risky asset, so we can neglect trade in the risky asset at date 1. Banks will pay off depositors at date 2 and pay whatever remains to equity holders. With no commercial bank failures, the deposit insurer will set \(t\) equal to zero. The equilibrium values of the risky asset are \([\varepsilon + \overline{\varepsilon}]^2/4 = E(\varepsilon_1\varepsilon_2)\) at date 0 and \([\varepsilon + \overline{\varepsilon}]/2 = E(\varepsilon_2)\) at date 1, as when there is no insurance. The riskless asset has value 1 at both dates. We label the maximum value of \(d\) consistent with all banks honoring deposit obligations without an insurance transfer as \(d^{I-II}\). We have

\[
d \leq d^{I-II} = (\varepsilon + 2/(\varepsilon + \overline{\varepsilon}))\varepsilon.
\]

Now suppose that \(d\) is slightly higher than \(d^{I-II}\), so that commercial banks with low \(\varepsilon_1\) will fail if \(\varepsilon_2\) is also low (note that here we are deferring to the following section
discussion of how optimal trading in the risky asset 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 $p_1 = (\varepsilon + \bar{\varepsilon})/2$ clears the market for the risky asset under the higher value for $d$, as in Region I. Define $\tilde{\varepsilon}(\varepsilon_1)$ as the value of $\varepsilon_2$ such that banks with given $\varepsilon_1$ and $\varepsilon_2 < \tilde{\varepsilon}(\varepsilon_1)$ will fail and banks with $\varepsilon_2 > \tilde{\varepsilon}(\varepsilon_1)$ will not. If $\varepsilon_1$ is high enough so that the bank cannot fail, set $\tilde{\varepsilon}(\varepsilon_1)$ equal to $\bar{\varepsilon}$. Finally, define $\hat{\varepsilon}$ as the lowest value of $\varepsilon_1$ such that $\tilde{\varepsilon}(\varepsilon_1) = \bar{\varepsilon}$. Then banks with $\varepsilon_1 > \hat{\varepsilon}$ 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 banks with $\varepsilon_1 < \hat{\varepsilon}$ 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 the risky asset more attractive to the bank. Because the equilibrium price of the risky asset is equal to its expected payoff, making no allowance for the effect of risky-asset purchases on the future transfer from the deposit insurer, banks which face the possibility of failure will strictly prefer to buy rather than sell the risky asset 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 the risky asset. This is so because the value of the deposit insurance guarantee is zero for these banks, and the conjectured equilibrium price of the risky asset makes no allowance for the value of a transfer from the insurance fund. If the aggregate amount of the risky asset demanded by buying banks is less than the aggregate amount of the risky asset selling banks are willing to supply, as it will be if $d$ is only slightly higher than $d^{II-III}$, the assumed price of the risky asset $p_1 = (\varepsilon + \bar{\varepsilon})/2$ will clear markets. This fact validates the conjecture that the date-1 equilibrium price of the risky asset is the same for $d > d^{II-III}$ as for $d \leq d^{II-III}$ (as in Region I).

Even though the equilibrium prices of the risky and the riskless asset 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 commercial banks know that they run the risk of drawing low values of $\varepsilon_1$ at date 1, in which case they will value the risky asset highly because, in addition to its direct date-2 payoff, the risky asset entitles its owner to the insurance transfer in the event of failure. The equilibrium date-0 price of the risky asset 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 the riskless asset. Its date-0 value also equals the expectation of its date-1 payoff. The value will exceed 1 because commercial banks with low $\varepsilon_1$ use the riskless asset to buy the risky asset, which in turn generates a surplus because its imputed value to buyers is greater than its purchase price.

