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Deposit Insurance and Moral Hazard

MITSURU IWAMURA

It is well known that deposit insurance creates a "moral hazard" problem as it increases the risk attaching to the asset portfolios of commercial banks. However, no precise answers have been given as to what characterize the risk incentive mechanism of commercial banks under deposit insurance systems, and as to whether the system of variable deposit insurance premiums, which is often regarded as a more consistent framework, can resolve the "moral hazard" problem. The purpose of this paper is to estimate the risk premiums of deposit insurance systems, using numerical integration under certain simplified assumptions, and to offer some answers to the above questions. The functions of Japan's deposit insurance system extend beyond simple insurance payoffs and include rescue operations and merger assistance. The former function guarantees only the principal of bank deposits while the latter covers both principal and interest. These functional differences create some difficulties in resolving the "moral hazard" problem.

I. Introduction

This paper considers theoretical issues relevant to the concept of *moral hazard*, which is often stressed when the soundness of banks is discussed, especially in relation to deposit insurance systems.[1]

In the context of a deposit insurance system, moral hazard is typically said to occur when a bank experiencing a management crisis tries to attract deposits by offering a high deposit rate and invests the funds so obtained in very risky projects. In this situation, deposit insurance itself has led to moral hazard because it has paralyzed the function of the deposit market, which would otherwise have properly evaluated the increased risk to bank assets. This situation indeed appears to be a realistic scenario and makes many

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[1]The standard approach to the moral hazard problem of deposit insurance is an analysis based on the options theory (Merton (1977)). Many studies along this approach have most recently been surveyed, for example, by Berlin, *et al.* (1991). However, this paper chose not to use the standard approach based on the options theory in order to facilitate an understanding of the issues by means of a more simplified specification.

uneasy. Upon examination, however, it is not necessarily clear which aspect of the scenario runs counter to our 'morals' and how it damages the rationality of economic society.

The scenario may be called a moral hazard because a bank should always exercise discipline in extending loans for risky projects. From this point of view, the problem is that a deposit insurance system encourages banks to invest in risky assets. Although moral hazard has other aspects,[2] this paper only considers the effect of deposit insurance on the investment behavior of banks and how this type of moral hazard is generated. Solutions to the problem are then explored.

The paper can be summarized as follows. Section II examines how the behavior of the stockholders or managers of a bank is influenced by the presence or absence of deposit insurance. It shows that a deposit insurance system creates an incentive for them to allocate a greater amount of assets to projects with a greater degree of risk (that is, a greater variance of the rate of return). Section III discusses how insurance premiums can be set to eliminate such an incentive (or the moral hazard aspect of deposit insurance)and presents several numerical examples to reveal how premiums may be calculated under certain assumptions. Section IV, which includes the remaining issues and an explanation of the usefulness of our analysis, discusses how the paper can be used to solve or minimize moral hazard.

II. The Moral Hazard Effect of Deposit Insurance

A. Without Deposit insurance

First, we model the optimal strategic behavior of bank stockholders (or managers) in the absence of deposit insurance. To simplify discussion, we assume riskless assets whose rate of return has zero variance in the financial market, also that the monetary authorities can perfectly control the rate of return of the riskless assets, represented by m.

We further assume that the liability side of the bank balance sheet is made up of one unit of capital and u units of deposits. Then, bank assets at the beginning and end of a period can be expressed as follows:[3]

Assets at the beginning of a period: $1 + u$
Assets at the end of a period: $(1 + u)x$

where x is a stochastic variable that shows how one unit of bank assets increases from the beginning to the end of a period. The density function of x is given by $f(x)$, its expected

[2] For example, a situation may be envisaged in which the managers (or stockholders) of a failing bank form an implicit coalition with the depositors to maximize receipts from deposit insurance.

[3] Here we ignore the cost of bank operations (or we assume that the cost is proportionate to asset size).

value by θ, and its variance by σ^2.[4]

Given these assumptions, we express the return (principal and interest) obtained by depositors at the end of the period as y, and the return obtained by stockholders as z. Both y and z then become stochastic variables whose values can be specified as follows. Here r is the contractual deposit rate agreed on between the bank and the depositors at the beginning of the period.

(i) When bank assets at the end of the period are less than the amount the bank had agreed to pay depositors at the beginning of the period, depositors will claim all bank assets and stockholders will receive nothing. That is, when

$$(1+u)\,x \le (1+r)\,u\,, \tag{1}$$

we have

$$y=(1+u)\,x\,, \qquad z=0. \tag{2}$$

(ii) When bank assets exceed the amount the bank at the beginning of the period had agreed to pay the depositors at the end of the period, depositors will receive the agreed amount and stockholders the residual. That is, when

$$(1+r)\,u \le (1+u)\,x\,, \tag{3}$$

we have

$$y=(1+r)\,u\,, \qquad z=(1+u)\,x-(1+r)\,u\,. \tag{4}$$

Let us assume that the objective of bank managers is to maximize the expected profits of stockholders $E(z)$. Then, by expressing the critical value of x obtained from equation (1) or (3) as

$$\alpha=\frac{(1+r)\,u}{1+u}\,,$$

we can obtain the following expression of $E(z)$,

$$\begin{aligned} E(z)&=\int_\alpha^\infty\{(1+u)x-(1+r)u\}\,f(x)dx \\ &=(1+u)\theta-(1+r)u+\int_0^\alpha\{(1+r)u-(1+u)x\}\,f(x)dx\,. \end{aligned} \tag{5}$$

Consequently, the objective of bank managers can be restated as maximizing the value of equation (5).

A noteworthy aspect of equation (5) is the third term, which takes a positive value within the domain of the integral ($0 \leqq x \leqq \alpha$), with the value depending on the distribution of ROA ($=x$), which is given by $f(x)$. If we assume that u is constant, the value of the term increases as the dispersion of $f(x)$ increases (*i.e.* as variance increases for a given

[4]That is, $f(x) \geqq 0$, $\int_0^\infty f(x)dx=\theta$, $\int_0^\infty (x-\theta)^2 f(x)dx=\sigma^2$.

expected value and distributional shape). This result seems to imply that, given the choice of several investment opportunities with the same expected returns (θ), that with greater risk (*i.e.* a greater variance of return) is preferred by bank managers (and more beneficial to stockholders). If this is the case, it is the organization of banks as limited liability corporations that creates a moral hazard problem (by increasing the risk of society's investment portfolio). The question of deposit insurance then becomes secondary.

However, it is still premature to make this judgement. The possibility remains that even if bank managers chose a riskier investment opportunity, the deposit market might properly assess the increased risk and raise the deposit interest rate. If this happened, the market mechanism would offset bank managers' incentives.

