# On Designing an Incentive Contract to Resolve Banks' Risk Incentives: A Comprehensive Analysis on the Credit Spreads of Banks Investing in Japanese Companies

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**ABSTRACT**

From the perspective of an incentive contract, this study's objective is to resolve a bank's risk incentive problem. Bank liquidation initiated by Deposit Insurance Corporation (DIC) to protect deposits is usually determined in such a way that the effect of deposit insurance is maximised. This study focuses on the condition under which a bank's risk incentive problem is always resolved. Using the option pricing theory on a perpetual American put option and a perpetual down and out call option, this study identifies the condition that resolves a bank's risk incentive problem by deriving a knockout price at which the bank's numerical measure of risk incentives is equivalent to zero. This incentive condition can be utilized in designing an incentive contract to resolve a bank's risk incentive problem. Moreover, consider a situation in which the risk incentive problem is resolved, a numerical example concerning the bank's credit spread, return on equity, and ratio of free cash flow to equity demonstrates stable and efficient bank management. In addition, this study shows that, under the proposed incentive contract, changes in the project's volatility may either increase or decrease the probability of a DIC-initiated liquidation without affecting the bank's credit spread and sustainable growth.

Keywords: Corporate finance; Deposit insurance system; Option pricing; Risk incentive.

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## 1. INTRODUCTION

Given the moral hazard problem caused by the deposit insurance system, risk incentives (or, risk-shifting incentives) fermented in a bank induce the bank to take riskier actions (i.e., risky behaviour). Eventually, such risky behaviour spreads across the banking system and increases the likelihood of a financial crisis. A properly designed incentive contract resolves a bank's risk incentive problem, entails stable bank operations, and helps prevent the occurrence of a financial crisis. As such, incorporating the incentive contract into the deposit insurance system pre-empts the spread of undesirable risky behaviour in the banking system.

A bank's risky behaviour lowers the probability of fully recovering bank loans from borrowers, which may force the bank to be liquidated by Deposit Insurance Corporation (DIC) in the worst scenario. This study addresses a bank's risk incentive problem by considering the bank's loan creation as an investment project, while the deposits held by the bank is the major source of fund to finance such investment. This idea is also conceivable within the principal-agent theoretical framework in which the depositors are


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the principals (lenders) while the bank is the agent (borrower). This implies that using a deposit insurance system to protect the depositors from potential losses of their deposits is likely to result in the bank's moral hazard problem.

This study considers the progress of an invested project as a hidden action associated with the bank's moral hazard problem because the depositors do not fully know all the facts about the project until the project result is revealed. Adequate protection of deposits using deposit insurance reduces the depositors' incentives in monitoring the bank until DIC initiates bank liquidation, which essentially turns the bank's risky behaviour into a hidden behaviour. Information asymmetry caused by this kind of hidden behaviour increases the bank's incentives to take higher risks and invest in more risky projects.

Designing an appropriate incentive contract is efficacious for resolving a bank's risk incentive problem in the presence of information asymmetry. The contract design is devised by exploring the condition under which the numerically measured risk incentives become zero. Incorporating this condition of incentive resolution in the deposit insurance system results in DIC's intensifying monitoring of banks. Resolving banks' risk incentive problem through such a deposit insurance system avoids excessive risk taking by banks.

Evaluating a bank's discounted cash flow (DCF) and credit spread assists the bank's managerial decision-making under various situations, e.g., mergers and acquisitions (M&A). Note that credit spread is calculated from corporate bond yield. This study focuses on DCF and its yield that allows evaluation of a bank's credit spread and ROE.

The remainder of this article is organized as follows. Section 2 defines a bank's risk incentive problem under the deposit insurance system. Section 3 discusses findings from a previous study by Seta and Inoue (2020) using option perpetuity. Sections 4 and 5 discuss the design of an incentive contract to resolve a bank's risk incentive problem and propose a numerical measure for a bank's credit spread using the DCF method, respectively. Section 6 provides several numerical examples simulating a bank's credit spread and the probability of liquidation initiated by DIC if the bank invests in a Japanese company. Finally, Section 7 concludes the article.

## 2. BANK'S RISK INCENTIVE PROBLEM

Consider the moral hazard problem associated with financial contracting in which the lender is the principal and the borrower is the agent. The risk incentive problem can be interpreted as a risk-shifting problem or asset substitution problem. A bank's risk incentive problem affects the sharing of a project's profits because the bank has incentives to invest the deposits at the expense of the depositors' interest by increasing project risks. The bank's speculative behaviour triggered by risk incentives may even violate commonly accepted rules and standards, leading to depositor distrust and a bank run in the worst scenario.

Past studies on risk incentive problems associated financial contracting primarily focused on the effect of the borrower's risk incentives on project risks. The present study focuses on the risk incentives of banks as borrowers. An increase in a borrower's risk incentives might increase the borrower's equity by increasing project risks. However, switching to risky projects may result in project failure and even insolvency in the worst scenario.


