KEIO UNIVERSITY
MARKET QUALITY RESEARCH PROJECT
(A 21st Century Center of Excellence Project)

KUMQRP DISCUSSION PAPER SERIES

DP2005-005

Bank's Disclosure and the Efficiency of Allocation

Masatomo Akita*
Yasuo Maeda**

Abstract

This paper specifies the bank's decisions on information disclosure, and investigates how these decisions affect the efficiency of allocations. When banks hold relatively safe assets, information disclosure becomes wasteful; on the other hand, when banks hold relatively risky assets, information disclosure contributes to the efficiency of allocations. In the latter case, the disclosed information is used to liquidate bad loans efficiently. These results imply that there should be a moderate level of discipline toward banks. When banks can choose between safe assets and risky assets, disclosure may be used to signal the safety of the bank's assets. Disclosure thus has several different roles, and the adequate level of disclosure differs depending on the role being played. This implies that if we recklessly request information disclosure from banks without due consideration of the roles and levels, the disclosure will be socially inefficient. We can also show that when bankruptcy costs of banks are considered, mandatory disclosure improves social efficiency.

* Graduate student, Graduate School of Economics, Osaka University
** Professor, Faculty of Economics, Keio University

Graduate School of Economics and Graduate School of Business and Commerce,
Keio University
2-15-45 Mita, Minato-ku, Tokyo 108-8345, Japan

Bank's Disclosure and the Efficiency of Allocation*

Masatomo AKITA
Graduate School of Economics, Osaka University

Yasuo MAEDA
Faculty of Economics, Keio University

May 16, 2005

Abstract This paper specifies the bank's decisions on information disclosure, and investigates how these decisions affect the efficiency of allocations. When banks hold relatively safe assets, information disclosure becomes wasteful; on the other hand, when banks hold relatively risky assets, information disclosure contributes to the efficiency of allocations. In the latter case, the disclosed information is used to liquidate bad loans efficiently. These results imply that there should be a moderate level of discipline toward banks. When banks can choose between safe assets and risky assets, disclosure may be used to signal the safety of the bank's assets. Disclosure thus has several different roles, and the adequate level of disclosure differs depending on the role being played. This implies that if we recklessly request information disclosure from banks without due consideration of the roles and levels, the disclosure will be socially inefficient. We can also show that when bankruptcy costs of banks are considered, mandatory disclosure improves social efficiency.

Keywords: Disclosure; Banks; Market discipline

JEL Classification Number: G21; G28

*An earlier version of this paper was presented at the 2003 Spring Meeting of the Japanese Economic Association, Macroeconomics Seminar at Osaka University, and the seminar at Doshisha University. We are grateful to Hiroshi Osano, Hirofumi Uchida, and participants of the above seminars for their helpful comments and suggestions.

1 Introduction

The idea that utilization of market discipline is useful for disciplining banks has spread in recent years. The use of subordinated debt is the primary device mentioned for utilizing market discipline. In the United States, Gramm-Leach-Bliley Act has actually proposed that banks be obligated to issue subordinated debt periodically. If subordinated debt is correctly priced based on the bank's asset risk, the subordinated debt premium will increase with the bank's risk taking, and the financing cost of a bank will increase. Therefore, when the issue of subordinated debt accounts for a certain percentage of a bank's finances, banks will not prefer excessive risk.

However, it is an important element for utilizing such market discipline that banks disclose information appropriately. In this paper, we focus on banks' disclosure and analyze the efficiency of resource allocation. In the case of disciplining banks by subordinated debt, although banks are monitored through information produced by subordinated debt holders and/or securities companies, the effectiveness of such monitoring depends on what information banks disclose.

The first studies on disclosure are Milgrom (1981) and Grossman (1981). Both papers conclude that all sellers of a commodity disclose information about its quality if the information is credible and can be transmitted without cost to the market's participants. There are a large number of studies on disclosure in the fields of accounting, finance, and economics.[1] However, most of these have been studies on typical firms (non-financial institutions), and very few theoretical works have been performed on the information disclosure of banks.[2] This paper specifies the bank's decisions on information disclosure, and investigates how these decisions affect the efficiency of allocations.

Recently, there has been considerable discussion regarding the form of disclosure (Investor Relations), not only by banks but also by general firms. If quarterly disclosure is introduced, although the amount of information will increase, there is a concern that the increase in information will confuse the investors. However, the form of disclosure has become an important element of corporate strategy because, in the latest markets, stock prices react to information (regardless of whether it is good or bad) more sensitively than before.

As an example from Japan, according to the results of a questionnaire submitted by the Life Insurance Association of Japan to 173 companies employing institutional investors, 50 percent or more of the institutional investors were not satisfied with the form of information disclosure of their firms. While firms which positively disclose information exist, firms with negative disclosure also exist due to the judgment that information explaining the progress of the settlement of accounts will surely cause confusion. However, a firm with negative disclosure is not necessarily a bad firm. For example, there is a firm in which the operating income margin is high and the confidence from stock markets is high, but the firm discloses little information. Thus

[1] For example, Verrecchia (2001) surveys the studies on disclosure.

[2] Cordella and Yeyati (1997) show that a bank's disclosure is effective against the stabilization of the financial system if a bank can control the risk of assets.

the mechanism of information disclosure is highly complex, and is an appropriate candidate for theoretical analysis.

This paper focuses on the decision-making of banks for which disclosure is important, and theoretically analyzes the determinants and mechanism of disclosure, as well as the influence of disclosure on resource allocation. Banks differ from other typical firms in three main ways. First, assets held by banks are very opaque and complex. Second, the present banking system is inherently fragile, as shown by Diamond and Dybvig (1983). And third, the network system of banks organizes a payment system and has a public role. For all of these reasons, we consider that the analysis of banks' disclosure is very important.

We consider two types of assets that a bank may hold, safe and efficient assets and risky and inefficient assets. We first consider the case where only one or the other of these types of assets exists. Second, we consider the case where a bank can choose between the two types of assets.

In the case that there is only one type of assets, the conclusions are as follows. When banks hold relatively safe assets, information disclosure has no effect and becomes wasteful. On the other hand, when banks hold relatively risky assets, information disclosure contributes to the efficiency of allocations. In the latter case, disclosure plays two main roles. One is that disclosed information is used to liquidate bad loans efficiently. The other is that disclosure is used to prevent liquidation of good loans. In this paper, the results indicate that it is efficient to use the former disclosure. Moreover, these results have an important implication regarding the form of market discipline toward banks, namely, that there should be a moderate level of discipline toward banks, since market discipline toward banks is inefficient when it is too strict or too soft.

When banks can choose between safe assets and risky assets, disclosure may be used to signal the safety of the bank's assets. When banks disclose some level of information, they can persuade investors of the safety of their assets. If a signaling cost is relatively small, then banks use disclosure as a signal and hold safe assets. On the other hand, if a signaling cost is relatively large, then banks use disclosure as a device to liquidate inefficient assets and hold risky assets. Furthermore, the adequate level of disclosure has the following property. When the expected payment to depositors increases due to an increase in the depositors' power, the disclosure level chosen by banks increases regardless of whether the assets of the bank are safe or not. Then, the condition for holding safe assets becomes more restrictive, and hence banks are more likely to hold risky assets.

Finally, we introduce bankruptcy costs of banks, and show that project choices of banks may be inconsistent with social efficiency. In such cases, an adequate level of disclosure regulation can improve the social welfare. However, if bankruptcy costs of banks are large enough, then the social welfare can not be improved only by information disclosure regulation.

A crucial implication of the results of this paper is that disclosure has several different roles, and that the adequate level of disclosure differs depending on the role being played. Therefore, if we recklessly request information disclosure from banks without due consideration of the roles and levels, the disclosure will be socially inefficient.

In our model, the bank's decision to disclose has two effects on its expected profit. One is the cost effect; disclosure has a direct cost known as the information transfer cost. If a bank chooses a higher disclosure level, disclosure-related costs must be higher. The other is the benefit effect; a bank can lower its financing cost by proposing a deposit contract with disclosure. As described above, the type of benefits accruing from disclosure changes with the type of assets a bank holds. When a bank with risky assets discloses information, it can lower its financing costs through liquidation of inefficient assets. When a bank with safe assets discloses information above a certain level, it can be transmitted to investors that the assets of the bank are safe, and then the bank can propose a lower deposit rate. From these properties, we have the results described above.

Our model is related to the disciplining role of depositors on banks. Calomiris and Kahn (1991) propose a theoretical model that specifies such market discipline. They show that demandable debt plays an important role for disciplining banks. Chen (1999) extends the Diamond and Dybvig (1983) model and emphasizes that the use of subordinated debt is an efficient mechanism for disciplining banks. Although he introduces existence of subordinated debt holders (informed depositors) exogenously, we endogenously derive the ratio of depositors who perceive the bank's asset risk (informed depositors) from introduction of the bank's disclosure.