To be specific, from equations (1), (2), (3), and (4), we can express depositors' expected rate of return $E(y)$ as:

$$E(y)=\int_0^{\alpha}(1+u)\,xf(x)dx+\int_{\alpha}^{\infty}(1+r)\,uf(x)dx$$
$$=(1+r)u+\int_0^{\alpha}\{(1+u)x-(1+r)u\}\,f(x)dx\,.$$

If we assume that depositors are risk neutral and have perfect information about the behavior of bank managers, this value would equal the rate of return obtainable from investing u units of funds in riskless assets.[5]

$$E(y) = (1 + m)\,n$$

By transforming this, we obtain

$$r = m+\frac{1}{u}\int_0^{\alpha}\{(1+r)u - (1+u)x\}\,f(x)dx\,. \tag{6}$$

By substituting equation (6) for equation (5), we have

$$E(z) = (1+u)\theta-(1+m)u\,. \tag{7}$$

If we further assume that there is perfectly risk neutral arbitrage between riskless assets and the investment opportunities of the bank, we have the following relationship:

$$\theta = 1 + m.$$

This means that equation (7) can be further reduced to

$$E(z) = 1 + m. \tag{8}$$

This is, if depositors fully assess the investment behavior and the risk of the bank at

[5]We assume that depositors completely ignore the value of deposit services (*e.g.* settlement services). If they value such services, the expected yield of deposits ($E(y)/u$) will be less than the rate of riskless assets return (m) by the amount equal to the marginal cost of deposit services under perfect competition and other assumptions.

the beginning of the period (at the time of the deposit contract), the additional profits the bank obtains from investing in riskier investment projects are absorbed by an increase in the deposit rate (equation (6)). As a result, no benefit accrues to stockholders (equation (7) or (8)). In other words, moral hazard arising from the limited liability of stockholders is prevented by the operation of the deposit market.[6]

The validity of the assumption that depositors fully assess the investment behavior and risk of a bank at the beginning of a period is open to question. Realistically, it is difficult to imagine that depositors fully monitor a bank's asset composition and investment strategy. If this is the case, some form of moral hazard must be inherent in the depositor-bank relationship because of the limited liability of stockholders, regardless of the existence of a deposit insurance system.[7] Although this problem is beyond the scope of this paper, it is important to note that deposit insurance is not the only cause of moral hazard.

B. With Deposit Insurance

We will discuss how depositors' return (y) and stockholders' return (z) change when there is deposit insurance. Here we should keep in mind two possible broad interpretations of the function of deposit insurance.

The Deposit Insurance Law of Japan stipulates that deposit insurance covers the principal (Article 54), not the interest.

However, the activities of the deposit insurance system go beyond the payment of principal when it rescues the depositors of financial institutions experiencing payment difficulties. For example, it can provide financial assistance to a failing institution while arranging for a merger with other institutions (Articles 59 to 67). In effect, such activities cover not only the principal, but also the interest.

In recognition of these two aspects of the function of the deposit insurance system, we will hereafter term the first 'deposit insurance guaranteeing principal' and the second, 'deposit insurance guaranteeing principal and interest.'

1. Deposit insurance guaranteeing principal

Depositors' return (y) and stockholders' return (z) at the end of the period can be

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[6]If bank stockholders had unlimited liability, their expected return becomes

$$E(z) = \int_{\alpha}^{\infty}\{(1+u)x - (1+r)u\}f(x)dx = (1+u)\theta - (1+r)u.$$

If we assume that depositors are not concerned about the ability of stockholders to raise additional funds, the deposit interest rate (r) under unlimited liability would coincide with the rate of riskless assets (m). That is,

$$E(z) = (1+u)\theta - (1+m)u, \quad \text{or} \quad E(z) = 1+m.$$

Viz, equation (7) or (8) is equal to the stockholders' rate of return under unlimited liability.

[7]This problem is discussed more generally in the context of corporate finance, in which agency cost arises between stockholders and bondholders.

specified as follows; p is deposit insurance premium (per unit of deposit):

(i) When bank assets at the end of the period after the payment of insurance premium are less than deposit principal, depositors will receive the principal from deposit insurance and stockholders nothing. That is, when

$$(1+u)x - pu \leq u, \tag{9}$$

we have

$$y = u, \quad z = 0, \tag{10}$$

(ii) When bank assets at the end of the period after the payment of insurance premium are sufficient to repay the deposit principal but not enough to pay the interest agreed on, depositors will receive all bank assets and stockholders nothing. That is, when

$$u \leq (1+u)x - pu \leq (1+r)u\,, \tag{11}$$

we have

$$y = (1+u)x - pu, \qquad z = 0\,. \tag{12}$$

(iii) When bank assets at the end of the period after the payment of insurance premium are sufficient to pay the interest agreed on, depositors will receive the agreed amount and stockholders the residual. That is, when

$$(1+r)u \leq (1+u)\,x - pu, \tag{13}$$

we have

$$y = (1+r)u, \quad z = (1+u)x - (1+r+p)u. \tag{14}$$

In this case, let us express the critical value of x obtained from equation (13), or the right-hand side of equation (11), as

$$\beta = \frac{u}{1+u}(1+r+p).$$

Stockholders' expected return $E(z)$, which bank managers maximize, can then be expressed as

$$\begin{aligned} E(z) &= \int_{\beta}^{\infty}\{(1+u)x-(1+r+p)u\}f(x)dx \\ &= (1+u)\theta-(1+r)u-pu-\int_{0}^{\beta}\{(1+u)x-(1+r+p)u\}f(x)dx\,. \end{aligned} \tag{15}$$

On the other hand, let us express the critical value of x obtained from equation (9), or the left-hand side of equation (11), as

$$\gamma = \frac{u}{1+u}(1+p)\,.$$

Depositors' expected return can then be expressed as

$$E(y)=\int_0^{\gamma} uf(x)dx+\int_{\gamma}^{\beta}\{(1+u)x-pu\}f(x)dx+\int_{\beta}^{\infty}(1+r)uf(x)dx$$
$$=(1+r)u+\int_0^{\gamma}\{(1+p)u-(1+u)x\}f(x)dx+\int_0^{\beta}\{(1+u)x-(1+r+p)u\}f(x)dx\ .$$

However, if we assume that depositors are risk neutral and have perfect information, as we did in A. of this section, we have the following relationship.

$$\mathrm{E}(y) = (1 + m)u$$

This means that we can obtain the following arbitrage condition in the deposit market:

$$\int_0^{\beta}\{(1+u)x-(1+r+p)u\}\,f(x)dx=(m-r)u-\int_0^{\gamma}\{(1+p)u-(1+u)x\}\,f(x)dx. \quad (16)$$

By substituting equation (16) for equation (15) and rearranging, we have

$$E(z)=(1+u)\theta-(1+m)u-pu+\int_0^{\gamma}\{(1+p)u-(1+u)x\}f(x)dx$$
$$=(1+u)\theta-(1+m)u-pu+\int_0^{\frac{u}{1+u}(1+p)}\{(1+p)u-(1+u)x\}f(x)dx. \quad (17)$$

With the further assumption of perfect arbitrage between riskless assets and the investment opportunities of the bank (*i.e.* $\theta=1+m$), we can reduce equation (17) to

$$E(z)=1+m-pu+\int_0^{\frac{u}{1+u}(1+p)}\{(1+p)u-(1+u)x\}f(x)dx. \quad (18)$$

That is, all the benefits or costs of deposit insurance accrue to the stockholders. As a result, stockholders' expected return differs from the return obtainable in the absence of deposit insurance by the difference between equation (18) and equation (8), *i.e.*,[8]

$$M=-pu+\int_0^{\frac{u}{1+u}(1+p)}\{(1+p)u-(1+u)x\}f(x)dx. \quad (19)$$

If M (hereafter termed the net benefit of deposit insurance) is positive, stockholders receive benefits from deposit insurance; if negative, they incur losses.