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Protecting deposits by deposit insurance creates banks' moral hazard problem and simultaneously discourages depositors from withdrawing their deposits from banks. The present study takes this point of view and assumes that bank run does not occur in the analysis of a bank's risk incentive problem under the deposit insurance system. Seta and Inoue (2020) showed that a bank's risk incentives become chronic even if deposits are only partially protected. To resolve the moral hazard problem of a bank, the bank's risk incentive problem under the deposit insurance system must be resolved. An appropriate design of a bank's risk incentive contract mitigates the bank's moral hazard problem.

In numerically measuring a bank's risk incentives using the option pricing theory, the Black-Scholes formula cannot be directly applied because the option value of an infinity-volatility project is implicitly assumed. Instead, a bank's equity is evaluated by a down and out call option with a knockout price equivalent to the project's value when liquidation occurs. In addition, according to Ziegler (2004), such an analysis using the option pricing theory shows that the bankruptcy probability can be measured as a risk neutral probability. In the presence of the deposit insurance system, the bankruptcy probability is related to the risk neutral probability of the bank being liquidated by DIC.

In formulating a model using the option pricing theory, fluctuations of the equation's parameters are especially interesting because some of these parameters are controlled and influenced by the counterparties under the option contract. These parties include depositors, bank shareholders, bank management, investee companies, and DIC. Their behaviour at the time when the bank is investing the deposits in an investment project can be interpreted as an option transaction. A proper design for an incentive contract to resolve a bank's risk incentive problem can be obtained by identifying the conditions of parameters under which the numerically measured risk incentives in trading the options become zero.

## 3. NUMERICALLY MEASURING BANKS' RISK INCENTIVES AND THE EFFECT OF DEPOSIT INSURANCE

First, consider a bank with $n$ depositors and suppose that the deposits and the deposit trend of each depositor follow a deposit distribution $u \coloneqq \{u_1, \cdots, u_n\}$ and a trend distribution $v \coloneqq \{v_1, \cdots, v_n\}$, respectively. For a certain amount $X_0$ in a currency unit, the actual amount in each deposit account is expressed by $(v_i u_i)X_0$ $(i = 1, \cdots, n)$ and the trend of each depositor is $v_i > 0$ $(i = 1, \cdots, n)$. Each depositor withdraws his/her deposits if $v_i < 1$, deposits more money with the bank if $v_i > 1$, and does nothing if $v_i = 1$. Considering deposits as a claim against the bank, the face value of debt $X_i(t)$ $(1, \cdots, n)$ with interest income $r^*$ at time $t$ is expressed as $X_i(t) = u_i X_0 e^{r^* t}$.

Next, suppose the bank invests the deposits and capital increase into an investment project. Regarding the initial project value $S_0$, the rate of capital growth $x$ $(x > 0)$, and a liquidation cost $\beta$ $(0 < \beta < 1)$, by setting $X_0 = S_0$, the initial investment amount is calculated as $\sum_{i=1}^{n}(1-\beta)(1+x)(v_i u_i)S_0$. The bank's liquidation cost $\beta$ is lower than the liquidation cost $\alpha$ $(0 < \alpha < 1)$ if a bank run is triggered by a deterioration of the depositors' trust in the bank. Furthermore, as for the bank lending rate $r$ $(r > r^*)$, we assume that money is deposited with the bank for a sufficiently long time such that


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the deposit spread $r - r^*$ yields an expected liquidation cost of $\alpha$. Thus, under the assumption that the project value $S_t$ follows the geometric Brownian motion with drift $\mu$ and volatility $\sigma$, $S_t$ satisfies the following stochastic differential equation:

$$dS_t = \mu S_t dt + \sigma S_t dZ_t \tag{1}$$

where, $dZ_t$ is a standard Wiener process. The present value of this investment is calculated as $\sum_{i=1}^{n}(1-\beta)(1+x)(v_i u_i)S_t$. The knockout price $K(t)$ is equivalent to the project value at the time of a DIC-initiated liquidation. The rebate $R_i(t) = v_i X_i(t)$ is interpreted as the deposits that depositors are unable to withdraw at that time. Seta and Inoue (2020) analysed this situation using a perpetual down and out call option $C_i := C\big((1-\beta)(1+x)(v_i u_i)S, (1-\beta)(1+x)(v_i u_i)K(t)\big)$ and a perpetual American put option $P_i := P\big((1-\beta)(1+x)(v_i u_i)S, (1-\beta)(1+x)(v_i u_i)K(t)\big)$. For $\gamma^* := \frac{2(r-r^*)}{\sigma^2}$ and the compensated amount covered by the deposit insurance system $Y_i(t)$ $(i = 1, \cdots, n)$, these option prices are evaluated as follows.

$$C_i = \begin{cases} (1-\beta)(1+x)(v_i u_i)S \\ \quad +\big((1+x)R_i(t) - (1-\beta)(1+x)(v_i u_i)K(t)\big)\left(\frac{S}{K(t)}\right)^{-\gamma^*} & \big(S \geq K(t)\big) \\ (1+x)R_i(t) & \big(S < K(t)\big) \end{cases}$$

$$P_i = \big((1+x)Y_i(t) - (1-\beta)(1+x)(v_i u_i)K(t)\big)\left(\frac{S}{K(t)}\right)^{-\gamma^*} \tag{2}$$