In our model, the assets of a bank are liquidated by the withdrawals of depositors, and this action of the depositors is induced by disclosed information from the bank. Such information-based bank runs are analyzed by Jacklin and Bhattacharya (1988) and Alonso (1996). Their model is completely distinct from Gorton (1985) and Chari and Jagannathan (1988), in which bank runs are caused by misreading and the fear of depositors with regard to the bank's asset risk; instead, their runs are based on correct information with regard to the bank's asset risk. Park (1991) describes that past bank runs in the United States were mainly based on lack of information about the banks' asset risk and suggests the importance of disclosure by banks.

The rest of the paper is organized as follows. The basic model is proposed in Section 2. In Section 3, we analyze the role of disclosure in the case where a bank has only one type of projects, i.e., safe or risky projects. In Section 4, we analyze the role of disclosure in the case where a bank can choose one of the two types of projects described in Section 3. Section 5 investigates the availability of disclosure regulation with consideration of the bankruptcy cost of banks. Finally, Section 6 summarizes this paper.

2 Basic Model

Consider a three-period model (period 0, period 1, and period 2) in which there are a bank and a continuum $[0, 1]$ of investors. The bank and investors are assumed to both be risk neutral. Each investor has 1 unit of goods as an asset in period 0, which implies that the total group of investors is endowed with 1 unit of goods.

Investment project A bank has an investment project, and by investing goods in period 0, it can produce returns in period 2. There are two types of projects: the type G project (project G) and the type B project (project B). A bank can invest in one of these projects. Project G produces G units of goods in period 2 from 1 unit of investment in period 0. The output from project B depends on the state of the economy in period 1. The state of the economy becomes good (the state g) with probability p, and becomes bad (the state b) with probability $1-p$. Project B produces B units of goods in period 2 from 1 unit of investment in period 0 when the state of the economy in period 1 is good. However, when the state of the economy in period 1 is bad, it produces B units of goods with probability s and produces nothing with probability $1-s$. This implies that the expected output of project B from 1 unit of investment becomes $(p+(1-p)s)B$.

Define $Q \equiv (p+(1-p)s)$. We assume that there exist a safe short-term inventory technology and a safe long-term inventory technology, both of which can be accessed by both banks and investors. The short-term inventory technology transforms 1 unit of goods in period 0 to 1 unit in period 1 (and 1 unit of goods in period 1 to 1 unit in period 2), and the long-term inventory technology transforms 1 unit of goods in period 0 to $r \geq 1$ in period 2.

The type of project chosen by the bank in period 0 is private information of the bank, and so is the state of the economy in period 1. The values of variables G, B, p, s, and r are public information.

With respect to investment projects, we assume the following:

Assumption 1 $G > QB > r,\ G < B.$

This assumption means that project G is more efficient than project B, project B is the high risk and high return project, and project B is more efficient than the inventory technology.

We also assume that either project can be liquidated in period 1. When liquidation is necessary, the bank can liquidate 1 unit of assets to $L \geq 1$ units of goods [3], where L is a fixed number which is independent of the type of the project and the state of the economy. We assume the following with respect to the relationship between the value of liquidation L and investment projects:

Assumption 2 $sB < L \leq r,\ L < \dfrac{G-pB}{1-p}.$

[3] The setting $L \geq 1$ may seem to be inconsistent with the reality. The purpose of this assumption is, however, to simplify the calculation of the bank's profit maximization problem. This assumption implies that the bank does not need to hold the reserve by using the short-term inventory technology in period 0. Although we can think of a situation in which $L < 1$ without changing the result, the calculation becomes much more complicated.

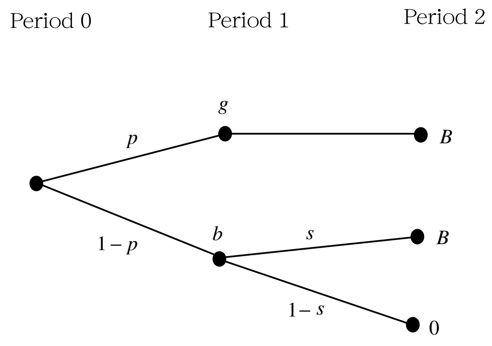

Figure 1: The type B project

The first inequality in the first equation implies that to liquidate project B is efficient when the state becomes B. The second inequality in the first equation implies that the value of liquidation L is less than the return of the long-term inventory investment r, which also implies that liquidation of project G, or of project B in state g is inefficient. The second equation implies that the return from project B is less than that from project G even if project B is liquidated in state b.

Disclosure The bank can disclose in period 1 the state of the economy and the type of the project chosen to investors. The bank cannot tell a lie. The cost to disclose the information to a fraction $\theta \in [0, 1]$ of investors is assumed to be $C(\theta)$. Since the bank is not endowed with goods, this cost is paid from the assets invested by investors in period 0.[4] We define the fund to be used for the productive investment project as $\chi(\theta) \equiv 1 - C(\theta)$, and we assume that $\chi(0) = 1,\ \chi(1) > 0$. We also assume the following:

Assumption 3 $\chi'(\theta) < 0,\ \chi''(\theta) < 0,\ \chi'(0) = 0,\ \chi'(1) = -\infty$.

This assumption implies the following environment. The first and second assumptions mean, respectively, that more cost must be sustained in order to let more investors know the information, and that this marginal cost is increasing. The third and fourth assumptions are necessary to insure the internal solution with respect to θ.

The disclosure we are considering here does not mean transmitting the information to θ of investors exclusively. Our θ indicates the attitude of banks toward

[4]As we have described, the bank does not hold the reserve. Therefore, the disclosure cost is prepared by liquidating some of the projects. If we write the direct information cost as $c(\theta)$, then we have $C(\theta) = c(\theta)/L$. There is no problem in interpreting $C(\theta)$ as the reserve.

information disclosure. For example, the amount of information that investors will obtain is different between the case that information is disclosed by using an Internet homepage and the case that information is disclosed by silently piling documents in the corner of the shop. And, even if all the investors know the information, depending on the amount and quality of information, the number of investors who can recognize the risk of banks will differ. In the model, θ indirectly expresses the means or incentive to disclose.[5] Therefore, we can also refer to θ as the information disclosure level.

Investors Investors choose whether they will invest the goods they have in period 0 in inventory technology or invest them in the bank. We assume that if the expected returns are the same, they will invest them in the bank.

Contract The investment contract (lending contract) to the bank is proposed by the bank in period 0. Investors decide whether to accept it or not. The individual contract is expressed as $((R', R), \theta)$, where R' is the short-term interest rate, R is the long-term interest rate, and θ is the information disclosure level. The short-term interest rate is the interest rate adopted when funds are withdrawn in period 1, and the long-term interest rate is the interest rate adopted when funds are withdrawn in period 2.

Investors invest in the bank when the expected return of investment is higher than r, which is the return expected when they invest somewhere other than the bank. When the bank can obtain funds, it invests funds in the project $\eta \in \{G, B\}$. The state of the economy is known at the beginning of period 1, and the bank discloses the state of the economy $i \in \{g, b\}$ and the type of the project η based on the value of θ that the bank proposed in period 0.

Investors who want to withdraw their funds from the bank in period 1 claim R' to the bank. The bank responds to this claim by liquidating some of its projects. At the beginning of period 2, the return from the project is realized, and all investors who do not withdraw in period 1 claim R to the bank. Unless the return from the project is 0, the bank pays R to investors. However, if the return from the project is 0, this payment is not completed.

Time line

- Period 0: The bank proposes $((R', R), \theta)$. Investors decide whether to deposit or not. When deposited, the bank invests these funds to project η.

- Period 1: The bank observes the state of the economy i. The bank discloses information based on the disclosure level θ. If some or all of investors withdraw in this period, the bank responds by liquidating some of the projects.

[5]We can also formalize the model as follows if more precise modeling is necessary. Let $e \in [0, \bar{e}]$ be an incentive to disclose, and θ be the function of e. We assume $\theta'(e) > 0$, $\theta(0) = 0$, and $\theta(\bar{e}) = 1$. The decision of banks is indifferent between e and θ.

- Period 2: The return of the project η is realized. Unless the return from the project is 0, all investors who did not withdraw in period 1 obtain R from the bank.

In the next section, we analyze the case where the bank has one type of project, and examine the characteristics of contracts proposed by the bank and the role of disclosure. Then, in section 4, we analyze the case where the bank has two types of projects and can choose only one of them.

3 The role of disclosure in deposit contracts

In this section, we consider the case where the bank has only one type of project. First, we examine the case where the bank has project G, and second, we look at the case where the bank has project B. We assume that investors know the type of projects chosen by the bank. Hence, information is symmetric in the case of project G. On the other hand, in the case of project B, information about the state of nature is asymmetric. The bank can let θ of investors know the state of the economy by information disclosure.

We define an equilibrium in the economy with one type of project as follows.