2. *Deposit insurance guaranteeing principal and interest*

Next we specify depositors' return and stockholders' return when deposit insurance covers both principal and interest.

(i) When bank assets at the end of the period after the payment of insurance premium are less than the amount that the bank had agreed to pay at the beginning of the period, depositors receive the agreed on amount from deposit insurance and stockholders nothing. That is, when

$$(1 + u)\,x - pu \leq (1 + r)\,u, \quad (20)$$

we have

$$y = (1 + r)\,u, \qquad z = 0. \quad (21)$$

[8]Without assuming perfect arbitrage between riskless assets and the investment opportunities of the bank, M would be obtained by subtracting equation (7) from equation (17). The result would be the same.

(ii) When bank assets at the end of the period after the payment of premium exceed the amount agreed on with depositors, depositors receive the agreed on amount and stockholders the residual. That is, when

$$(1+r)\,u \leq (1+u)\,x - pu, \tag{22}$$

we have

$$y = (1+r)\,u, \quad z = (1+u)\,x - (1+r+p)\,u. \tag{23}$$

By expressing critical value as

$$\beta = \frac{u}{1+u}\,(1+r+p)$$

we can express stockholders' expected return $E(z)$ as

$$\begin{aligned} E(z) &= \int_{\beta}^{\infty}\{(1+u)x-(1+r+p)u\}\,f(x)dx \\ &= (1+u)\theta-(1+r)u-pu+\int_0^{\beta}\{(1+r+p)u-(1+u)x\}\,f(x)dx\,. \end{aligned} \tag{24}$$

By noting that deposits are now made riskless by virtue of the existence of deposit insurance, the following relationship must hold:

$$r = m.$$

Thus, critical value (β) is expressed as

$$\beta = \frac{u}{1+u}\,(1+m+p)$$

and equation (23) can be expressed as

$$\begin{aligned} E(z) &= (1+u)\theta-(1+m)u-pu+\int_0^{\beta}\{(1+m+p)u-(1+u)x\}f(x)dx \\ &= (1+u)\theta-(1+m)u-pu+\int_0^{\frac{u}{1+u}(1+m+p)}\{(1+m+p)u-(1+u)x\}f(x)dx. \end{aligned} \tag{25}$$

Assuming perfect arbitrage between riskless assets and the investment opportunities of the bank, equation (24) can be further reduced to

$$E(z) = 1+m-pu+\int_0^{\frac{u}{1+u}(1+m+p)}\{(1+m+p)u-(1+u)x\}f(x)dx. \tag{26}$$

When deposit insurance guarantees both principal and interest, M can be obtained by subtracting equation (8) from equation (26), that is,[9]

$$M = -pu + \int_0^{\frac{u}{1+u}(1+m+p)}\{(1+m+p)\,u - (1+u)x\}\,f(x)dx. \tag{27}$$

[9]Without assuming perfect arbitrage between riskless assets and the investment opportunities of the bank, M is obtained by subtracting equation (7) from equation (25). The result would be the same.

The result differs from that obtained when deposit insurance only guaranteed principal because the riskless yield (m) appears both in the domain of integration and in the integrand.

C. Moral Hazard Effect of Deposit Insurance

The preceding analysis has clarified the function of a deposit insurance system. The presence such a system has no effect on depositors' expected return; its effect accrues entirely to stockholders. How much stockholders will benefit (or lose) is expressed as the net benefit of deposit insurance (M), given either by equation (19), when the insurance guarantees principal only, or equation (27), when it guarantees principal and interest.

The net benefit of deposit insurance (M) depends not only on insurance premium (p) and the ratio of deposits to capital (u), but also on the distribution of asset return $f(x)$. As the dispersion of $f(x)$ increases (*i.e.* as the variance increases for a given mean value and distributional shape), M increases. From this we can conclude that a deposit insurance system creates an incentive for bank managers or stockholders to hold riskier portfolios. Thus, moral hazard aspect of a deposit insurance system stems from this risk-increasing effect.

However, it is not fair to say that because of this tendency to heighten risk that deposit insurance only has negative consequences for society. The possibility exists that some degree of risk is necessary in society's portfolio in order to encourage investment in new ideas and projects, thereby improving social welfare in the long run. From this standpoint, the risk increasing effect of deposit insurance becomes problematic only when it increases the level of risk beyond the socially agreed on acceptable level.

Deposit insurance does affect the portfolio selection behavior of banks. However, it is difficult to predetermine the optimal amount of risk bearing (or risk averse) incentive that should be included in the insurance system. However, some might hold that the actual behavior of banks could become more risk bearing than is socially acceptable. The moral hazard aspect of the deposit insurance system should be criticized only when it is not equipped with a mechanism to prevent banks from taking more risk (as a result of deposit insurance) than is socially permissible. Thus, we will next discuss the concept of variable deposit insurance premiums, which control the risk bearing incentives of bank managers.

III. Risk Neutral Insurance Premiums

A. Risk Neutral Insurance Pemiums

Let us look at either equation (19) or equation (27), which show the net benefit of deposit insurance to stockholders. Of the variables included (*i.e.*, deposit insurance premium (p), ratio of deposits to capital (u), rate of asset return (x) and its probability density $f(x)$, and rate of riskless asset return (m)), policymakers can only control insurance premium. The concept of variable insurance premiums is based on the idea that policymakers eliminate the risk bearing incentive of deposit insurance by means of p. In the following, insurance premium, fixed set to eliminate the risk bearing incentive of deposit insurance, is termed 'risk neutral insurance premium.'

This concept is not the same as the monitoring of bank portfolio selections and policymakers subsequently raising premiums as penalties when banks undertake excessive risk. This follows from the fact that once such increased penalties have been imposed *ex post*, insurance premiums no longer control subsequent portfolio selection. Risk neutral insurance premiums must be such that the extent to which they are raised as a result of a particular risk-bearing activity is demonstrated *ex ante*, influencing the future behavior of banks. That is, risk-neutral insurance premiums should be given in a table that shows how premiums will change according to risk variation (premiums are variable in the sense they vary with the degree of risk).