The bank's total equity is calculated as $\sum_{i=1}^{n} C_i$. In addition, the bank's total risk incentives and the overall effect of deposit insurance are calculated as $\sum_{i=1}^{n} \frac{\partial C_i}{\partial \sigma}$ and $\frac{1}{1+x}\sum_{i=1}^{n} P_i$, respectively. The risk neutral probability of bank liquidation initiated by DIC is computed as:

$$\left(\frac{S}{K(t)}\right)^{-\gamma^*}.$$

There are three deposit insurance schemes, namely, the fixed-ratio deposit insurance coverage with a fixed rate $a$ $(0 < a \leq 1)$, the maximum insurance coverage limited by a maximum amount $M$ $(M > 0)$, and the deposit insurance coverage with deduction at a fixed rate $d$ $(0 \leq d < 1)$. The compensated amount covered by each of these deposit insurance schemes is $Y_i(t)$ given as follows:

$$Y_i(t) = \begin{cases} a v_i X_i(t) & \text{(fix-ratio deposit coverage)} \\ min(v_i X_i(t), M) & \text{(maximum insurance coverage limit)} \\ (1-d) v_i X_i(t) & \text{(deduction)} \end{cases} \tag{3}$$

Note that parameters $a$ and $d$ are between 0 and 1. The situation in which the deposits are 100% protected is also considered. Although offering a 100% protection to the deposits seems to be an extreme condition, the deposits were temporarily 100% protected in some economies (e.g., in Hong Kong) during the financial crisis caused by the Lehman


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Brothers bankruptcy. The results from this study's analysis can also be applied to such unusual situations.

## 4. DESIGN OF INCENTIVE CONTRACT TO RESOLVE BANKS' RISK INCENTIVES

Focusing on bank liquidation triggered by DIC, this study proposes an approach to designing a risk incentive contract that simultaneously resolves two types of risk incentive problems – one for depositors and the other one for bank shareholders. In Seta and Inoue (2020), from the perspective of depositor protection, DIC would liquidate a bank at the optimal exercise price to maximise the overall effect of deposit insurance. However, such an optimal exercise price is not sufficient to simultaneously eliminate the two types of risk incentive problems. Therefore, we seek to look for a knockout price $K(t,\sigma)$ that simultaneously resolves all the bank's risk incentives in designing a risk incentive contract for the deposit insurance system. If $S \geq K(t,\sigma)$, we can numerically measure a bank's risk incentives as follows.

$$\sum_{i=1}^{n}\frac{\partial C_i}{\partial\sigma} = \left(\frac{2}{\sigma}\gamma^* ln\frac{S}{K(t,\sigma)}\sum_{i=1}^{n}\big(R_i(t)-(1-\beta)(1+x)(v_iu_i)K(t,\sigma)\big) + \frac{1}{K(t,\sigma)}\frac{\partial K(t,\sigma)}{\partial\sigma}\sum_{i=1}^{n}\big(\gamma^* R_i(t)-(1+\gamma^*)(1-\beta)(1+x)(v_iu_i)K(t,\sigma)\big)\right) \times\left(\frac{S}{K(t,\sigma)}\right)^{-\gamma^*} \tag{4}$$

To resolve the bank's risk incentive problem, the knockout price $K(t,\sigma)$ should satisfy $\sum_{i=1}^{n}\frac{\partial C_i}{\partial\sigma}=0$. Since $S \geq K(t,\sigma)$, setting $\frac{\partial K(t,\sigma)}{\partial\sigma}=0$ provides the following condition:

$$\sum_{i=1}^{n}R_i(t)-(1-\beta)(1+x)\left(\sum_{i=1}^{n}v_iu_i\right)K(t,\sigma)=0 \tag{5}$$

Consequently,

$$\bar{K}(t,\sigma) := \frac{\sum_{i=1}^{n}R_i(t)}{(1-\beta)(1+x)(\sum_{i=1}^{n}v_iu_i)} = \frac{X_0e^{r^*t}}{(1-\beta)(1+x)}$$

ensures $\frac{\partial\bar{K}(t,\sigma)}{\partial\sigma}=0$ and enables the design of the risk incentive contract to resolve the bank's risk incentive problem. The probability of liquidation when the bank's risk incentives are cleared is given as follows:

$$\left(\frac{S}{\bar{K}(t,\sigma)}\right)^{-\gamma^*} = \left(\frac{(1-\beta)(1+x)S}{X_0e^{r^*t}}\right)^{-\gamma^*} \tag{6}$$

From the following relationship:


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$$\left(\frac{S}{\bar{K}(t,\sigma)}\right)^{-\gamma^*} < 1 \Leftrightarrow \sum_{i=1}^{n}(1-\beta)(1+x)(v_i u_i)S > \sum_{i=1}^{n} v_i X_i(t)\,,$$

we obtain the result that DIC may not liquidate the bank as long as the present value of the bank's investment exceeds the total deposits including payable interests.