At higher values of $d$ more commercial banks run the risk of failure. Thus more banks strictly prefer to buy the risky asset at its equilibrium price, and fewer banks are indifferent as to whether to sell or not. For $d$ above a borderline value $d^{II-III}$ banks buying the risky asset demand more of the asset than is available at the price
\( p_1 = (\varepsilon + \epsilon)/2 \) from the selling banks. In that case the date-1 equilibrium price of the risky asset must increase to a level above \((\varepsilon + \epsilon)/2\). At the higher price all banks with high \( \varepsilon_1 \) now strictly prefer to sell the asset rather than hold it. Having sold all of their risky asset, the date-2 equity values of these banks do not depend on the date-2 asset shocks. Banks buying the risky asset each purchase less of the asset at the equilibrium price than they would at the lower price \( p_1 = (\varepsilon + \epsilon)/2 \), making market clearing possible. The borderline value of \( \varepsilon_1 \) that separates the buyers of the risky asset 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, commercial banks with low values of \( \varepsilon_1 \) impute values to the risky asset strictly higher than its transaction price \( p_1 \). The lower is \( \varepsilon_1 \), the higher is the imputed value of the risky asset. This is so because at low values of \( \varepsilon_1 \) the conditionally expected payment from the insurance fund is high. Commercial banks with values of \( \varepsilon_1 \) greater than \( \hat{\varepsilon} \), on the other hand, impute value \( p_1 \) to the risky asset because they sell their entire holding of the risky asset at that price. Because the date-0 price of the risky asset 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 the risky asset can avoid failure with a sufficiently high realization of \( \varepsilon_2 \). Thus each bank that is buying the risky asset 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 \( d^* \).

For \( d > d^* \) commercial 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 the risky asset 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 \( d \leq d^* \), 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

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\(^6\)It would seem that one could avoid the indeterminacy problem by specifying that banks that are certain to fail cannot trade assets. This restriction in fact does not resolve the problem. Even if banks that are certain to fail are prohibited from trading assets, the imputed date-1 values of the risky asset for these banks are not well defined, implying that the equilibrium date-0 values of the risky and the riskless asset 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.
to equal some arbitrary number in the interval \([0, d^*]\) 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 the risky and the riskless asset. The equilibrium date-0 value of both types of assets increases with \(d\), and strictly increases in Regions II and III. Therefore the equilibrium level of \(d\) is \(d^*\): commercial banks set deposits at the highest level permitted by the regulator.

4 An Example

We now present an example of the equilibrium under deposit insurance. Our example will set \(\varepsilon\) equal to 2 and \(\bar{\varepsilon}\) equal to .5, implying that the risky asset is 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 the risky asset 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 asset 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 \(d\) functions of \(d\) between 0 and 2.47. The boundaries for the equilibrium regions discussed in Section 3 are as follows: \(d_{II-I} = 0.65\) and \(d_{II-II} = 1.16\).

The existence of deposit insurance increases the date-0 equilibrium price of the risky asset from 1.56 to 1.82, and it increases that of the riskless asset from 1 to 1.11. This increase in the value of 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 the risky asset occurs at \(\hat{\varepsilon} = 1.54\). The date-1 imputed value of the risky asset ranges between 1.63 and \(p_1\) as \(\varepsilon_1\) ranges between \(\varepsilon\) and \(\hat{\varepsilon}\), and equals \(p_1\) for \(\varepsilon_1 \geq \hat{\varepsilon}\). For a bank with date-1 shock \(\varepsilon_1\) that buys the risky asset \((\varepsilon_1 < \hat{\varepsilon})\) there exists a value of \(\varepsilon_2\), denoted \(\bar{\varepsilon}(\varepsilon_1)\), such that the bank will fail if \(\varepsilon_2 < \bar{\varepsilon}(\varepsilon_1)\) and will not fail if \(\varepsilon_2 > \bar{\varepsilon}(\varepsilon_1)\). In Region III the equilibrium value \(\bar{\varepsilon}(\varepsilon_1)\) lies in the interior of \([\varepsilon, \hat{\varepsilon}]\).\(^7\) The value \(\bar{\varepsilon}(\varepsilon_1)\) is the level of \(\varepsilon_2\)

\(^7\)If we had \(\bar{\varepsilon}(\varepsilon_1) = \varepsilon\) for some level of \(\varepsilon_1\) some banks buying the risky asset would have no risk of failure. But these banks would find the risky asset overpriced in Region III because they do not
Figure 1: Equilibrium asset prices as a function of deposits. Agents set $d$ to maximize expected date-2 consumption, which is equivalent to maximizing $p_0 + q_0$. The equilibrium level of $d$ is $d^*$. 
at which banks generate income just sufficient to pay off the depositors, with nothing left for the equity holders. Thus the borderline point $\tilde{e}(\varepsilon_1)$ equals the value of $\varepsilon_2$ that solves

$$(\varepsilon_1 + x^*(\varepsilon_1))\varepsilon_2 + 1 - p_1 x^*(\varepsilon_1) = d.$$ (1)