Risk neutral insurance premiums can typically be given by setting p to equate expected deposit insurance payments to premiums, that is,

$$M = 0.$$

In this case, deposit insurance is risk neutral in the sense that it gives neither benefit nor loss to the bank (or stockholders) concerned. At the same time, premiums are then considered to be fair.

If our objective is only to eliminate the risk bearing incentive of deposit insurance, the expected payment from deposit insurance need not be the same as the premium. The necessary condition for eliminating the risk bearing incentive of deposit insurance is that when the expected payment changes, premiums change by the same margin. Premiums need not be the same as expected payments in absolute terms. The condition which insurance premiums must satisfy to eliminate the risk bearing incentive of deposit insurance is given by

$$M = C \quad (C \text{ is a constant}).$$

That is, there are as many risk-neutral insurance premiums as the value of C. The case of fair insurance premiums is only a special case in which C=0 is satisfied.[10]

In general, existing literature suggests that a system in which insurance premiums

[10]Let us here consider the sustainability of risk neutral insurance premiums. If the deposit insurance system is optional in its participation, we cannot set the premium so that C<0 because no bank would join the system. On the other hand, if deposit insurance is operated by a private insurance company on a profit basis, premiums cannot be set C>0 because no insurance company would make a profit. Consequently, as long as deposit insurance is optional and provided by a private insurance company in a fashion similar to any other type of insurance, the only feasible insurance premiums are achieved at C=0 (*i.e.* fair premiums). Put differently, if the deposit insurance system is operated by the government and participation is mandatory, risk neutral insurance premiums need not be fair, thus C can take any value.

vary according to degree of risk is an effective approach to eliminating the risk bearing incentive of deposit insurance. At the same time, it points out the technical difficulty in determining premiums, as well as the greater burden such a system would place on the management of smaller financial institutions, by raising them in accordance with degree of risk.[11] However, analysis here suggests there is a technical solution to smaller financial institutions being subjected to a greater burden under a variable insurance system. This is because we can initially set C high for financial institutions whose insurance premiums are likely to jump when a variable insurance system is adopted.[12] Setting a positive value for $C\,(C>0)$ is seen as a subsidy to certain banks, and it is not a desirable policy in the long run (conversely, setting a negative value for $C\,(C<0)$ is a form of tax).[13] In this respect, it is possible, for example, to use a schedule of premiums that gradually approaches $C=0$. Thus, the argument that variable insurance premiums is not a realistic approach because it places a greater burden on the management of smaller financial institutions by raising applicable insurance premiums is a misunderstanding that arises from the confusion of risk neutral premiums with fair premiums. At least theoretically it is possible to introduce risk neutral insurance premiums so as not to place a greater burden on the management of smaller financial institutions.

B. Feasibility of Asset Risk Assessment

The technical difficulty involved in introducing risk neutral insurance premiums concerns the feasibility of assessing the true risk of bank management. Equations (19) and (27) include the density function $f(x)$, which indicates the riskiness of a bank's investment position and the ratio of deposits to capital (u), which indicates the riskiness of its funding position. Of these two variables, u is observable while the shape of $f(x)$ (θ and variance σ^2) is not easily observable. Even if it could be observed, it cannot be easily incorporated in the fixing of insurance premiums for two reasons.

(i) To incorporate the assessed risk of bank assets in the fixing of premiums, it is necessary beforehand to have an objective assessment of the risk adhering to the assets of each bank. But this is difficult to do. Should we somehow manage to do it, we might still be criticized as being unfair or arbitrary in our method of assessment.

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[11]It is not clear to what extent smaller financial institutions are, in fact, riskier in their funding and investment positions forcing them to likely have to pay higher premiums when a risk-based variable insurance system is adopted. For the sake of argument, however, we accept the conventional view that the introduction of risk-based variable insurance premiums will place a greater burden on the management of smaller financial institutions.

[12]Alternatively, for each bank we can derive the value of C from p so that the premium remains unchanged (*i.e.* the current rate of p continues to be used) when a variable insurance system is adopted.

[13]If premiums are set so that C (or average value) is positive ($C>0$) for all banks, this will deter non-bank corporations outside the coverage of deposit insurance to provide services (*e.g.* financial intermediation and settlement) that compete with banks. On the other hand, if C is set negative ($C<0$), banks will lose customers to non-bank corporations in the provision of such services.

(ii) Even if we could have an assessment of the asset risk of each bank, it would not be desirable to incorporate such assessment in the determination of premiums. If premiums were raised in the context of that assessment, it might be taken as a warning signal with respect to the bank concerned, perhaps leading to overreaction on the part of depositors.

However, these points are valid when evaluation is made according to specific criteria by the authorities on the basis of information unknown to general depositors (for example, information obtained from a bank examination). If the assessment were made according to publicly disclosed criteria on the basis of similarly disclosed information (for example, balance sheets), the incorporation of that information in premiums would not provide any new information to the market. Consequently, problem (ii) does not arise. As long as assessment criteria is publicly disclosed, problem (i) could also be minimized.

Then, what are some of the possible criteria to be used in assesing risk on the basis of publicly disclosed information? One possibility is hinted at by the capital adequacy requirement of the Bank for International Settlements (BIS). In particular, following BIS rules we can classify bank assets into such items as national government bonds, housing loans, and other loans.[14] If the authorities specify the risk adhering to each asset (*i.e.* the variance of the rate of return), the distribution of the rate of asset return of each individual bank $f(x)$ will be the weighted composite of the rates of return of different assets owned. This distribution can then be used to assess risk.[15] Although the authorities could still be criticized for an error of judgment or arbitrariness in assigning a certain risk weight to a particular category of assets, the same criticism applies to BIS rules. The criticism about arbitrariness in identifying the risk of assets may be mitigated somewhat by mechanically referring to previous utilization of bad debt reserves or loan performance.

We understand that, the risk adhering to bank assets as calculated above is not true risk. The measure is also imperfect in that it does not fully reflect all information the authorities have obtained from bank examinations. It would also be unjustifiable to apply the same premiums to a bank that is conservatively lending to blue-chip companies or investing in government bonds and to a bank that is adventurously lending to venture businesses or investing in junk bonds.[16] If so, the incorporation of asset risk assessment in

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[14]To follow the BIS rules means that we classify assets into different categories and assign a risk weight to each. The specific method of classification need not be the same as the BIS rules.

[15]Assume that a given bank has n categories of assets, that their respective shares are given by p_i (i=1, ..., n), that the expected rate of return on each is θ_i (i=1, ..., n), and that the variance-covariance matrix of the rates of return is $\{\sigma_{ij}\}$ (i=1, ..., n; j=1, .., n). The expected rate of return θ on the bank's overall assets then becomes $\Sigma p_i\theta_i$, and the variance σ^2 of the rate of return becomes $\Sigma p_i p_j \sigma_{ij}$. If we further assume that the rates of return on different assets are independent of each other, we have $\sigma^2 = \Sigma p_i^2 \sigma_i^2$ where the σ_i^2 is the variance of the rate of return on the i asset.