Note that an unspecified bank liquidation triggered by DIC will cause contradictions in the above analysis and produce inaccurate results. Therefore, the conditions for an DIC-initiated liquidation under the incentive contract must be specified as $S \geq \bar{K}(0,\sigma)$ and $S_0 = X_0$, indicating that $\frac{x}{1+x} \geq \beta$.

## 5. NUMERICALLY MEASURING CREDIT SPREAD THROUGH THE DCF METHOD

A bank's credit spread can be obtained numerically after calculating the cost of equity by the DCF method. Consider the influence of time $t$ and volatility $\sigma$, the DCF method can be applied by incorporating the cost of equity $\rho(t,\sigma)$, the discounted present value of equity $DPV(t,\sigma)$, the FCF $CF(t,\sigma)$, and the growth rate $g(t,\sigma)$ as follows:

$$\rho(t,\sigma) = \frac{CF(t,\sigma)}{DPV(t,\sigma)} + g(t,\sigma) \tag{7}$$

The cost of equity $\rho(t,\sigma)$ minus the risk-free rate $r_F$ is equal to the equity risk premium $RP_E(t,\sigma)$. The following results regarding the FCF yield are obtained:

$$\psi(t,\sigma) := \frac{CF(t,\sigma)}{DPV(t,\sigma)}$$
$$\psi(t,\sigma) - r_F = RP_E(t,\sigma) - g(t,\sigma) \tag{8}$$

The yield spread $\psi(t,\sigma) - r_F$ can be interpreted as the equity risk premium numerically corrected for the permanent growth rate if $\psi(t,\sigma) - r_F \geq 0$, or conversely as the growth rate numerically adjusted for the equity risk premium if $\psi(t,\sigma) - r_F < 0$. This value measures the bank's credit spread that represents an equity risk premium in the positive case and a sustainable growth rate in the negative case.

The yield spread of a corporate bond is called credit spread and is sometimes used to measure default risk. Considering market liquidity, we focus on the FCF yield and assume that the excess of the FCF yield over the risk-free interest rate is a consideration for liquidation, which implies the following relationship between the bank's total equity and yield spread:

$$\psi(t,\sigma) - r_F = \frac{1}{t}\left(ln\sum_{i=1}^{n} v_i X_i(t) - ln\sum_{i=1}^{n} C_i\right) \tag{9}$$


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Through Equation (9), the yield spread $\psi(t,\sigma) - r_F$ can be calculated by using the bank's total equity derived from the sum of option prices. Investing the deposits and capital increase in an investment project will sustain a growth rate $g(t,\sigma)$. Given a dividend payout ratio $\delta(t)$, $ROE(S,t,\sigma)$ is determined as follows:

$$ROE(S,t,\sigma) = \frac{g(t,\sigma)}{1-\delta(t)}$$
$$= \frac{1}{1-\delta(t)}\left(RP_E(t,\sigma) - \frac{1}{t}\left(ln\sum_{i=1}^{n} v_i X_i(t) - ln\sum_{i=1}^{n} C_i\right)\right) \quad (10)$$

An approximate of Equation (10) can be obtained if the equity risk premium $RP_E(t,\sigma)$ is substituted for the product of market risk premium and beta based on CAPM or the factor sensitivity from Fama and French's (1993) three-factor model. If $ROE(S,t,\sigma) < 0$, $g(t,\sigma)$ is considered to be sustainable and the bank's financial condition will not be hampered by a balance-sheet insolvency despite a negative growth. Therefore, the investment in a project with a value $S$ that is likely to maximize ROE will entail the most efficiently management of the bank and generate profits for the bank's shareholders. This risk incentive contract prevents the bank from taking excessive risks and thus is expected to provide the bank with stable and efficient management.

## 6. SIMULATION ANALYSIS OF BANKS INVESTING IN JAPANESE COMPANIES

We conduct a numerical simulation to analyse the nature of a bank's credit spread and the influence of the bank's risk incentives if the bank invests in Japanese companies. Instead of using actual data, the numerical simulation method using random numbers is more desirable in the context of this study because actual data on deposit distribution and depositors' trend distribution are not available in Japan.

In the numerical simulation, if depositors are able to predict the distributions, prepare the necessary data, and analyse the financial conditions, they might be able to choose the right bank for their deposits and withdraw their deposits with precise timing. The bank itself may use actual data on the deposit distribution and depositors' trend distribution to identify the credit spread. As a result, the bank will obtain necessary information for choosing a project with a high growth rate and managing the project in a stable and efficient way.

The numerical simulation is performed by assuming that: a bank with $n = 100$ depositors invests in a project with an initial value $X_0 = 100$; the bank's shareholders increase the bank's capital up to 25% of the bank's investment (i.e. $x = 0.25$); the cost of bank liquidation is $\beta = 0.05$; the deposit spread is $r - r^* = 0.05$; and, the cost of sale is $\alpha = 0.10$. Regarding volatility, $\sigma = 0.2$ or $0.4$ is considered in accordance with the actual value ranging from $20\%$ to $40\%$ in Japan. This study focuses on


ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

projects with two alternative volatility levels and the same initial value, and analyses how a bank's risk incentives will affect its credit spread and the probability of a DIC-initiated liquidation.