Definition 1 *An equilibrium in the economy with one type of project is defined as* $((R', R), \theta)$*, where* (R', R) *is the interest rate,* θ *is the information disclosure level, and* $((R', R), \theta)$ *maximizes the bank's expected profits.*

We will obtain an equilibrium for each type of project in the following.

3.1 Safe asset and information disclosure

Here, we consider the economy where the bank has only project G. As described above, investors know that the bank can choose only project G. Since the return on project G does not depend on the state of the economy, information is considered as symmetric between the bank and the investors.

3.1.1 The bank's profit maximization problem

The bank proposes the contract $((R', R), \theta)$ in order to maximize its expected profit. Here, we divided the set of interest rates into two subsets, namely, $\mathcal{A}^N(G) \equiv \{(R', R) | R' \leq R\}$ and $\mathcal{A}^A \equiv \{(R', R) | R' > R\}$.

$\mathcal{A}^N(G)$ is the area where no liquidation occurs. In this area, the long-term interest rate is larger than the short-term interest rate. Since project G produces G with probability 1, the investors do not withdraw in period 1. On the other hand, in $\mathcal{A}^N(G)$, the short-term interest rate is larger than the long-term interest rate. This means that all investors withdraw in period 1.

The bank's profit Here, we calculate the profit of the bank when it proposes the contract $((R', R), \theta)$ in each area.

[In $\mathcal{A}^N(G)$] The investment after the bank pays the disclosure cost becomes $\chi(\theta)$. Hence, the profit of the bank when $(R', R) \in \mathcal{A}^N(G)$ is calculated as $\chi(\theta)G - R$.

[In $\mathcal{A}^A$] In $(R', R) \in \mathcal{A}^A$, all investors withdraw in period 1, and the bank responds by liquidating assets. Hence, the profit of the bank is calculated as $\left(\chi(\theta) - \frac{R'}{L}\right) G$.

To summarize the above, the profit of the bank becomes

$$\pi^G((R', R), \theta) = \begin{cases} \chi(\theta)G - R & \text{if } (R', R) \in \mathcal{A}^N(G) \\ \left(\chi(\theta) - \dfrac{R'}{L}\right) G & \text{if } (R', R) \in \mathcal{A}^A. \end{cases} \tag{1}$$

The investor's participation constraint We calculate the constraint of investors to participate in the contract $((R', R), \theta)$ proposed by the bank in each area of interest rates.

[In $\mathcal{A}^N(G)$] The expected return for investors is R in this area. Hence, the participation constraint becomes $R \geq r$. The value of R' does not affect the behavior of investors in this area.

[In $\mathcal{A}^A$] Since, in $(R', R) \in \mathcal{A}^A$, the investors always withdraw, the expected return for investors is R'. Hence, the participation constraint becomes $R' \geq r$. The value of R does not affect the behavior of investors in this area.

Hence, by defining $\mathcal{R}^G((R', R), \theta)$ as

$$\mathcal{R}^G((R', R), \theta) = \begin{cases} R - r & \text{if } (R', R) \in \mathcal{A}^N(G) \\ R' - r & \text{if } (R', R) \in \mathcal{A}^A, \end{cases} \tag{2}$$

the participation constraint of investors becomes $\mathcal{R}^G((R', R), \theta) \geq 0$. The contract proposed by the bank satisfies $\mathcal{R}^G((R', R), \theta) = 0$.

The bank's profit maximization problem with project G By using the functions defined above, the bank's profit maximization problem with project G becomes

$$\begin{aligned} &\max_{((R', R), \theta)} \pi^G((R', R), \theta) \\ &\text{subject to } \mathcal{R}^G((R', R), \theta) = 0. \end{aligned}$$

3.1.2 Equilibrium

Here, we describe the equilibrium.

[In $\mathcal{A}^N(G)$] Substituting the investor's participation constraint $R = r$ into the bank's profit function $\chi(\theta)G - R$, we obtain $\chi(\theta)G - r$. Therefore, when the bank proposes a contract in this area, the bank chooses $\theta = 0$, and its profit becomes $\pi^G_N = G - r$.

[In $\mathcal{A}^A$] Substituting the investor's participation constraint $R' = r$ into the bank's profit function $\left(\chi(\theta) - \frac{R'}{L}\right) G$, we obtain $\left(\chi(\theta) - \frac{r}{L}\right) G$. Therefore, the bank proposes $\theta = 0$, the bank's profit becomes $\pi_A^G = G - \frac{G}{L} r$, and we have $\pi_A^G < \pi_N^G$.

Then, we have the following proposition.

Proposition 1 *In the economy with only project G, the equilibrium becomes*

$$((R', R), \theta) = ((0, r), 0).$$

We adopt $R' = 0$ as the equilibrium short-term interest rate, although we obtain the same results for all $R' \in [0, r]$. This result is rather trivial. Since the bank holds only safe assets, information disclosure is not necessary. Even if the bank's assets are risky, as long as there are sufficient assets to pay the investors, there does not exist a problem of asymmetric information. Therefore, in this case, disclosure serves no purpose, and is wasteful.

3.2 Risky asset and information disclosure

Here, we consider the economy where the bank has only project B. Investors also know that the bank uses project B. The behavior of investors depends on the disclosure about the state of the economy.

3.2.1 The bank's profit maximization problem

The bank proposes a contract $((R', R), \theta)$ so as to maximize its expected profit. Here, we divide the set of interest rates into several subsets: $\mathcal{A}^N(B) \equiv \{(R', R) | R' \leq sR\}$, $\mathcal{A}^L(B) \equiv \{(R', R) | QR \geq R' > sR\}$, $\mathcal{A}^E(B) \equiv \{(R', R) | R \geq R' > QR\}$, and $\mathcal{A}^A \equiv \{(R', R) | R' > R\}$. Each area is characterized by the bank's liquidation decision.

Decision on liquidation The bank can control liquidation by a proposed contract. Actually, when $(R', R) \in \mathcal{A}^N(B)$, even when the economy is in state b, no investors withdraw, since R' is greater than sR. This implies that no liquidation occurs.

When $(R', R) \in \mathcal{A}^L(B)$, investors have an incentive to withdraw when the economy is in state b. Investors who obtain information that the state has become b know that the expected return in period 2 is sR, which is less than the return in period 1 R'. On the other hand, the expected return in period 2 for investors who do not obtain information is still QR. Therefore, these investors wait until period 2. In state g, investors do not withdraw in period 1 irrespective of the information they obtain. Hence, in this area, θ of investors withdraw in state b. So, liquidation occurs when $\theta > 0$.

When $(R', R) \in \mathcal{A}^E(B)$, investors who do not obtain information withdraw, since $R' > QR$ holds. On the other hand, the investors who obtain information withdraw

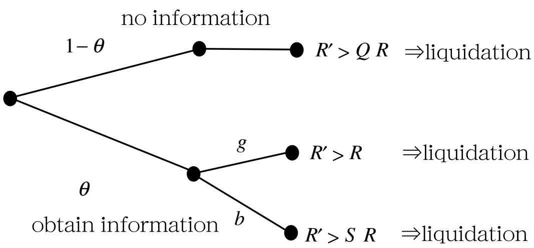

Figure 2: Behavior of investors

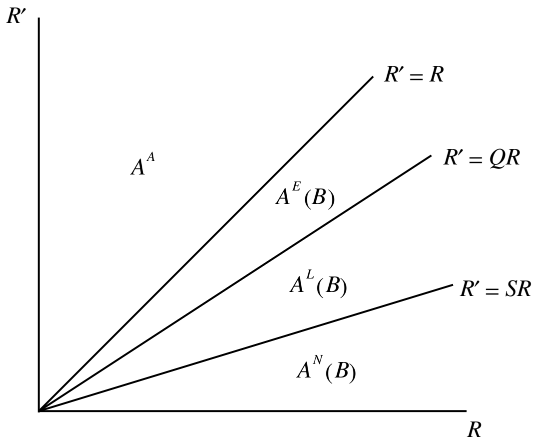

Figure 3: Interest rate and behavior of investors

in state b, and wait in state g. Hence, in this area, only the investors who received the information of state g wait. So, if $\theta < 1$, liquidation occurs even in state g.

When $(R', R) \in \mathcal{A}^A$, all the investors withdraw in period 1 irrespective of the information, and liquidation occurs. See Figure 2 and Figure 3.

The bank's profit Here, we calculate the bank's profit when the contract $((R', R), \theta)$ is proposed for each area of interest.

[In $\mathcal{A}^N(B)$] The bank's profit in this area is calculated as follows. As described above, in this area, investors do not withdraw. Hence, the bank's profit in this area becomes $Q\left(\chi(\theta)B - R\right)$.

[In $\mathcal{A}^L(B)$] In this area, the investors who have obtained information withdraw in period 1. The bank needs $\theta R'$ to prepare this withdrawal by liquidation. This means that assets are liquidated by $\frac{\theta R'}{L}$. Hence, the expected return from the remaining assets becomes

$$s\left\{\left(\chi(\theta) - \frac{\theta R'}{L}\right)B - (1-\theta)R\right\}.$$

And, in the case that the economy is in state g in period 1, no investors withdraw.