[16]We impose higher insurance premiums on banks that are more biased toward higher risk investments, not because we want to discourage riskier investments, but because we want to secure the increased expected insurance income obtained when investment in risky assets is increased.

determining insurance premiums may be a first-order approximation of the ideal structure of insurance premiums.

C. Numerical Examples and Their Evaluation

We will here compute risk-neutral insurance premiums by giving specific numerical values to the riskless rate of return, bank capital adequacy ratios, and asset risk.

We assume that the riskless rate of return is 5 %. For the deposit capital ratio (*i.e.* a measure of capital adequacy), we assume three separate values of u=11.5, 24, 49, corresponding to capital adequacy ratios of 8 %, 4 %, and 2 %. We assume that the rate of return on bank assets is normally distributed with the expected value of 1.05 (θ=1.05) and that standard deviation takes three separate values of $\sigma = 1.94 \times 10^{-2}$, 2.15×10^{-2}, and 2.43×10^{-2}.[17] These values mean that the probability of the value of bank assets falling short of the principal is 0.5 % (σ=1.94×10^{-2}), 1 % (σ=2.15×10^{-2}), and 2% (θ=2.43×10^{-2}), respectively.[18]

First, let us obtain insurance premiums that are both risk neutral and fair. When the deposit insurance system only guarantees principal premiums are given first by assuming that the density function $f(x)$ in equation (19) is normal with expected value of θ = 1.05, and then by making the equation equal to zero.

$$-pu + \int_0^{\frac{u}{1+u}(1+p)} \{(1+p)u - (1+u)x\} \cdot \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-1.05)^2}{2\sigma^2}} dx = 0 \tag{28}$$

The premium is obtained by solving this equation for p.

Similarly, when deposit insurance guarantees both principal and interest premiums are given by assuming that the density function in equation (27) is normal by substituting m = 0.05 for the riskless rate of return, and then by making the equation equal to zero.

$$-pu + \int_0^{\frac{u}{1+u}(1.05+p)} \{(1.05+p)u - (1+u)x\} \cdot \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-1.05)^2}{2\sigma^2}} dx = 0 \tag{29}$$

The premium is then obtained by solving this equation for p.

Because the second (integral) term is not analytically solvable (*i.e.* the original function cannot be derived), conventional methods cannot be used to solve equations (28) and (29). It is possible, however, to integrate the second term numerically by specifying an appropriate value for p. Table 1 shows the values of p thus obtained.[19]

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[17]Strictly speaking, the assumption that x is not-negative contradicts the assumption that x follows a normal distribution. In these numerical examples, however, the probability that x becomes less than zero is so small that it can be ignored. Here we assume that the expected value (θ) of x is 1.05 because there is perfect risk neutral arbitrage between risk free assets (with the rate of return of 5%) and other investment opportunities.

[18]When distribution of the rate of asset return follows $f(x)$, the probability that the value of the asset falls short of the principal is given by $\int_0^1 f(x)dx$.

[19]When it is difficult to obtain an analytical solution to a definite integral, the value of the definite integral can be approximated by computing the value of the integrand at many points over the interval of integration. This method is called numerical integration.

Table 1
Risk Neutral and Fair Insurance Premiums

A. Deposit Insurance Guaranteeing Principal Only

Asset risk / Capital adequacy	$\theta=1.05$, $\sigma=1.94\times10^{-2}$, $x=5$, $y=0.5$	$\theta=1.05$, $\sigma=2.15\times10^{-2}$, $x=5$, $y=1$	$\theta=1.05$, $\sigma=2.43\times10^{-2}$, $x=5$, $y=2$
$u=11.5$, $z=8$	0 (below 10^{-20})	0.345×10^{-13}	0.125×10^{-10}
$u=24$, $z=4$	0.141×10^{-9}	0.430×10^{-8}	0.118×10^{-6}
$u=49$, $z=2$	0.417×10^{-7}	0.449×10^{-6}	0.446×10^{-5}

B. Deposit Insurance Guaranteeing Principal and Interest

Asset risk / Capital adequacy	$\theta=1.05$, $\sigma=1.94\times10^{-2}$, $x=5$, $y=0.5$	$\theta=1.05$, $\sigma=2.15\times10^{-2}$, $x=5$, $y=1$	$\theta=1.05$, $\sigma=2.43\times10^{-2}$, $x=5$, $y=2$
$u=11.5$, $z=8$	0.905×10^{-9}	0.198×10^{-7}	0.394×10^{-6}
$u=24$, $z=4$	0.239×10^{-4}	0.220×10^{-3}	0.456×10^{-3}
$u=49$, $z=2$	0.166×10^{-2}	0.232×10^{-2}	0.340×10^{-2}

x : Expected rate of profit (%)
y : Probability that asset value falls below principal (%)
z : Capital adequacy ratio (%)

The first thing to notice about Table 1 is that premiums vary widely not only horizontally (with increasing asset risk), but also vertically (with declining capital adequacy). Although previous discussions on variable insurance premiums generally recognize the need to also link premium to the risk of bank assets, they do not recognize the need to link it to the capital adequacy ratio. Even in cases where such a need is recognized, the link between premium and capital adequacy has not been considered as strong. In discussions on the feasibility of adopting variable insurance premiums, therefore, it seems that too much emphasis has been placed on the difficulty of evaluating the asset risk and that the importance of capital adequacy considerations (to which no such difficulty adheres) has been neglected. The above mentioned tables, however, suggest that even if we ignore the difficulty of evaluating asset risk for the time being, variable insurance premiums based on the capital adequacy ratio can still be meaningful as a realistic way of solving or reducing the problem of moral hazard.

The second thing to notice is the large discrepancy in insurance premiums between Tables 1-A and 1-B, which suggests that deposit insurance can serve as a subsidy or tax to banks (or stockholders) if premiums in Table 1-A (premiums for insurance guarnteeing only principal hereafter) are applied under a system guaranteeing principal and interest, or if premiums in Table 1-B (premiums for insurance guaranteeing principal and interest hereafter) are applied under a system only guaranteeing principal. In what follows, we will consider this point further.