Concerning the deposit distribution and depositors' trend distribution, two sets of random numbers $u$ and $v$ are prepared for this simulation, which follow the normal distribution and uniform distribution, respectively. Moreover, the average value of each set is fixed at 1, the variance of the deposit distribution $u$ is adjusted to 0.1, and the depositors' trend distribution $v$ takes a value in the interval [0.6, 1.4]. Numerical examples obtained through the simulation are provided graphically to illustrate the influences of the bank's risk incentives.

Case (i): Volatility $\sigma = 0.2$
Figure1 is plotted with the project value $S$ on the horizontal axis and the bank's credit spread on the vertical axis if the bank invests in a project with volatility = 0.2. Figure 1 demonstrates two alternative scenarios respectively with and without a resolution of the bank's risk incentive problem by applying the result of $a = 0.50$ or $0.75$ from Seta and Inoue (2020) and an incentive contract with $\overline{K}(t,\sigma)$ in Equation (9).

The measured values of the bank's credit spread are provided in Tables 1 and 2. The credit spread is calculated by offsetting the equity risk premium with the sustainable growth rate. In general, the equity risk premium is reduced by only the part corresponding to the sustainable growth rate, i.e., the sustainable growth rate corrected for equity risk premium is either positive or negative. Over the phase in the credit spread is zero, the equity risk premium and the sustainable growth rate exactly offset each other.

Note that a positive equity risk premium is observed if the bank's risk incentive problem is unresolved. In addition, the negative sustainable growth rate takes a larger absolute value if the bank's risk incentive problem is resolved by the incentive contract.

Case (ii): Volatility $\sigma = 0.4$
Changes in the bank's total equity value have nothing to do with project volatility if the bank's risk incentive is zero. From Equation (9), if the bank's risk incentive problem is resolved, the bank's credit spread is not affected by project volatility. When the bank's risk incentive problem is unresolved, the bank's credit spread takes the same value as that in case (i), and thus the financial condition of the bank can be analysed on the basis of Figure 1. Furthermore, if the risk incentive problem is unresolved and the bank takes risky behaviour to increase project volatility, results regarding the influence of risk incentives can be obtained by comparing it with the case where the risk incentive problem is resolved.

Given that the absolute value of a bank's credit spread is proportional to the project value if the latter is higher than the project's initial price, the bank's financial condition can be considered as healthy as long as the measured value of the bank's credit spread is positive.


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Figure 2 shows that the resolution of the bank's risk incentive problem by the incentive contract offsets the equity risk premium and sustainable growth rate. As the project value approaches the value at which DIC would liquidates the bank, the equity risk premium decreases. Therefore, from Equation (9), the bank's credit spread is reduced by the equity risk premium but not by the sustainable growth rate.

Comparing with case (i), case (ii) has a smaller equity risk premium. However, in case (i), the equity risk premium decreases and the sustainable growth rate increases as the proportion of deposit insurance coverage increases. Regarding the sustainable growth rate, the magnitude of the relationship in absolute value is reversed relative to that of case (i). In comparison with case (i), the value of $\overline{K}(t,\sigma)$ implies that, if the bank's risk incentive problem is resolved by the incentive contract, the project value at which DIC liquidates the bank is not affected by the project's volatility.