Therefore, the expected profit of the bank is calculated as

$$
\begin{aligned}
& p(\chi(\theta)B - R) + (1-p)s\left\{\left(\chi(\theta) - \frac{\theta R'}{L}\right)B - (1-\theta)R\right\} \\
&= Q\chi(\theta)B - (p + (1-p)s(1-\theta))R - (1-p)s\theta\frac{B}{L}R'.
\end{aligned}
$$

The first term in this equation expresses the potential expected return in the case that there is no liquidation. In state g, all investors withdraw R, and in state b, the investors without information withdraw R when the project succeeds. The expected value of these withdrawals is expressed in the second term. The third term expresses the decrease of return due to liquidation.

[In $\mathcal{A}^E(B)$] In $(R', R) \in \mathcal{A}^E(B)$, the investors with information withdraw only in state of b. On the other hand, the investors without information withdraw irrespective of the state of the economy. Hence, in state g, the bank needs to obtain the fund $(1-\theta)R'$ by liquidation. And, in state g, the bank needs to obtain the fund R'. Therefore, the bank's expected profit becomes

$$
\begin{aligned}
& p\left\{\left(\chi(\theta) - (1-\theta)\frac{R'}{L}\right)B - \theta R\right\} + (1-p)s\left(\chi(\theta) - \frac{R'}{L}\right)B \\
&= Q\chi(\theta)B - p\theta R - (p(1-\theta) + (1-p)s)\frac{B}{L}R'.
\end{aligned}
$$

What each term in the above equation expresses is the same as the case in $\mathcal{A}^L(B)$.

[In $\mathcal{A}^A$] In $(R', R) \in \mathcal{A}^A$, all investors withdraw regardless of whether or not they receive information. The bank's expected profit becomes

$$
\begin{aligned}
& p\left(\chi(\theta) - \frac{R'}{L}\right)B + (1-p)s\left(\chi(\theta) - \frac{R'}{L}\right)B \\
&= Q\left(\chi(\theta) - \frac{R'}{L}\right)B.
\end{aligned}
$$

Summarizing the above results, we have

$$
\pi^B((R', R), \theta) = \begin{cases}
Q\left(\chi(\theta)B - R\right) & \text{if } (R', R) \in \mathcal{A}^N(B) \\
Q\chi(\theta)B - (p + (1-p)(1-\theta)s)R - (1-p)s\theta\frac{B}{L}R' & \text{if } (R', R) \in \mathcal{A}^L(B) \\
Q\chi(\theta)B - p\theta R - (p(1-\theta) + (1-p)s)\frac{B}{L}R' & \text{if } (R', R) \in \mathcal{A}^E(B) \\
Q\left(\chi(\theta) - \frac{R'}{L}\right)B & \text{if } (R', R) \in \mathcal{A}^A.
\end{cases} \tag{3}
$$

The investor's participation constraint Here, we calculate the investor's participation constraint when the contract $((R', R), \theta)$ is proposed by the bank.

[In $\mathcal{A}^N(B)$] In $(R', R) \in \mathcal{A}^N$, as described above, the investors do not withdraw in period 1. Hence, the investors' expected return becomes QR. In this case, the investor's participation constraint needs to satisfy $QR \geq r$. R' can take any value in this area.

[In $\mathcal{A}^L(B)$] In $(R', R) \in \mathcal{A}^L(B)$, all investors receive R when the economy is in state g. In state b, the informed investors withdraw R'. The uninformed investors do not withdraw in period 1, and receive R in period 2 when the project succeeds. Therefore, the investor's expected return becomes

$$pR + (1-p)(\theta R' + (1-\theta)sR) = (1-p)\theta R' + (p + (1-p)(1-\theta)s)R.$$

The investor's participation constraint is calculated as $(1-p)\theta R' + (p+(1-p)(1-\theta)s)R \geq r$.

[In $\mathcal{A}^E(B)$] In $(R', R) \in \mathcal{A}^E(B)$, when the state is good, the investors who obtain information (θ of investors) wait to withdraw by the second period, and the investors who do not obtain information ($1-\theta$ of investors) withdraw R' in period 1. When the state becomes b, all the investors withdraw R' in period 1. Therefore, the investor's expected return becomes

$$p(\theta R + (1-\theta)R') + (1-p)R' = (1-p\theta)R' + p\theta R.$$

The investor's participation constraint is calculated as $(1-p\theta)R' + p\theta R \geq r$.

[In $\mathcal{A}^A$] In $(R', R) \in \mathcal{A}^A$, investors withdraw in period 1 regardless of whether or not they receive information. The investor's expected return becomes R'. Therefore, the investor's participation constraint is calculated as $R' \geq r$. Regarding R, we only need $R < R'$.

To summarize the above, the investor's participation constraint becomes $\mathcal{R}^B((R', R), \theta) \geq 0$ by defining $\mathcal{R}^B((R', R), \theta)$ as

$$\mathcal{R}^B((R', R), \theta) = \begin{cases} R - \dfrac{r}{Q} & \text{if } (R', R) \in \mathcal{A}^N(B) \\ R - \dfrac{r - (1-p)\theta R'}{p + (1-p)(1-\theta)s} & \text{if } (R', R) \in \mathcal{A}^L(B) \\ R - \dfrac{r - (1-p\theta)R'}{p\theta} & \text{if } (R', R) \in \mathcal{A}^E(B) \\ R' - r & \text{if } (R', R) \in \mathcal{A}^A. \end{cases} \tag{4}$$

The contract which the bank offers satisfies $\mathcal{R}^B((R', R), \theta) = 0$.

The bank's profit maximization problem with project B By using the functions defined above, the bank's profit maximization problem with project B becomes

$$\max_{((R',R),\theta)} \pi^B((R', R), \theta)$$
$$\text{subject to } \mathcal{R}^B((R', R), \theta) = 0.$$

3.2.2 Equilibrium

By using the bank's profit function and the investor's participation constraint, we obtain an equilibrium. First, we solve the bank's profit maximization problem in each area of interest rates. Second, we compare these profits, and the largest becomes an equilibrium.

[In $\mathcal{A}^N(B)$] Substituting the investor's participation constraint $R = \frac{r}{Q}$ into the bank's profit function $Q(\chi(\theta)B - R)$, we have $Q\chi(\theta)B - r$. Therefore, the bank chooses $\theta = 0$, and the bank's expected profit becomes $\pi_N^B = QB - r$. In this area, the information does not affect the investor's behavior, and $\theta = 0$ becomes optimal.

[In $\mathcal{A}^L(B)$] In this area, the bank's expected profit is $Q\chi(\theta)B - (p + (1-p)(1-\theta)s)R - (1-p)s\theta\frac{B}{L}R'$. Substituting the investor's participation constraint into this equation, we have

$$Q\chi(\theta)B + (1-p)\theta\left(1 - \frac{sB}{L}\right)R' - r.$$

By Assumption 2, the bank's expected profit becomes larger as R' is larger. Hence, from the maximum value in this area $R' = QR$, and the participation constraint, we have $R' = \frac{Qr}{Q+(1-Q)p\theta}$. By substituting this R', the bank's expected profit becomes

$$\pi_L^B(\theta) = Q\chi(\theta)B + (1-p)\theta\left(1 - \frac{sB}{L}\right)\frac{Qr}{Q + (1-Q)p\theta} - r.$$

By differentiating this equation with respect to θ, we have

$$-Q\chi'(\theta)B = \frac{(1-p)\left(1 - \frac{sB}{L}\right)Q^2 r}{(Q + (1-Q)p\theta)^2}. \tag{5}$$

The left-hand side of (5) is the marginal cost of disclosure, which is the increase in disclosure cost due to the decrease in investment. The right-hand side is the marginal profit, which is the increase of profit due to the increase in liquidation in the state b. The bank tries to equate them. In the analysis below, we express θ which satisfies (5) as θ_L.

Hence, the bank proposes the contract

$$((R', R), \theta) = \left(\left(\frac{Qr}{Q + (1-Q)p\theta_L}, \frac{r}{Q + (1-Q)p\theta_L}\right), \theta_L\right),$$

and its expected profit becomes

$$\pi_L^B = Q\chi(\theta_L)B + D(\theta_L) - r,$$

where $D(\theta) \equiv (1-p)\theta\left(1 - \frac{sB}{L}\right)\frac{Qr}{Q+(1-Q)p\theta}$. In this area, the disclosure can contribute to the efficiency. When $\theta = 0$, the expected profit is $QB - r$, which is equal to π_N^B. In the environment where $L > sB$ holds, the liquidation of assets in period 1 improves the efficiency. Hence, the bank discloses its information, and liquidates assets due to the investor's withdrawal. The profit obtained from this mechanism can be seen in the second term in π_L^B.