Table 2 cites the values of M when premiums in Table 1-A are substituted into equation (27). These represent net benefits M of bank stockholders when insurance guaranteeing principal and interest is provided for the premiums of insurance only guaranteeing principal. What we should note is that the value of M sharply increases as asset risk increases or the capital adequacy ratio falls (*i.e.* as we move from the northwest to the southeast corner of the table). If the value of M is relatively stable, deposit insurance may not be fair, but it can be risk neutral when premiums for that guaranteeing principal are applied that guaranteeing principal and interest. However, this is not the case in Table 2. When insurance guaranteeing principal and interest is offered at the premiums for just the guarantee of principal, deposit insurance does not completely

Table 2
M Values when Premiums for Insurance of
Principal Only are Applied to that of Principal and Interest

Asset risk / Capital adequacy	$\theta=1.05$, $\sigma=1.94\times10^{-2}$, $x=5$, $y=0.5$	$\theta=1.05$, $\sigma=2.15\times10^{-2}$, $x=5$, $y=1$	$\theta=1.05$, $\sigma=2.43\times10^{-2}$, $x=5$, $y=2$
$u=11.5$, $z=8$	0.104×10^{-7}	0.228×10^{-6}	0.453×10^{-5}
$u=24$, $z=4$	0.570×10^{-3}	0.515×10^{-2}	0.105×10^{-1}
$u=49$, $z=2$	0.690×10^{-1}	0.935×10^{-1}	0.131

x : Expected rate of profit (%)
y : Probability that asset value falls below principal (%)
z : Capital adequacy ratio (%)

eliminate the incentive of banks to hold a riskier portfolio. As a result, deposit insurance ends up promoting risk.[20]

Conversely, Table 3 cites the values of M when premiums in Table 1-B are substituted into equation (19) in order to see what will happen when premiums for insurance guaranteeing principal and interest are applied to that only guaranteeing principal. The value of M is negative because premiums are too high relative to benefits, thus the insurance has the effect of a tax on the bank (or stockholders). What should be noted here is that the absolute value of M sharply increases as we move from the northwest to the southeast corner of the table.[21] This means that the deposit insurance system is giving banks too much incentive to avoid risk, suggesting the possibility that it may excessively reduce the entrepreneurial spirit of venturing into new projects.

With this perspective, we can see that a troublesome problem for risk neutral insurance premiums arises from the dual nature of the Japanese deposit insurance system: Article 54 of the Deposit Insurance Law allows the payment of benefits (guaran-

Table 3
M Values when Premiums for Insurance of Principal and Interest are Applied to that of Principal Only

Asset risk / Capital adequacy	$\theta=1.05$, $\sigma=1.94\times10^{-2}$, $x=5$, $y=0.5$	$\theta=1.05$, $\sigma=2.15\times10^{-2}$, $x=5$, $y=1$	$\theta=1.05$, $\sigma=2.43\times10^{-2}$, $x=5$, $y=2$
$u=11.5$, $z=8$	-0.104×10^{-7}	-0.228×10^{-6}	-0.453×10^{-5}
$u=24$, $z=4$	-0.573×10^{-3}	-0.529×10^{-2}	-0.109×10^{-1}
$u=49$, $z=2$	-0.811×10^{-1}	-0.114	-0.166

x : Expected rate of profit (%)
y : Probability that asset value falls below principal (%)
z : Capital adequacy ratio (%)

[20]When depositors expect benefits from deposit insurance to cover principal and interest, the deposit interest rate will not rise even if the bank holds a riskier portfolio. If the bank does, the risk promoting incentive of deposit insurance cannot be eliminated by premiums that only cover principal (Table 1A), which are set on the assumption that the deposit interest rate will rise to reflect the greater probability of default on interest payments. This is why M increases as we move from the northwest to the southeast corner of Table 2.

[21]If depositors do not expect deposit insurance to cover interest, the deposit interest rate will rise with the risk taking behavior of the bank. As a consequence, the deposit insurance system will give the bank an adverse incentive toward risk taking if premiums do not take account of the rise in the deposit interest rate.

tee of principal), and Articles 59-67 of the same law allow a relief merger (guarantee of principal and interest). We then have the following results. Variable insurance premiums (Table 1-A) that are based on guaranteeing only principal (i) serve to neutralize the risk taking incentive if many depositors of a bank expect the system to close down the bank and pay out benefits if the bank fails; but (ii) allow the risk taking incentive to remain if many depositors believe that the bank is too big to be closed down and that the authorities will attempt a merger with a stronger bank. Conversely, variable insurance premiums (Table 1-B) that are set to be risk neutral under a system guaranteeing principal and interest (i) can fully neutralize the risk taking incentive if many depositors expect a merger; but (ii) can excessively reduce the risk taking incentive if many depositors expect the bank will be closed down and that the system will pay out benefits. To summarize, it is impossible to set perfectly risk neutral premiums in the Japanese deposit insurance system, where it is not clear whether only principal or both principal and interest are guaranteed. If we want to be successful in using variable insurance premiums as a means of neutralizing the moral hazard aspect of deposit insurance, the overall framework of the system must be considerably reformed.

IV. Conclusion

This paper has considered ways to solve moral hazard associated with deposit insurance. Although recent discussions in the United States have raised doubts about the ability of a deposit insurance system to contribute to the stability of the credit system, this issue has not been considered in the paper. Instead, we simply accepted the existence of a deposit insurance system and considered ways of solving or reducing the problem of moral hazard associated with it.

There is a general tendency to think that the moral hazard aspect of deposit insurance refers to the use of the insurance scheme to provide relief to a bank experiencing management difficulties. However, the moral hazard aspect of deposit insurance in fact refers to its risk taking incentive, which always exists as the rational choice of a sound bank. If we were to emphasize this point, it would be more desirable to think of moral hazard accruing to deposit insurance not as a kind of pathological problem whose solution requires such symptomatic treatment as inspection or prosecution, but as a general incentive problem inherent in any bank (including sound banks and those in difficulty). Thus a desirable approach would be to take preventive measures to eliminate such an incentive. In this context, variable insurance premiums are discussed as a measure to solve the moral hazard aspect of deposit insurance.

In consideration once more of the reason why a deposit insurance may create moral hazard, the essential point is that a conditional payment scheme (*i.e.* the deposit insurance) alters optimal strategy (*i.e.* the behavior to maximize expected profits) of bank managers.[22] This means that if we want to solve or reduce such moral hazard, we need only to establish a mechanism that, when bank managers try to earn more profits by changing strategy, the additional gain in expected profits to stockholders will somehow be offset by a corresponding loss. What is needed is a proper function in which even if deposit insurance causes bank managers to change strategies, the expected profits of the stockholders remain the same. Although the idea of variable insurance premiums is one way of solving the problem, it is not the only one. For example, moral hazard would not arise if there were a mechanism (*i.e.* an enforceable rule) by which, when bank managers take action to assume greater risk, the deposit interest rate under the insurance system would increase by the same amount as the deposit rate outside the system.[23] Alternatively, if there were a system in which surveillance by the authorities would intensify as bank managers took more risk, a similar result might be expected. In comparison with these methods, on balance, the system of variable insurance premiums is better because it clearly makes the cost of changing strategies known to bank managers and ensures a greater availability of management choices.[24]

The argument and the numerical examples we have presented in this paper are not necessarily realistic because they are based on many restrictive assumptions, including the assumption that both depositors and stockholders are risk neutral. It may therefore be necessary to modify the implications of some of the arguments or numerical examples by making the underlying assumptions more realistic. For example, in the numerical examples in Section III.C., we saw that risk neutral insurance premiums were significantly influenced by asset risk and the capital adequacy ratio. However, if stockholders were not risk neutral but risk averse, the influence of asset risk and capital adequacy ratio on variable insurance premiums would be much less significant. Moreover, it would be necessary to consider more explicitly other aspects of banking, such as the settlement service aspect of bank deposits and the information production aspect of bank lending. In this sense, we need further examination and discussion before we can make a more realistic case of the arguments and numerical examples than those presented in the paper.