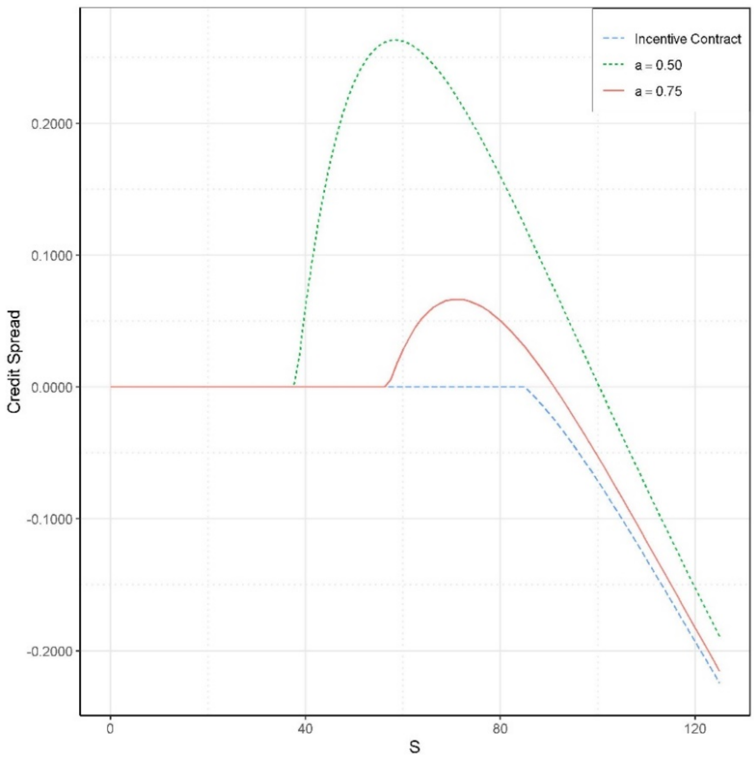


Figure 1: Bank credit spread for volatility $\sigma$ = 0.2

Table 1: Bank credit spread for volatility $\sigma$ = 0.2

| ***S*** | **20** | **40** | **60** | **80** | **100** | **120** |
|---|---|---|---|---|---|---|
| **Incentive Contract** | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0714 | -0.1933 |
| ***a* = 0.50** | 0.0000 | 0.0612 | 0.2625 | 0.1599 | 0.0023 | -0.1526 |
| ***a* = 0.75** | 0.0000 | 0.0000 | 0.0284 | 0.0502 | -0.0528 | -0.1829 |


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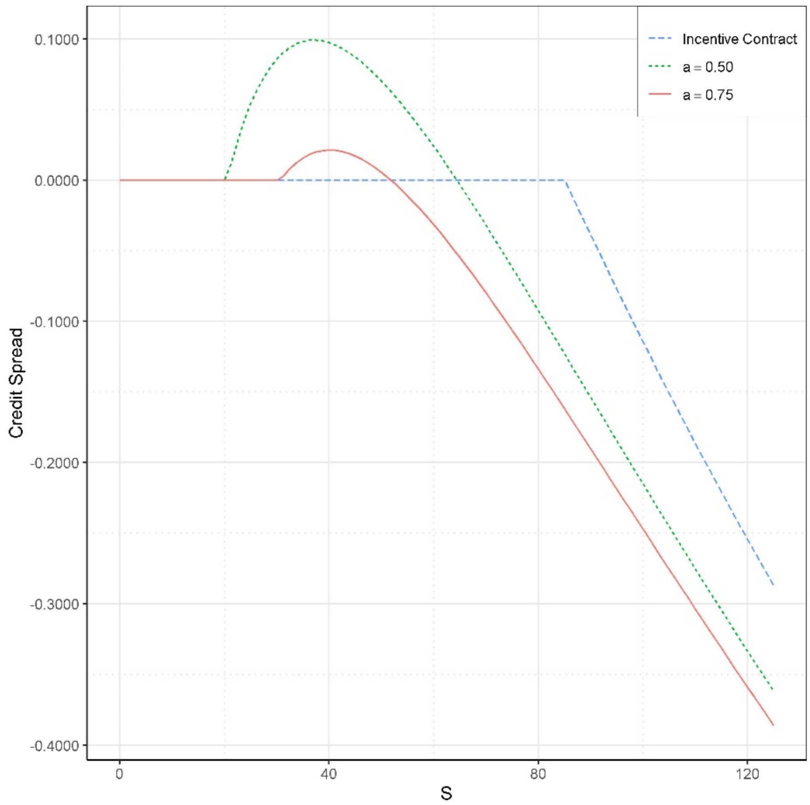


Figure 2: Bank credit spread for volatility $\sigma$ = 0.4

Table 2: Bank credit spread for volatility $\sigma$ = 0.4

| ***S*** | **20** | **40** | **60** | **80** | **100** | **120** |
|---|---|---|---|---|---|---|
| **Incentive Contract** | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.1145 | -0.2546 |
| ***a* = 0.50** | 0.0000 | 0.0974 | 0.0238 | -0.0923 | -0.2151 | -0.3335 |
| ***a* = 0.75** | 0.0000 | 0.0213 | -0.0316 | -0.1339 | -0.2472 | -0.3591 |

Case (iii): Probability of DIC-initiated liquidation

Given that the incentive contract's design is independent of the form of the deposit insurance system and that the liquidation probability in the case of $a = 0.50$ is strongly influenced by the bank's risk incentives, it is possible to analyse the relationship between the DIC-initiated liquidation probability and risk incentives under the deposit insurance system with a rate of compensation $a = 0.50$. Concerning the deposit insurance system incorporated with the incentive contract, the graph showing the probability of bank liquidation remains unchanged regardless of the form of the deposit insurance system.

By assuming that the project value will fall, Table 3 shows that the liquidation probability attains 100% at the fastest pace when the bank's risk incentive problem is resolved by the incentive contract. That is to say, the resolution of the bank's risk incentive problem leads to early DIC-initiated bank liquidation. Therefore, incorporating the incentive contract in the deposit insurance scheme is likely to prevent the bank from taking risky behaviour even in a situation where the bank is not well monitored by DIC.


ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Although the project value $S$ decreases by 50% below the project's initial price in Figure 3, the probability of bank liquidation remains high if the project volatility is high regardless of whether the bank's risk incentive problem is resolved or not. This implies that, if the project value is lower than 50% of the initial price, the liquidation probability of a bank investing in a low-volatility project is higher than that of a bank investing in a high-volatility project.

Consider a financially healthy bank. A high probability of bank liquidation is observed in the case where the bank invests in a project with high volatility even if the project value is rising. This implies that the incentive contract is effective in preventing the bank from taking excessive risks.