[In $\mathcal{A}^A$] Substituting the investor's participation constraint $R' = r$ into the bank's profit function $Q\left(\chi(\theta) - \frac{R'}{L}\right)B$, we have $Q\left(\chi(\theta) - \frac{r}{L}\right)B$. The bank chooses $\theta = 0$, and its expected profit becomes $\pi_A^B = QB - \frac{QB}{L}r$. In this area, the disclosure does not affect the investor's behavior as in $\mathcal{A}^N(B)$. Hence, $\theta = 0$ becomes the optimal solution.

[In $\mathcal{A}^E(B)$] The bank's expected profit in this area is $Q\chi(\theta)B - p\theta R - (p(1-\theta) + (1-p)s)\frac{B}{L}R'$. Substituting the investor's participation constraint into this equation, we have

$$\pi_E^B(R', \theta) = Q\chi(\theta)B + \left((1 - p\theta) - (p(1-\theta) + (1-p)s)\frac{B}{L}\right)R' - r.$$

By partially differentiating $\pi_E^B(R', \theta)$ with respect to R' and θ, we have

$$\frac{\partial \pi_E^B}{\partial R'} = (1 - p\theta) - (p(1-\theta) + (1-p)s)\frac{B}{L}, \tag{6}$$

$$\frac{\partial \pi_E^B}{\partial \theta} = Q\chi'(\theta)B + p\left(\frac{B}{L} - 1\right)R'. \tag{7}$$

The first term in (6) expresses the decrease in expected payment in period 2 by the increase in the short-term interest rate, the marginal profit of R'. The second term expresses the decrease in expected profit in period 2 by the increase in the expected payment due to the increase in the short-term interest rate, the marginal cost of R'. The first term in (7) is the marginal cost of disclosure, i.e., the increase in costs due to the decrease in investment, as in (5). The second term is the marginal profit, i.e., the increase in profit due to the decrease in liquidation which is inefficient in state g.

From (7), we have

$$\theta = -\gamma\left(\frac{p\left(\frac{B}{L} - 1\right)}{QB}R'\right), \tag{8}$$

where $\gamma = (\chi')^{-1}$. Substituting this equation into (6), we obtain

$$\frac{\partial \pi_E^B}{\partial R'} = -\left(\frac{QB}{L} - 1\right) - p\left(\frac{B}{L} - 1\right)\gamma\left(\frac{p\left(\frac{B}{L} - 1\right)}{QB}R'\right).$$

Solving this equation without considering the area constraint of R' (if there exists an R' which makes the above equation 0), we have

$$R' = \frac{-QB}{p\left(\frac{B}{L} - 1\right)}\chi'\left(\frac{\frac{QB}{L} - 1}{p\left(\frac{B}{L} - 1\right)}\right).$$

Substituting this equation into (8), we have

$$\theta = \frac{QB - L}{p(B - L)} \equiv \theta_E.$$

Therefore, we express $R' = \frac{-QB}{p(\frac{B}{L}-1)}\chi'(\theta_E) \equiv R'(\theta_E)$. However, this $R'(\theta_E)$ depends on the slope of χ, and there is no guarantee that this satisfies the investor's participation constraint in this area, $R \geq R' > QR$. R' in this area should satisfy

$$r \geq R'(\theta_E) > \frac{Qr}{Q + (1 - Q)p\theta_E} \equiv \underline{R}'(\theta_E),$$

from the investor's participation constraint and the area constraint. To simplify the analysis, we assume that $R'(\theta_E)$ satisfies the area constraint. See the appendix for the case that this assumption is not satisfied.

From $R' = R'(\theta_E)$ and the participation constraint, we have $R = \frac{B-L}{QB-L}\left\{r - \frac{B(1-Q)}{B-L}R'(\theta_E)\right\} \equiv R(\theta_E)$. From these expositions, in this area, the bank proposes the contract $((R'(\theta_E), R(\theta_E)), \theta_E)$, and the expected profit becomes [6]

$$\pi_E^B = Q\chi(\theta_E)B - r.$$

In this area, we can see that disclosure contributes to the efficiency. When $\theta = 0$, the expected profit becomes $QB - \frac{QB}{L}r$, which is equal to π_A^B. In this area, in the case of no disclosure, the investors withdraw even in the state g. This implies an inefficient liquidation. Hence, by disclosing information, the bank can prevent inefficient liquidation of assets. As a result of this, the second term in $\pi_A^B = QB - \frac{QB}{L}r = QB - \left(\frac{QB-L}{L}\right)r - r$ vanishes.

From the above analysis, we have the following proposition.

Proposition 2 *The equilibrium in the economy with only project B becomes*

$$((R', R), \theta) = \left(\left(\frac{Qr}{Q + (1 - Q)p\theta_L}, \frac{r}{Q + (1 - Q)p\theta_L}\right), \theta_L\right).$$

Proof We can compare π_N^B, π_L^B, π_A^B, and π_E^B as follows. In $\mathcal{A}^L(B)$, when $\theta = 0$ is chosen, the bank can have π_N^B. However, the bank chooses θ_L and π_L^B. Therefore, $\pi_L^B > \pi_N^B$ holds. In $\mathcal{A}^E(B)$, when $\theta = 0$ is chosen, the bank can have π_A^B. However, the bank chooses θ_E and π_E^B. Therefore, $\pi_E^B > \pi_A^B$ holds. And, it is clear that $\pi_N^B > \pi_E^B$ holds. Hence, we have $\max \pi^B = \pi_L^B$, and

$$((R', R), \theta) = \left(\left(\frac{Qr}{Q + (1 - Q)p\theta_L}, \frac{r}{Q + (1 - Q)p\theta_L}\right), \theta_L\right)$$

[6] Since this expected profit is derived by assuming that the above contract satisfies the area constraint, this value is not lower than the expected profit when this constraint is not satisfied. The contract proposed when this condition is not satisfied is in the appendix. However, the characteristics of the contract and disclosure are the same. The assumption that $((R'(\theta_E), R(\theta_E)), \theta_E)$ satisfies the area constraint does not affect the argument in this paper.

is proposed. (Q.E.D.)

Proposition 2 first shows that, when the bank holds risky assets, the disclosure contributes to the efficiency. Secondly, the disclosure used to liquidate inefficient assets is efficient. When $L > sB$, it is clearly desirable to liquidate assets in state b. However, when disclosure is necessary, the bank may not choose to disclose to all investors (by choosing $\theta = 1$). The disclosure in $\mathcal{A}^L(B)$ having an efficient role in state b, does not have such a role in state g. The optimal level of disclosure depends on the probability that state b will realize $(1-p)$, the benefit of the liquidation of bad assets $(L - sB)$, and the property of the disclosure cost (the form of $\chi(\theta)$). Therefore, even if the bank's assets are very risky, a high level of disclosure may become inefficient.

Also, the fact that the optimal deposit contract with information disclosure is chosen in $\mathcal{A}^L(B)$ has an important implication with regard to the form of market discipline toward banks. Since, in $\mathcal{A}^N(B)$, investors do not withdraw regardless of whether or not they receive information, banks are not disciplined. In $\mathcal{A}^E(B)$, investors who do not receive good information withdraw. Hence, the most strict discipline is imposed in this area. In $\mathcal{A}^L(B)$, investors who receive bad information withdraw. The degree of discipline in this area is intermediate between those of the other two areas. This implies that market discipline toward banks is inefficient when it is too strict or too soft.

There have been no other theoretical researches on the optimal degree of market discipline, although some empirical researches have investigated whether or not the market has the power to discipline banks. Our paper investigates the optimal degree of market discipline, and our results indicate that it is important to consider the specific role the information disclosure will play, as well as the particular effects of disclosure, when discussing bank's disclosure.

In the next section, we investigate the case in which the bank can choose one of the two projects introduced above.

4 Information disclosure as signaling

In this section, we introduce asymmetric information with respect to the bank's project choice. The bank can choose between the type G project and the type B project. In period 0, the bank invests in a project after making a deposit contract with investors. We assume that the project the bank chooses can not be written into the contract, and hence we analyze an environment in which the bank has the incentive of potential moral hazard with respect to the choice of projects.

In this section, the asymmetric information between the bank and investors is of two kinds: the state of the economy in period 1 and the projects chosen by the bank. In contrast to the previous section, in this section information disclosed by the bank in period 1 is (i, η), or a combination of the state of the economy i and the type of project η. Through the information (i, η), investors can perceive the probability of success of a project in period 1, i.e., the probability that investors will receive the long-term interest rate R.

4.1 The bank's profit maximization problem

The bank proposes the contract $((R', R), \theta)$ and chooses the project η in order to maximize its expected profit. The bank discloses the information (i, η) in period 1 based on θ proposed in period 0. Investors expect the project the bank will choose in period 0 under restrictions that the contract $((R', R), \theta)$ maximizes the expected profit of the bank. We write the expectation of investors with respect to the project the bank will choose as η^e hereafter. We do not consider the area $\mathcal{A}^A \equiv \{(R', R) | R' > R\}$ below, and hence the contracts the bank proposes exclusively concern the area $R' \leq R$.