Nevertheless, the present analysis and experiences in the United States clearly indicate that the current system of fixed insurance premiums is not conducive to the stability of the credit system. If this is the case, we should seriously consider ways for

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[22] In reality, it is not the depositors but bank stockholders who receive benefits from deposit insurance. Consequently, it is bank managers (as agents of stockholders) who consciously change strategy by virtue of deposit insurance.

[23] When bank managers take more risk, deposit interest rates both inside and outside the insurance system should rise. Inside the system, however, rates should rise less by an amount corresponding to the expected benefit coming from deposit insurance. This serves as an incentive for bank managers to take a riskier composition of assets and liabilities. Thus, if the deposit rate under the insurance system were linked to the deposit rate outside the system, the incentive would disappear and moral hazard be eliminated.

[24] Appendix discusses the relationship between the concept of risk neutral insurance premiums and the BIS capital adequacy requirements.

making existing insurance premiums more risk neutral, independently of how one can theoretically compute perfectly risk neutral insurance premiums. For example, the idea of incorporating capital adequacy ratios in the determination of insurance premiums may be worth considering as a practical prescription.

Another problem with risk neutral insurance premiums is that the actual operation of deposit insurance can either guarantee only principal (in the form of benefit payments) or both principal and interest (in the form of a relief merger). Thus, even if risk neutral insurance premiums were to be introduced, the incentive problem would not be solved unless an institutional change were made with respect to the dual nature of the present system. For example, if depositors think that a bank is too big to fail (*i.e.* they expect it will be merged with a stronger one), deposit insurance will be unable to neutralize its risk promoting incentive. On the other hand, if depositors think that the insurance will pay out benefits but will not cover interest in the case of small and medium-sized banks, variable insurance premiums will excessively reduce the necessary risk-taking incentive.[25] To improve this aspect of the deposit insurance system, it is necessary to apply different structures of insurance premiums to different types of financial institutions and deposits by first determining whether the insurance applicable guarantees only principal or both principal and interest. We must then additionally consider whether such a system is feasible or has undesirable consequences.

Appendix. Deposit Insurance and Capital Adequacy Requirements

This appendix discusses the relationship between the risk neutral deposit insurance system and the BIS capital adequacy requirements.

It is convenient to start with equation (28), which specifies the necessary conditions for deposit insurance systems to be risk neutral.[26] Combining the asset risk of banks (σ), the deposit/capital ratio (u), and the deposit insurance premium (p) that are derived from this equation, we can graphically represent the risk neutral deposit insurance system (*i.e.*, risk neutral deposit insurance premiums) in a 3-dimensional graph as in Figure A-1. It shows that as the asset risk and the deposit /capital ratio increase, the risk neutral deposit insurance premium raises.

Figure A-2 represents the (σ, p) plane of this 3-dimensional graph.[27] It shows that the insurance premium should be raised in accordance with an increase in the asset risk. This corres-

[25]This is not the same as the problem of equity associated with being too big to fail because the latter can be solved by adjusting the value of M. The problem here is that because of the inconsistency between the structure of premiums and the payment of benefits, deposit insurance can become either overly risk taking or too risk averse, contrary to its original intention.

[26]To be precise, we should call "risk neutral and fair" instead of just "risk neutral." However, since it is not important whether the system is "fair" (*i.e.*, the equation value is zero) or not in our paper, we will simply call "risk neutral" in the remaining of this paper.

[27]Figure A-2 shows the (σ, p) plane that is cut at u=24.

Figure A-1

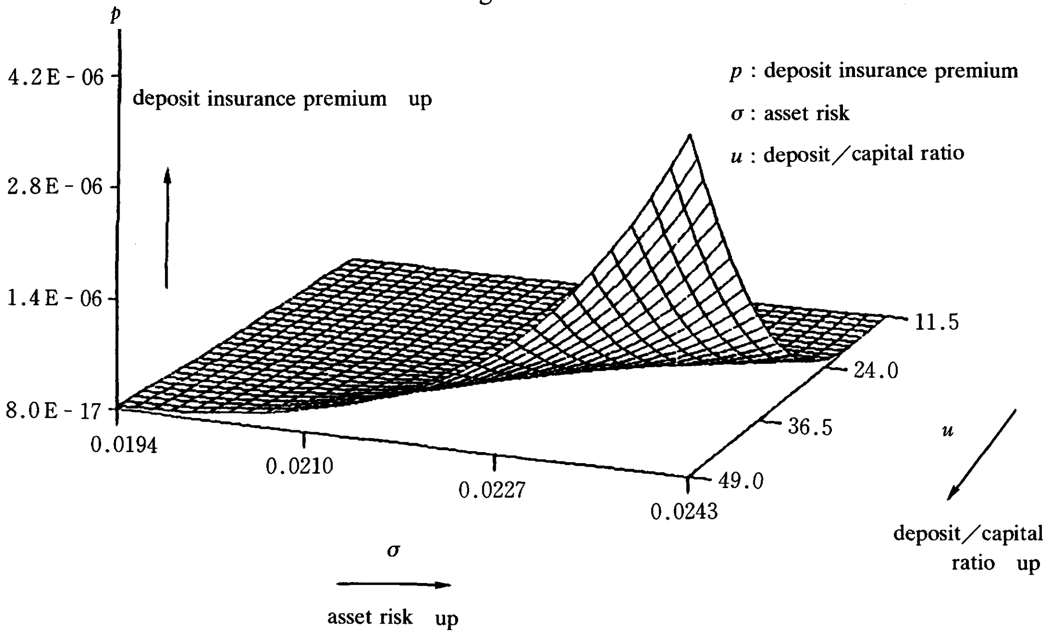
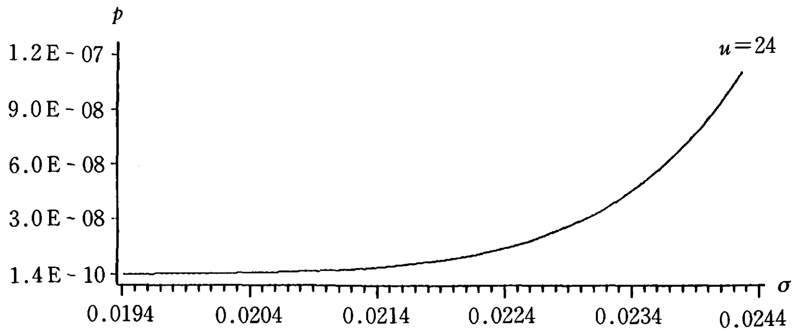


Figure A-2



σ : asset risk

p : deposit insurance premium

ponds to the system of "variable deposit insurance premiums according to the asset risk." In other words, the system of "variable deposit insurance premiums according to the asset risk" represents a special solution to the risk neutral deposit insurance system that we have discussed in the text—under the condition that the capital adequacy ratios are the same for all banks. Similarly, the (p, u) plane of the 3-dimensional graph in Figure A-1 represents the system of "variable deposit insurance premiums according to the capital adequacy ratio (Figure A-3)."[28] Such a system of variable deposit insurance premiums is also a special solution to the risk neutral deposit insurance system that we have discussed in the text.