Suppose the bank takes higher risks by switching the project volatility from 20% to 40%. If the bank's risk incentive problem is unresolved, this upward volatility switch will increase the probability of bank liquidation due to a low trigger value. Even if the bank's risk incentive problem is already resolved, the incentive contract prevents a risky extension of the bank's life and dangerous business recovery, which motivates the bank to stabilize itself.

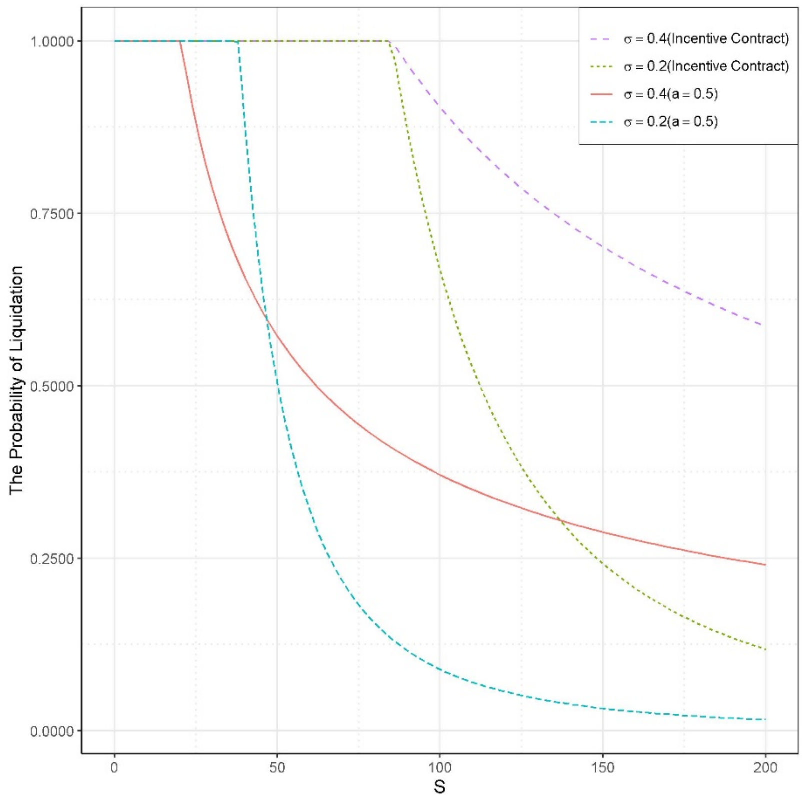


Figure 3 Probability of DIC-initiated liquidation


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Table 3 Probability of liquidation initiated by DIC

| ***S*** | **20** | **40** | **60** | **80** | **100** |
|---|---|---|---|---|---|
| **$\sigma$=0.2(Incentive Contract)** | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.6672 |
| **$\sigma$=0.4(Incentive Contract)** | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.9038 |
| **$\sigma$=0.2(a = 0.50)** | 1.0000 | 0.8780 | 0.3186 | 0.1552 | 0.0888 |
| **$\sigma$=0.4(a = 0.75)** | 1.0000 | 0.6574 | 0.5103 | 0.4263 | 0.3708 |
| ***S*** | 120 | 140 | 160 | 180 | 200 |
| **$\sigma$=0.2(Incentive Contract)** | 0.4230 | 0.2877 | 0.2061 | 0.1535 | 0.1180 |
| **$\sigma$=0.4(Incentive Contract)** | 0.8065 | 0.7324 | 0.6737 | 0.6259 | 0.5860 |
| **$\sigma$=0.2(a = 0.50)** | 0.0563 | 0.0383 | 0.0274 | 0.0204 | 0.0157 |
| **$\sigma$=0.4(a = 0.75)** | 0.3309 | 0.3005 | 0.2764 | 0.2568 | 0.2404 |

Findings from the numerical examples presented so far reveal the process by which risk incentives impose a negative impact on the bank's stability. The incentive contract can potentially eliminate such a negative effect. Moreover, the analysis of a bank's credit spread suggests that the bank is motivated by the incentive contract to choose a project with low volatility.

A bank's risk incentive problem induces it to increase its equity by investing in risky projects. That is to say, as long as the measured value of the bank's risk incentives is positive, the bank switches its investments to more risky projects so as to increase its total equity. The increase in equity appears to lower the trigger price and delay a DIC-initiated bank liquidation, but liquidation will become certain as the liquidation probability increases due to high risks. Moreover, a further reduction in the sustainable growth rate will place the bank in negative growth because the bank's risk incentive problem hinders its stable growth in the long term. Consequently, the bank's survival will be threatened by the fall in project value.

The resolution of a bank's risk incentive problem through the incentive contract makes it undesirable for the bank to switch to projects with higher volatility. Figure 3 demonstrates that investing in risky projects increases the probability of a DIC-initiated bank liquidation whilst keeping the trigger value constant. Therefore, projects with low volatility will be selected, through which the bank can stabilize its financial condition. An increase in project value raises the sustainable growth rate, and such stabilization yields a decrease in the probability of bank liquidation. As such, the incentive contract increases the bank's risk aversion.