Decision on liquidation The information investors can obtain in period 1 is (i, η), or the state of the economy $i \in \{g, b\}$ and the type of the project $\eta \in \{G, B\}$. Hence, there are four kinds of information that investors can obtain; $(g, G), (g, B), (b, G)$, and (b, B).

The action of investors with information in period 1 is as follows. No investor has an incentive to withdraw regardless of the project chosen by the bank in the case of state g. Moreover, investors have no incentive to withdraw independently of the state of the economy when the bank chooses the project G. Therefore, it is only the case of information (b, B) that will lead investors who obtained information to withdraw their assets in period 1. Specifically, when the contract consists of $R' \leq sR$ (i.e., when the contract is proposed in $\mathcal{A}^N(B)$), no liquidation occurs, but when it consists of $R' > sR$ (i.e., when it is proposed in $\mathcal{A}^L(B) \cup \mathcal{A}^E(B)$), liquidation occurs. Even if η^e differs from η, the action of investors with information does not depend on η^e, because they update η^e to η.

On the other hand, the action of investors without information is based on η^e. Suppose that investors have $\eta^e = G$ in period 0. Then, investors without information do not withdraw in period 1, since they expect that they can obtain R with probability 1 in period 2. Next, suppose that investors have $\eta^e = B$ in period 0. Then, the action of investors without information will depend on the area in which the contract is proposed. Specifically, when the contract consists of $R' \leq QR$ (i.e., when the contract is proposed in $\mathcal{A}^N(B) \cup \mathcal{A}^L(B)$), no liquidation occurs, but when it consists of $R' > QR$ (i.e., when it is proposed in $\mathcal{A}^E(B)$), liquidation occurs.

Participation constraint of investors Suppose that investors expect η^e with regard to the project the bank will choose in period 0. Then, the participation constraint of investors follows the equation (2) in $\eta^e = G$ and the equation (4) in $\eta^e = B$, and hence becomes

$$\mathcal{R}^{\eta^e}((R', R), \theta) \geq 0.$$

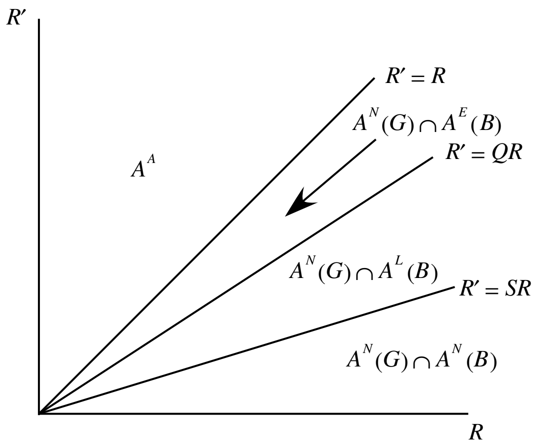

Figure 4: The area of interests

Expected profit of the bank Here, we calculate the expected profit of the bank that chooses the project η. We define the profit function as $\pi((R', R), \theta; \eta, \eta^e)$, where the bank chooses the project η and investors expect η^e.

First, we consider the expected profit of the bank in the case of $\eta = \eta^e$. When $\eta = G$, from the equation (1), we have

$$\pi((R', R), \theta; G, G) = \chi(\theta)G - R \quad \text{if } (R', R) \in \mathcal{A}^N(G).$$

When $\eta = B$, from equation (3), we obtain

$$\pi((R', R), \theta; B, B) = \begin{cases} Q\left(\chi(\theta)B - R\right) & \text{if } (R', R) \in \mathcal{A}^N(B) \\ Q\chi(\theta)B - (p + (1-p)(1-\theta)s)R - (1-p)s\theta\dfrac{B}{L}R' & \text{if } (R', R) \in \mathcal{A}^L(B) \\ Q\chi(\theta)B - p\theta R - (p(1-\theta) + (1-p)s)\dfrac{B}{L}R' & \text{if } (R', R) \in \mathcal{A}^E(B). \end{cases}$$

Next, we calculate the expected profit of the bank in the case that the bank chooses a project different from that expected by investors, $\eta \neq \eta^e$. In this case, the expected profit of the bank differs from the case of $\eta = \eta^e$.

[In $\mathcal{A}^N(G) \cap \mathcal{A}^N(B) = \mathcal{A}^N(B)$]

$$\begin{aligned} \pi((R', R), \theta; G, B) &= \chi(\theta)G - R, \\ \pi((R', R), \theta; B, G) &= Q\left(\chi(\theta)B - R\right). \end{aligned}$$

In this area, no investors withdraw their goods regardless of η^e and interim information. Even if investors have $\eta^e = G$ in period 0 and receive information (b, B) in period 1, they have no incentive to withdraw in period 1 since $R' \leq sR$. Therefore, the profit function of the bank is as described above.

[In $\mathcal{A}^N(G) \cap \mathcal{A}^L(B) = \mathcal{A}^L(B)$]

$$\pi((R', R), \theta; G, B) = \chi(\theta)G - R,$$
$$\pi((R', R), \theta; B, G) = p(\chi(\theta)B - R) + (1-p)s\left\{\left(\chi(\theta) - \frac{\theta R'}{L}\right)B - (1-\theta)R\right\}.$$

In this area, even if $\eta^e = G$, liquidation occurs when information (b, B) is disclosed. When $\eta^e = G$, investors think that it is not necessary to withdraw goods in period 1 before they receive information (b, B). However, if investors receive information (b, B), they withdraw goods, and thus liquidation occurs, since $R' > sR$. On the other hand, when $\eta^e = B$, whether investors receive information or not, no investor withdraws goods because $\eta = G$ in $R' \leq QR$. Hence, the profit function in this case is equivalent to that in the case of $\mathcal{A}^N(B)$, and is as described above.

[In $\mathcal{A}^N(G) \cap \mathcal{A}^E(B) = \mathcal{A}^E(B)$]

$$\pi((R', R), \theta; G, B) = \left(\chi(\theta) - (1-\theta)\frac{R'}{L}\right)G - \theta R,$$
$$\pi((R', R), \theta; B, G) = p(\chi(\theta)B - R) + (1-p)s\left\{\left(\chi(\theta) - \frac{\theta R'}{L}\right)B - (1-\theta)R\right\}.$$

In this area, when $\eta = B$ and $\eta^e = G$, the profit function of the bank is equivalent to that in the case of $\mathcal{A}^L(B)$. When $\eta^e = G$, since investors think that it is not necessary to withdraw goods before they receive information, only the investors of ratio θ actually withdraw goods after receiving information (b, B). When $\eta^e = B$, even if $\eta = G$, liquidation occurs. In this area, investors without information surely withdraw goods in period 1 because $R' > QR$. Therefore, the profit function of the bank is as described above.

The bank's profit maximization problem By using the functions defined above, the bank's profit maximization problem in the case that the bank thinks that investors expect project η^e becomes

$$\begin{aligned}
&\max_{(R',R),\theta,\eta} \pi((R', R), \theta; \eta, \eta^e) \\
&\text{subject to} \\
&\mathcal{R}^{\eta^e}((R', R), \theta) \geq 0 \\
&\pi((R', R), \theta; G, \eta^e) \geq \pi((R', R), \theta; B, \eta^e) \text{ if } \eta^e = G \\
&\pi((R', R), \theta; G, \eta^e) \leq \pi((R', R), \theta; B, \eta^e) \text{ if } \eta^e = B.
\end{aligned}$$

Let $\mathcal{P}(\eta^e)$ be the solution about the project of this problem.

Rational expectations condition of investors Here, we assume that the expectations of investors are rational by the following rational expectations condition:

$$\eta^e = \mathcal{P}(\eta^e)$$

Definition of equilibrium We define an equilibrium in the economy with two types of projects as follows.

Definition 2 *An equilibrium in the economy with two types of projects consists of interest rate (R', R), the information disclosure level θ, the selection of the bank's project $\eta \in \{G, B\}$, and the investors' expectation of the bank's project $\eta^e \in \{G, B\}$ as follows:*
(1) (Bank's maximization of expected profits) Given η^e, $((R', R), \theta, \eta)$ maximizes the bank's expected profits,
(2) (Consistency of investor's expectation) $\eta^e = \mathcal{P}(\eta^e)$.

Briefly, the process of calculating the equilibrium is as follows. (1) In each area, assuming $\eta^e = G$, we solve the bank's expected profit maximization problem under the bank's incentive-compatibility constraint $\pi((R', R), \theta; G, G) \geq \pi((R', R), \theta; B, G)$, and the investor's participation constraint $\mathcal{R}^G((R', R), \theta) \geq 0$, and we derive $\eta = G$. (2) In each area, assuming $\eta^e = B$, we solve the bank's expected profit maximization problem under the bank's incentive-compatibility constraint $\pi((R', R), \theta; B, B) \geq \pi((R', R), \theta; G, B)$, and the investor's participation constraint $\mathcal{R}^B((R', R), \theta) \geq 0$, and we derive $\eta = B$. (3) Comparing the solutions of (1) and (2), the larger one is accepted as the final solution.