Here $x^*(\varepsilon_1)$ is the amount of the risky asset optimally purchased, or sold, if negative, by a bank with shock $\varepsilon_1$. The higher the value of $\varepsilon_1$ the lower the failure threshold $\tilde{e}(\varepsilon_1)$. Solving for $\varepsilon_2$, we have

$$\tilde{e}(\varepsilon_1) = (p_1 x^*(\varepsilon_1) + d - 1)/(\varepsilon_1 + x^*(\varepsilon_1)).$$ (2)

For reference below, we have

$$\text{probability of non-failure} = \frac{\varepsilon - \tilde{e}(\varepsilon_1)}{\varepsilon - \varepsilon},$$ (3)

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

$$\text{expected equity} = (\varepsilon_1 + x^*(\varepsilon_1))((\varepsilon + \tilde{e}(\varepsilon_1))/2) + 1 - p_1 x^*(\varepsilon_1) - d.$$ (4)

We turn to the determination of $x^*(\varepsilon_1)$. As noted above, we assume that banks that buy the risky asset do so using their endowment of the riskless asset to make payment. They cannot sell short the riskless asset, implying that their maximal purchase of the risky asset is $1/p_1$. Similarly, banks selling the risky asset cannot sell it short. Because of these restrictions, $x$ is constrained to lie in the interval $[-\varepsilon_1, 1/p_1]$, assuring the existence of optimal $x$.

Banks choose $x$ to maximize date-1 bank equity, equal to the probability of non-failure, (3), multiplied by the expectation of date-2 bank equity conditional on non-failure, (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)

$$= \max_{x \in [-\varepsilon_1, 1/p_1]} \left( \frac{\varepsilon - \tilde{e}(\varepsilon_1)}{\varepsilon - \varepsilon} \right) \left( \varepsilon_1 + x \left( \frac{\varepsilon + \tilde{e}(\varepsilon_1)}{2} \right) + 1 - p_1 x - d \right),$$ (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 the risky asset above cost, $(\varepsilon_1 + x)\varepsilon_2 - p_1 x$, but also on the expectation of the next-period benefit from deposit insurance. Therefore they would prefer to sell rather than buy the risky asset. All banks selling an asset is inconsistent with market clearing.
insurance payment, because the latter is capitalized into the date-1 value of the risky asset. (Recall that, from Table 4, date-1 bank equity equals the expected date-2 direct payoff on the risky asset plus the expected date-2 insurance payout, plus the holding of the riskless asset, less deposits).\footnote{Note that because banks' choices of \( x \) affect the value of the insurance payout as well as the date-2 payoff on the risky asset, the imputed value of the risky asset at date 1 does not necessarily equal the conditional expectation of its payoff at date 2.}

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 the risky asset. 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 the risky asset more highly than banks with higher \( \varepsilon_1 \). There exists a boundary point \( \hat{\varepsilon} \) such that \( x^*(\varepsilon_1) = 1/p_1 \) for \( \varepsilon_1 < \hat{\varepsilon} \) and \( x^*(\varepsilon_1) = -\varepsilon_1 \) for \( \varepsilon_1 > \hat{\varepsilon} \).

We can define a function \( v(\varepsilon_1 + x^*(\varepsilon_1)) \) giving the date 1 unit value of the risky asset post-purchase or -sale associated with each value of \( \varepsilon_1 \). For banks buying the risky asset 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 of the risky asset 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 \( \varepsilon_1 \), reaching \( p_1 \) at \( \varepsilon_1 = \hat{\varepsilon} \).

For banks with \( \varepsilon_1 > \hat{\varepsilon} \) the risky asset is valued at \( p_1 \) since these banks will sell their risky asset at that price.\footnote{To see that \( v \) is continuous at \( \hat{\varepsilon} \), note that we have} 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)

\( (9) \) (this extension is necessary as a separate specification because the date-1 bank balance

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

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

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.