What about if we cut the 3-dimensional graph vertically at the p axis? Figure A-4 shows such a (σ, u) plane.[29] It shows that as the asset risk of banks raises, the deposit/capital ratio should be reduced or the capital adequacy of banks should be strengthened. This is the basic idea behind the BIS capital adequacy requirements. In other words, the BIS requirements can be understood as a special solution to the risk neutral deposit insurance system that we have discussed in the text. The difference between the BIS capital adequacy requirements and the system of variable deposit insurance premiums is that the former impose the condition of a constant deposit insurance premium on the risk neutral deposit insurance system, while the latter imposes the condition of a constant asset risk or a constant deposit/capital ratio.[30]

Let us examine the implications of our finding that the BIS capital adequacy requirements represents a special case of the more general "risk neutral deposit insurance system." Suppose that there are four commercial banks (A, B, C, D) in the world of a fixed deposit insurance premium. Bank A has a high capital adequacy ratio and a low asset risk; Bank B has a low capital adequacy ratio and a low asset risk; Bank C has a high capital adequacy ratio and a high asset risk; and Bank D has a low capital adequacy ratio and a high asset risk. Their locations are depicted in the (σ, u) plane in Figure A-4.

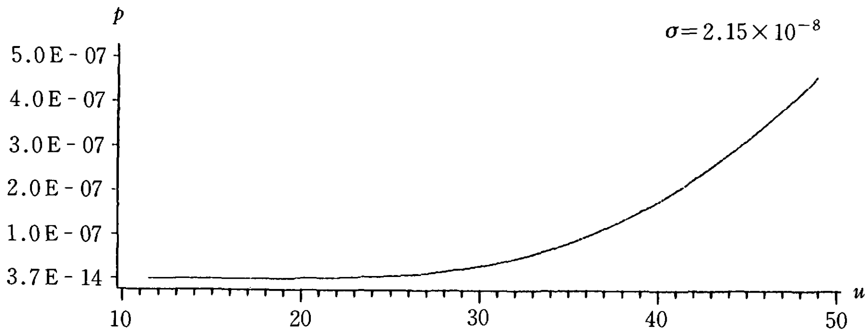
What will happen to these four banks if the BIS capital adequacy requirements are imposed? The BIS requirements is represented by the curve in Figure A-4. They are not binding for Bank A, Bank B, and Bank C, and therefore will not affect them. However, they are binding for Bank D, and therefore Bank D will have to either improve its capital adequacy ratio or reduce its asset risk to meet the BIS requirements. If Bank D cannot easily improve its capital adequacy position as is often the case in the real world, its remaining option will be to sell its risky assets to Bank A. In fact, we have often observed such cases in the real world. However, it will not necessarily be the

[28]At $\sigma = 2.15 \times 10^{-2}$.

[29]At $p = 0.43 \times 10^{-2}$.

[30]Ikeo (1990b) approaches this problem from the viewpoint of "duality" between variable insurance premiums and capital adequacy requirements with respect to the asset risk. Certainly, there is an element of "duality" in that the schemes of variable insurance premiums and capital adequacy requirements emerge depending on how to cut the 3-dimensional graph in Figure A–1. However, instead of taking such a "duality" approach, we have approached this problem in terms of building a more general "risk neutral deposit insurance system," and then derived the schemes of variable insurance premiums and capital adequacy requirements as its special solutions.

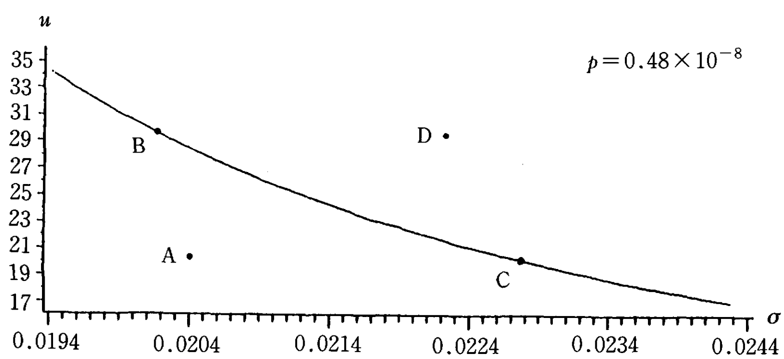
Figure A-3



u : deposit/capital ratio

p : deposit insurance premium

Figure A-4



u : deposit/capital ratio

σ : asset risk

best solution because there is a problem of economic inefficiency due to informational asymmetry and there is no guarantee that the asset Bank D wants to sell matches the asset Bank A wants to buy.

What will happen if the more general risk neutral deposit insurance system is introduced instead of the BIS capital adequacy requirements? Now, instead of selling its assets, Bank D can pay a higher insurance premium that is associated with its high asset risk and low capital adequacy ratio in the 3-dimensional graph in Figure A-1. On the other hand, Bank A can pay a lower insurance premium that is associated with its low asset risk and high capital adequacy ratio. None of them would be forced to sell or buy assets under the risk neutral deposit insurance system.

A high asset risk does not necessarily mean sloppy investment behavior on the part of commercial banks; instead, it may reflect their strong portfolio management skills. Similarly, a low asset risk does not necessarily mean sound portfolio management; instead, it may simply reflect a lack of risk and portfolio management skills. Therefore, instead of the system of fixed risk requirements, it may be desirable to have a deposit insurance system in which banks with high risk management skills can invest in high risk assets on their own responsibilities while paying higher variable deposit insurance premiums. That way, we can avoid the case in which some banks end up purchasing high risk assets beyond their risk management capabilities under forced asset sales by other banks to meet the BIS requirements. And, most of all, it would provide commercial banks with a incentive mechanism that balances the benefits of a high degree of management freedom with its costs, and thus is more conducive to the rational economic decision making of commercial banks.

Mitsuru Iwamura: Manager and Senior Economist, Research Division I, Institute for Monetary and Economic Studies, Bank of Japan, (now at the Japan Bond Research Institute)

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