4.2 Rational expectations of investors and choice of projects

4.2.1 $\eta^e = G$

In $(R', R) \in \mathcal{A}^N(G) \cap \mathcal{A}^N(B)$ In $(R', R) \in \mathcal{A}^N(G) \cap \mathcal{A}^N(B)$, the incentive-compatibility constraint (IC hereafter) becomes

$$\chi(\theta)G - R \geq Q(\chi(\theta)B - R),$$

and can be rewritten as

$$R \leq \chi(\theta)\frac{G - QB}{1 - Q}. \tag{9}$$

The right-hand side of (9) is maximized by $\theta = 0$, and the left-hand side is minimized by $R = r$, which is the minimum value of R satisfying the participation constraint of investors. Therefore, these offers are the most likely to satisfy IC and also maximize the expected profit of the bank. Substituting these offers into (9), we have

$$r \leq \frac{G - QB}{1 - Q} \equiv \hat{r}.$$

Therefore: (1) when $r \leq \hat{r}$, the bank chooses the project G, $\theta = 0$, $R = r$, and $R' \leq sr$, and thus the expected profit of the bank becomes $\pi_N^G = G - r$; and (2) when $r > \hat{r}$, the bank does not choose the project G in this area.

In the case of (1), since the social optimal is attained in this area, we do not need to perform an analysis. Hence, we assume the following:

Assumption 4 $r > \dfrac{G - QB}{1 - Q}$.

In $(R', R) \in \mathcal{A}^N(G) \cap (\mathcal{A}^L(B) \cup \mathcal{A}^E(B))$ In $(R', R) \in \mathcal{A}^N(G) \cap (\mathcal{A}^L(B) \cup \mathcal{A}^E(B))$, IC becomes

$$\chi(\theta)G - R \geq Q\chi(\theta)B - (p + (1-p)(1-\theta)s)R - (1-p)s\theta\frac{B}{L}R',$$

and can be rewritten as

$$\chi(\theta)(G - QB) \geq (1-p)(1 - s(1-\theta))R - (1-p)\theta s\frac{B}{L}R'.$$

The offer $R = R' = r$ minimizes the right-hand side of this equation and is also consistent with the profit maximization of the bank. Substituting these into above equation, we have

$$\chi(\theta)(G - QB) \geq (1-p)\left\{(1-s) - s\left(\frac{B}{L} - 1\right)\theta\right\}r. \tag{10}$$

The disclosure level $\theta = 0$ does not satisfy IC because of assumption 4. However, since the right-hand side of (10) is decreasing in θ, (10) may be satisfied by some $\theta > 0$. That is, if the reduction of the right-hand side is larger than that of the left-hand side in θ, some θ may fulfill signaling. If such a θ exists, when the bank undertakes project G, it will choose the minimum θ which makes (10) equal, since the expected profit of the bank is decreasing in θ. Here, we present the following lemma:

Lemma 1 *Suppose* $\chi(1) \geq \dfrac{(1-p)\left(1 - \frac{sB}{L}\right)r}{G - QB}$. *Then, there surely exists some* θ *satisfying (10).*

The proof is given in the Appendix. Let θ_S be the minimum θ satisfying (10), given that the condition of lemma 1 is satisfied below. Hence, if the bank chooses project G, the expected profit becomes

$$\pi^S = \chi(\theta_S)G - r.$$

The choice of the bank in the case of $\eta^e = G$ From the above results, if the bank chooses project G, the bank proposes the contract $((R', R), \theta) = ((r, r), \theta_S)$, and thus obtains the expected profit $\pi^S = \chi(\theta_S)G - r$.

4.2.2 $\eta^e = B$

In $(R', R) \in \mathcal{A}^N(G) \cap \mathcal{A}^N(B)$ In $(R', R) \in \mathcal{A}^N(G) \cap \mathcal{A}^N(B)$, IC becomes

$$\chi(\theta)G - R \leq Q(\chi(\theta)B - R),$$

and can be rewritten as

$$R \geq \chi(\theta)\frac{G - QB}{1 - Q}. \tag{11}$$

Here, note that the optimal contract of project B without considering this constraint in this area is $R = \frac{r}{Q}$ and $\theta = 0$ (see section 3). Substituting these solutions into (11), we have

$$r \geq Q\frac{G - QB}{1 - Q}.$$

This condition satisfies assumption 4. Hence, the expected profit of the bank becomes $\pi_N^B = QB - r$.

In $(R', R) \in \mathcal{A}^N(G) \cap \mathcal{A}^L(B)$ In $(R', R) \in \mathcal{A}^N(G) \cap \mathcal{A}^L(B)$, IC becomes

$$\chi(\theta)G - R \leq Q\chi(\theta)B - (p + (1-p)(1-\theta)s)R - (1-p)s\theta\frac{B}{L}R',$$

and can be rewritten as

$$\chi(\theta)(G - QB) \leq (1-p)(1-(1-\theta)s)R - (1-p)s\theta\frac{B}{L}R'. \tag{12}$$

Again, note that the optimal contract of project B without considering this constraint in this area is

$$((R', R), \theta) = \left(\left(\frac{Qr}{Q + (1-Q)p\theta_L}, \frac{r}{Q + (1-Q)p\theta_L}\right), \theta_L\right)$$

(see section 3), and also that (R', R) is a function of θ. Given θ, substituting $(R'(\theta), R(\theta))$ into (12), after some calculation, we have

$$\chi(\theta)(G - QB) \leq \frac{(1-p)\left\{(1-s) - s\left(\frac{QB}{L} - 1\right)\theta\right\}r}{Q + (1-Q)p\theta}. \tag{13}$$

From assumption 4, the disclosure level $\theta = 0$ satisfies (13) (note that $(1-p)(1-s) = 1-Q$). In this area, therefore, the θ chosen by the bank is as follows. (1) if θ_L satisfies (13), then the bank chooses θ_L. (2) if θ_L does not satisfy (13), then the bank chooses $\theta = \hat{\theta}_L$, which satisfies (13) and maximizes $\pi_L^B(\theta)$. Here, $\hat{\theta}_L$ is considered. There are two kinds of θ which satisfy (13) with equality. Then, we describe such θ as $\theta \in \{\theta_l, \theta_h\}$, $(\theta_l < \theta_h)$. Note that if θ_L does not satisfy (13), then θ_L exists in the interval (θ_l, θ_h). As seen in the previous section, $\pi_L^B(\theta)$ is increasing in θ until θ_L, and is decreasing thereafter. Hence, although $\hat{\theta}_L \in \{\theta_l, \theta_h\}$ if θ_L does not satisfy (13), we hereafter assume $\pi_L^B(\theta_l) > \pi_L^B(\theta_h)$, that is, $\hat{\theta}_L = \theta_l$.[7]

From the above results, in this area, the bank with $\eta = B$ proposes the contract

$$((R', R), \theta) = \left(\left(\frac{Qr}{Q + (1-Q)p\theta_{\mathcal{L}}}, \frac{r}{Q + (1-Q)p\theta_{\mathcal{L}}}\right), \theta_{\mathcal{L}}\right) \equiv ((R'_{\mathcal{L}}, R_{\mathcal{L}}), \theta_{\mathcal{L}}),$$

[7] Although (13) is satisfied by $\theta = 0$, the left-hand and right-hand side of (13) are decreasing in θ. Hence, (13) may not be satisfied by θ_L. However, even if (13) is not satisfied by θ_L, the left-hand side intersects the right-hand side at least once in interval $[0, 1]$. If it intersects only once, we have $\hat{\theta}_L = \theta_l$ (then $\theta_h > 1$).

and obtains the expected profit

$$\pi_L^B(\theta_{\mathcal{L}}) = Q\chi(\theta_{\mathcal{L}})B + D(\theta_{\mathcal{L}}) - r \ , \quad (\theta_{\mathcal{L}} \in \{\theta_L, \hat{\theta}_L\}).$$

As described in the previous section, $\pi_L^B(\theta_{\mathcal{L}}) > \pi_N^B$.

In $(R', R) \in \mathcal{A}^N(G) \cap \mathcal{A}^E(B)$ In $(R', R) \in \mathcal{A}^N(G) \cap \mathcal{A}^E(B)$, the expected profit of the bank solved (with $\eta = B$ and $\eta^e = B$) without considering IC is $\pi_E^B = Q\chi(\theta_E)B - r$ (see the previous section). Moreover, π_E^B is inferior to $\pi_N^B = QB - r$, the expected profit in $\mathcal{A}^N(B)$. As seen above, the bank can propose a contract which generates π_N^B. Therefore, whether a contract satisfying IC with $\eta = B$ can be proposed or not, the bank does not propose in this area.

The bank's selection when $\eta^e = B$ From the above results, if the bank chooses project B, then the bank proposes the contract $((R', R), \theta) = ((R'_{\mathcal{L}}, R_{\mathcal{L}}), \theta_{\mathcal{L}})$ and obtains the expected profit $\pi_L^B(\theta_{\mathcal{L}})$.