\footnote{As the notation implies, the valuations of the risky asset apply only for optimal \( x \). For example, the valuation of the risky asset for banks selling the asset does not equal \( p_1 \) for \( x \neq -\varepsilon_1 \). To see this, note that for any bank with \( \varepsilon_1 > \hat{\varepsilon} \) continuity combined with 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 \(-\varepsilon_1\)) such that the bank will remain solvent with certainty for that \( x \). In that case the bank’s risky asset holding \( \varepsilon_1 + x \) has unit value \((\varepsilon + \hat{\varepsilon})/2\). This is strictly less than \( p_1 \), reflecting the suboptimality of \( x > -\varepsilon_1 \).}
sheet cannot be used to define \( v \) for \( \varepsilon_1 > \hat{\varepsilon} \) due to 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 the risky asset, who each buy \( 1/p_1 \) units, and the sellers, who sell \( \varepsilon_1 \) units, it is determined by the equilibration of supply and demand for the risky asset:

\[
(\hat{\varepsilon} - \varepsilon)/p_1 = E(\varepsilon_1|\varepsilon_1 \geq \hat{\varepsilon})(\varepsilon - \hat{\varepsilon}).
\] (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 the risky asset 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 the risky asset 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 the risky asset equals the expected date-1 value of the risky asset, with the expectation taken over the distribution of \( \varepsilon_1 \):

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

Similarly, the date-0 value of the agents’ endowment of the riskless asset is the expectation of its date-1 value:

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

The expression on the right-hand side results from the fact that a unit of the riskless asset at date 1 has value \( v(\varepsilon_1 + x^*(\varepsilon_1))/p_1 > 1 \) if the bank turns out to be a buyer of the risky asset, 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.\(^\text{12}\) Therefore \( t \) can be

\(^\text{12}\)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 \( \varepsilon_2 + \varepsilon_1^2/4 + 1 \), equal to the endowment of the riskless asset plus the expected date-2 value of the risky asset. The insurance program involves nothing more than a redistribution of the endowment, so the sum of the initial value of the risky and the riskless asset must exceed the value in the absence of deposit insurance by exactly the amount of the tax. Therefore the latter can be calculated directly.
evaluated by calculating the total payments to failed banks, which in turn equals the
sum of the date-0 values of the risky and the riskless asset 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 using lump-sum
taxes paid by the agents to the insurer. As noted, this specification has the convenient
implication that the financing of deposit insurance can be ignored in determining the
equilibrium. However, lump-sum financing of deposit insurance does not correspond
to the real-world situation. In the United States banks have historically paid insurance
premia to the Federal Deposit Insurance Corporation based either on the amount of
deposits that are insured or on such variables as the bank’s assets and the adequacy of
the FDIC’s insurance fund. In this section we assume that deposit insurance premia
are based on deposits.

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 to commercial banks 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. Commercial banks
take the insurance premium per unit of deposits $\delta$ as given. Agents can also create
shadow banks. These do not benefit from deposit insurance, and their deposits are
not subject to the insurance premium. 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 revenue-neutral when the lump-sum taxes aggregate to
zero under optimal portfolio choices of commercial banks. We will focus on this case.
If, on the contrary, premia are set below the revenue-neutral rate the equilibrium
combines features of the equilibrium discussed here and that treated in the preceding
section. If premia are higher than the revenue-neutral rate agents will not create
commercial banks.

In the preceding section we saw that when deposit insurance is financed entirely
using lump-sum taxes the tax is not capitalized into the values of the risky and the
riskless asset. This being so, asset values were seen to be an increasing function
of $d$ because the expected transfer from the insurer increased with $d$. The unique
equilibrium involved all agents forming commercial banks and operating these banks
so as to take maximal risk; bankers benefit maximally from the insurance transfer
only if they do so. They ignore the tax in their decision-making because they pay it
regardless of the amount of risk they take and regardless of whether or not they create
commercial banks. In contrast, under deposit-based insurance premia agents can
avoid paying the premium if they form shadow banks rather than commercial banks, and can benefit from low payments for deposit insurance if they form commercial banks but issue low levels of deposits.