The incentive contract, by motivating the bank to invest in projects with low volatility, not only reduces the probability of a DIC-initiated bank liquidation but also makes it possible for the sustainable growth rate to exceed the equity risk premium. Under such a circumstance, ROE calculated by Equation (10) always takes a positive value, implying that the bank is under stable and efficient management.

Assuming that the equity risk premium and dividend payout ratio are 0.07 and 0.30, respectively, ROE is approximately $31\%$ when the bank's credit spread takes the value


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of -0.15. In Japan, a research report by K. Ito (2014) (so-called Ito's report) regarding the ROE target pointed out that ROE should be higher than 8% in the first stage and then it should be higher than 10% in the second stage. Thus, in accordance with what suggested by Ito's report, the obtained ROE value of $31\%$ in the present study is well over the ROE target in the second stage in the scenario of a Japanese bank investing in Japanese companies. Moreover, if a project with low volatility ($\sigma = 0.2$) is selected, the bank's credit spread may reach -0.15 and the project value is close to $S = 115$. To summarize, the resolution of a bank's risk incentive problem through the incentive contract induces the bank to invest only in projects with low volatility, which allows the bank to achieve a desired level of ROE and create shareholder values.

## 7. CONCLUSIONS

This study proposes a risk incentive contract designated to resolve a bank's risk incentive problem. The contract design is based on a specific condition that Deposit Insurance Corporation (DIC) makes the liquidation decision for a bank. A scheme under which the liquidation probability of a bank is independent of the form of the deposit insurance system is formulated by incorporating the incentive contract into the system. Consequently, the possibility of bank liquidation initiated by DIC ensures that the bank's risk incentives are removed if the present value of the invested project is smaller than the bank's total deposits.

In general, it may be optimal to liquidate a bank if it is possible to evaluate the performance of the invested project and information asymmetry is resolved. If the present value of the invested project can be accurately evaluated from the project outcome, liquidation can be enforced by DIC regardless of whether information asymmetry exists. An incentive contract based on the option pricing theory is close to the optimal solution when information asymmetry leads to moral hazard. Therefore, the major difference between an incentive contract based on the option pricing theory and a contract based on the contract theory is that the former is closer to the optimal solution under asymmetric information.

The relationship between FCF yield spread and equity risk premium is specified by deriving the cost of equity using the DCF method. By evaluating the FCF yield spread that includes the bank's total equity calculated as an option value, the bank's credit spread can be numerically calculated to express the adjusted equity risk premium and sustainable growth rate. In addition, this study presents a method to calculate ROE, where the option value and equity risk premium can be substituted by the market risk premium and its sensitivity. This enables the bank to select a low-volatility project to achieve its ROE target through numerical simulations.

A graphical analysis on a bank's credit spread and the probability of a DIC-initiated liquidation when the bank invests in a Japanese company reveals a negative influence of the bank's risk incentives on its growth and a positive influence of the incentive contract on stabilizing the bank's financial condition. In the case of a recession that threatens a bank's survival and recovery, the bank's risky behaviour induced by its risk incentives leads to further negative growth. Therefore, using the incentive contract to resolve a bank's risk incentive problem achieves stable growth and efficient management by


ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

motivating the bank to achieve the ROE target through investing in low-volatility projects. The stable growth in turn supports a sound bank management that lowers the probability of a DIC-initiated bank liquidation.

This study's findings also suggest that the proposed incentive contract is independent of the form of the deposit insurance system, meaning that a bank's risky behaviour is restrained by DIC who is able to effectively monitor project outcomes. This analysis is based on the assumption that the depositors will never start a bank run. Even if the deposit insurance compensation is insufficient to cover the depositors' losses in the case of bank liquidation, a bank run does not occur as long as the depositors still believe that bank deposits are one of the safest assets. This assumption may not hold if the deposit insurance coverage is too low. As discussed in Seta and Inoue (2020), a bank's risk incentive problem arises if bank run remains a possible scenario. Therefore, designing a risk incentive contract to accommodate such a circumstance is suggested for future research.

As a matter of fact, the occurrence of risk incentive problems among banks is not limited to those situations with a deposit insurance system. Risk incentive problems can be found in various other situations, including the possibility of endogenous bankruptcy triggered by intrinsic factors and the need to diversify banks' risks. For instance, banks in Kazakhstan follow the traditional banking strategy of relying on deposits as the main source of financing. Pak (2017) documented that banking stability in Kazakhstan declined during 2007 to 2016, and empirically showed that enlarging bank scale, increasing lending, and investments in financial securities undermined the financial stability of banks in Kazakhstan. He also found that short-term bank loans had a positive effect on banking stability. Due to the lower risks of short-term bank loans, findings from this study imply that the incentive contract would bring stability and sustainable growth to banks in Kazakhstan if they make short-term investments in Japanese companies. Therefore, designing different incentive contracts to accommodate different situations is essential to solving the risk incentive problems among banks.

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