Derivation of date-0 asset 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 the risky and the riskless asset, as a function of \( d \). It is assumed that the insurance rate \( \delta \) is set so that deposit insurance is revenue-neutral when deposits are set equal to the maximal value consistent with all banks having a 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 facts that (1) the expected transfer from the insurance fund is a convex increasing function of \( d \), while (2) the funds collected from insurance premia are proportional to \( d \), and (3) the insurance is revenue-neutral for \( d = 0 \) (trivially) and \( d = d^* \) imply that the summed values of the risky and the riskless asset are equal at these extreme values of \( d \). The summed value of the risky and the riskless asset at intermediate values of \( d \) is lower than this value at the endpoints, implying that intermediate values of \( d \) are not candidates for optima.

Figure 2 also shows \( p_0 \) and \( q_0 \) separately. For low levels of \( d \) the value of the risky
asset $p_0$ decreases with $d$. The decrease reflects the convexity of the net transfer from the insurance fund as a function of $d$. To understand the convexity, 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 value of the risky asset will decline. At higher levels of $d$ the value of the insurance transfer increases with $d$ more than in proportion to $\delta d$, so the decreasing effect of $d$ on $p_0$ is reversed. At $d = d^*$ insurance is revenue-neutral, implying that the summed value of the risky and the riskless asset at $d = d^*$ equals that at $d = 0$. The effect of increasing $d$ on the price $q_0$ of the riskless asset shows the same pattern. This occurs because the excess of $q_0$ over 1 is based on the exchange value of the riskless asset in obtaining the surplus $v(\varepsilon_1 + 1/p_1) - p_1$ available to low-$\varepsilon_1$ commercial banks from buying the risky asset. The fact that increasing $d$ raises $v(\varepsilon_1 + 1/p_1)$ more than in proportion to $p_1$ implies that, for high $d$, $q_0$ will increase with $d$ just as $p_0$ does.

We have two candidate equilibria for bank behavior ($d = 0$ and $d = d^*$). Agents are indifferent between (1) creating shadow banks and issuing arbitrary levels of deposits, and (2) creating commercial banks and issuing maximal levels of deposits. Some agents will do one and some will do the other. The aggregate value of their assets is the same in either case. However, the equilibrium values of the risky and the riskless asset differ for commercial and shadow banks. This fact is consistent with equilibrium because by assumption agents forming commercial banks cannot trade with those forming shadow banks.

The assumption that agents cannot trade assets at date 0 seems, and is, arbitrary. In general, if it is relaxed the equilibrium behavior of commercial banks must be recomputed because if date-0 trade is nonzero agents have unequal holdings of the risky and the riskless asset. Doing so is a major undertaking. Rather than do this we opt to impose a requirement that agents can only create commercial banks with equal amounts of the risky and the riskless asset. This assumption, while no less arbitrary than the assumption that agents forming commercial banks cannot trade with agents forming shadow banks, results in an easy analysis of equilibrium.

Under the assumed respecification the only equilibrium involves the asset prices appropriate for the shadow banks. This is so because if agents trade at date 0 at those prices they necessarily value the risky and the riskless asset at the prices appropriate for shadow banks because by assumption they cannot employ whichever asset they purchase in creating commercial banks. In equilibrium agents will be indifferent about the direction and magnitude of trade at date 0. They are also indifferent about whether to create shadow banks or commercial banks; the shadow prices of assets are different in the two cases, but by assumption there is no way to exploit the difference.

In this case the assertion that revenue-neutral deposit insurance financed by deposit-based premia does not distort equilibrium asset prices is seen to be correct.

It should be noted that revenue-neutral insurance has the property that aggregate transfers from banks with high realizations of the shocks to banks with low realizations
sum to zero. Thus no support from taxpayers is involved. As noted, if a commercial bank were to adopt an intermediate risk profile it would find that deposit insurance is overpriced relative to the expected benefit; that is why the intermediate risk profile is suboptimal. Revenue-neutral insurance is not actuarially fair bank-by-bank and period-by-period, and does not obtain for suboptimal portfolios. After the date-1 shocks have been realized the insurance is, of course, not actuarially fair: banks with high realizations of $\varepsilon_1$ are net losers from deposit insurance (in expectation) and banks with low realizations of $\varepsilon_1$ are net beneficiaries. Under actuarially fair insurance premia, the insurance premium would depend on $\varepsilon_1$, so that banks with high $\varepsilon_1$ pay lower premia than banks with low $\varepsilon_1$. In that case actuarial fairness would imply that banks are indifferent whether to buy or sell the risky asset after drawing $\varepsilon_1$ since in that case they would value deposit insurance net of the premium at zero regardless of $\varepsilon_1$, so there would be no differences among banks in the attractiveness of the risky asset.\(^{13}\)

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. In the United States the Federal Deposit Insurance Corporation is now moving in that direction. We can easily adapt the present model so that insurance premia are based on holdings of risky assets rather than deposits. We assume that banks pay premia proportional to their date 1 holdings of the risky asset, with the factor of proportionality $\lambda$. Therefore a bank that gets the date-1 shock $\varepsilon_1$ and buys $1/p_1$ units of the risky asset pays the premium $\lambda(\varepsilon_1 + 1/p_1)$. A bank that sells all of its risky asset at date 1 does not pay an insurance premium. As with the deposit-based premia of the preceding section, it is assumed that the date-2 insurance transfer is net of the insurance premium and that $\lambda$ is set so that insurance is revenue-neutral under optimal behavior by banks.

In most respects replacing deposit-based insurance premia with risky-asset-based premia does not change the analysis much. As before, agents electing to form shadow banks are not affected by deposit insurance. Also, the maps from $d$ to $p_0$ and $q_0$ are convex under asset-based premia, and for the same reason as under deposit-based premia. Consequently deposit insurance is revenue-neutral when commercial banks take maximally risky positions, and would not be revenue-neutral when commercial banks choose a less extreme position. The only difference is that at low levels of $d$ values of the risky and the riskless asset under asset-based premia are flat rather than decreasing in $d$, reflecting the obvious fact that under deposit-based premia commercial

\(^{13}\)Prescott (2002) showed that if deposit insurance is actuarially fair and the regulator can observe bank behavior, then suitably chosen premia can eliminate the moral hazard problem. In the models presented here, in contrast, the moral hazard problem persists despite the absence of information asymmetries because deposit insurance is revenue-neutral, not actuarially fair.
Figure 3: Equilibrium asset prices with risk-based premia. For comparison the dashed horizontal lines show asset prices in the no deposit insurance case; in this case the price of the risky asset is 1.56 and that of the riskless asset is 1.
banks cannot decrease their premia by issuing low levels of deposits (Figure 3). This difference does not affect the equilibrium set, implying that the analysis of equilibrium laid out in the preceding section also applies here. We conclude that changing from deposit-based premia to asset-based premia has no material effect on the analysis of deposit insurance.

8 Conclusion

We have shown that, if one abstracts 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 insured deposits rises more than in proportion to bank leverage. If deposit insurance premia are based on deposit levels or risky asset holdings agents can avoid the premia by forming shadow banks. In equilibrium agents are indifferent between forming shadow banks and forming commercial banks, as long as maximally risky portfolios are chosen in the latter case. As to the effect of deposit insurance on equilibrium asset prices, that depends on the specification of what trades agents can implement. There always exists an equilibrium under which asset prices are the same as would prevail in the absence of deposit insurance, and there may or may not exist an additional equilibrium in which those prices coexist with a pair of prices that are distorted by deposit insurance.

We recognize that the clean conclusions of this paper do not extend in any simple way to the real world.\(^\text{14}\) Our model incorporated several major simplifications:

- It was assumed that 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 commercial banks to hold an infinite long position in some assets and an infinite

\(^{14}\) Nobu Kiyotaki expressed the view that the models in this paper are “too clean”, perhaps meaning that they depend too much on arbitrary simplifying assumptions. Maybe so.
short position in others, 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 revenue-neutral 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 there is no reason to exclude the relevant financial markets. Given the existence of complete financial markets, however, banks would disappear, as shown by Freixas and Rochet (2008). 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