4.3 Equilibrium

From the above analysis, we have the following proposition.

Proposition 3 *In an economy in which there are two types of projects, the equilibrium is as follows:*
(1) when $C(\theta_S) \leq \hat{C}$, $((R', R), \theta; \eta, \eta^e) = ((r, r), \theta_S; G, G)$,
(2) when $C(\theta_S) > \hat{C}$, $((R', R), \theta; \eta, \eta^e) = ((R'_{\mathcal{L}}, R_{\mathcal{L}}), \theta_{\mathcal{L}}; B, B)$,
where $\hat{C} \equiv 1 - \{Q\chi(\theta_{\mathcal{L}})B + D(\theta_{\mathcal{L}})\} \dfrac{1}{G}$.

$C(\theta_S) \leq \hat{C}$ is obtained by rewriting $\pi^S \geq \pi_L^B(\theta_{\mathcal{L}})$. $C(\theta_S)$ is the signaling cost in order to make investors believe that the bank holds safe assets. When $C(\theta_S) \leq \hat{C}$, i.e., when this cost is not particularly high, the bank sends this signal and chooses the safe assets. On the other hand, when $C(\theta_S) > \hat{C}$, i.e., when the signaling cost is high enough, the bank selects risky and inefficient assets. The important fact here is that the role of information disclosure differs depending on the project the bank chooses.

When the bank chooses project G, the information disclosure has the role of signaling. On the other hand, when the bank chooses the project B, the information disclosure serves the role of liquidating assets efficiently as in the case of Proposition 2. The disclosure as a signaling does not contribute to the bank's profit when the disclosure level is less than θ_S. When the disclosure level becomes greater than θ_S, the investor believes that the bank holds safe assets, and the interest rates which investors require decrease. This gives the bank an incentive to select project G, and, as a result, efficiency improves.

And, the disclosure whose level is greater than θ_S only incurs excess costs. On the other hand, the disclosure when project B is chosen affects the profit of banks at any level of θ. As is shown in (5), θ_L is decided at the level in which the marginal cost of disclosure and the marginal benefit become equal, and the bank can lower the deposit rate offered at all levels of θ. We need to recognize that the nature of disclosure differs according to the type of project that the bank chooses.

We investigate how θ_S, $\theta_{\mathcal{L}}$ and $\hat{C}$ react to the change of r. By substituting θ_S for (10), and differentiating with respect to θ_S and r, we have $\dfrac{d\theta_S}{dr} > 0$.[8] Next, we see $\theta_{\mathcal{L}} \in \{\theta_L, \hat{\theta}_L\}$. When $\theta_{\mathcal{L}} = \theta_L$, by substituting θ_L into (5), and differentiating similarly, we have $\dfrac{d\theta_L}{dr} > 0$.[9] When $\theta_{\mathcal{L}} = \hat{\theta}_L$, by substituting $\hat{\theta}_L$ for (13), and differentiating similarly, we have $\dfrac{d\hat{\theta}_L}{dr} > 0$.[10] Therefore, when r increases both θ_S and $\theta_{\mathcal{L}}$ increase.

Next, we investigate the change of $\hat{C}$. It is easy to see that $Q\chi(\theta_{\mathcal{L}}) + D(\theta_{\mathcal{L}})$ increases as a result of an increase in r (since $\theta_{\mathcal{L}}$ increases). Therefore, we have $\dfrac{\partial \hat{C}}{\partial r} < 0$. Hence, we have the following proposition.

Proposition 4 *When r increases, the signaling condition ($C(\theta_S) \leq \hat{C}$) becomes more restrictive.*

When r increases, $C(\theta_S)$ increases and $\hat{C}$ decreases. Hence, the condition to select project G using signaling becomes restrictive in this situation. The parameter r is the alternative expected return for investors, and is an index of the bank's interest payment. This can also be seen by including the power of depositors. Therefore, this proposition implies that the increase in depositors' power leads the bank's assets toward high-risk-high-return. This is the same as the general result of the debt contract, i.e., a borrower has an incentive to select high-risk-high-return projects when payments increase.

The decrease in profits π^S obtained by project G is larger than the decrease in profits $\pi_L^B(\theta_{\mathcal{L}})$ by project B when r increases. This is due to the fact that the characteristics of disclosure differ depending on the type of the project, as discussed above.

In the next section, we introduce social cost and bankruptcy cost due to bank failure, and investigate the effectiveness of disclosure regulation.

[8] We have $\frac{d\theta_S}{dr} = \frac{(1-p)\{(1-s)-s(\frac{B}{L}-1)\theta_S\}}{\chi'(\theta_S)+(1-p)s(\frac{B}{L}-1)r}$. As is clear from (10), when θ_S exists, at least at θ_S, the slope of the right-hand side of (10) is steeper than that of the left-hand side. Therefore, the denominator becomes positive, and we have $\frac{d\theta_S}{dr} > 0$.

[9] $\frac{d\theta_L}{dr} = \frac{(1-p)(1-\frac{sB}{L})Q^2}{(Q+(1-Q)p\theta_L)^2} \Big/ \left\{-Q\chi''(\theta_L)B + 2\frac{(1-p)(1-\frac{sB}{L})Q^2(1-Q)p}{(Q+(1-Q)p\theta_L)^3}r\right\} > 0$.

[10] We have $\frac{d\hat{\theta}_L}{dr} = \frac{(1-p)\{(1-s)-s(\frac{QB}{L}-1)\hat{\theta}_L\}}{Q+(1-Q)p\hat{\theta}_L} \Big/ \left\{\chi'(\hat{\theta}_L)(G-QB) + \frac{(1-p)\{sQ(\frac{QB}{L}-1)+(1-s)(1-Q)p\}}{(Q+(1-Q)p\hat{\theta}_L)^2}r\right\}$. As is clear from (13), when $\theta_{\mathcal{L}} = \hat{\theta}_L$, at least at $\hat{\theta}_L$, the slope of the right-hand side is steeper than that of the left-hand side. Therefore, the denominator becomes positive, and we have $\frac{d\hat{\theta}_L}{dr} > 0$.

5 Bank failure and disclosure regulation

So far, we have not taken account of the bank's bankruptcy costs. Here we analyze the case in which there exists social loss due to bank failure. The network system of banks organizes a payment system and has a public role. Hence, even the possibility of the failure of one bank causes a risk which affects the entire network, i.e., a systemic risk.

To analyze this effect, we introduce a social cost which is generated when a bank invests in project B in period 0 and cannot pay back the funds in period 2 (with probability $(1-p)(1-s)$).[11] Let $H(>0)$ be the expected default cost. We assume a limited liability of the manager or owner of the bank. Other environments are the same as in section 4. The profit of banks may be opposed to the social benefit.

Due to limited liability, the existence of a default cost does not affect the contract the bank offers or the choice of investment projects. Hence, in the laissez-faire economy, the bank's choice of contract or project follows proposition 3. However, socially desirable projects may not be chosen. Social welfare consists of the bank's profits, the investor's receipts, and the bankruptcy cost. The social welfare when a bank chooses project G, S^G, is given as $S^G = \pi^S + r = \chi(\theta_S)G$. On the other hand, the social welfare when a bank chooses project B, S^B, is given as $S^B = \pi_L^B + r - H = Q\chi(\theta_{\mathcal{L}})B + D(\theta_{\mathcal{L}}) - H$. The threshold value of choosing $C(\theta_S)$, the socially desirable project, $\hat{C}_H$, becomes

$$\hat{C}_H = 1 - \{Q\chi(\theta_{\mathcal{L}})B + D(\theta_{\mathcal{L}}) - H\}\frac{1}{G}.$$

Socially, it is desirable that a bank chooses project G when $S^G \geq S^B$, or $C(\theta_S) \leq \hat{C}_H$, and it is desirable that a bank chooses project B when $S^G < S^B$, or $C(\theta_S) > \hat{C}_H$. It is clear that $\hat{C} < \hat{C}_H$. When a bank goes bankrupt, the society suffers a loss. Hence, when $\hat{C} < C(\theta_S) \leq \hat{C}_H$, the bank's profit is opposed to the social welfare. Then, we have the following proposition.

Proposition 5 *Assume $\hat{C} < C(\theta_S) \leq \hat{C}_H$. When $C(\theta_S) \leq 1 - \{Q\chi(\theta_S)B + D(\theta_S)\}\frac{1}{G}$, the regulation which forces a bank to disclose information at the level θ_S increases social welfare.*

The proof of this proposition is given in the Appendix. When $\hat{C} < C(\theta_S) \leq \hat{C}_H$, a bank chooses project B in the laissez-faire economy. However, project G is socially desirable due to the bankruptcy costs. If the regulation which forces a bank to disclose at the level of θ_S is imposed, a bank will choose a project comparing the expected profit when project B ($\pi^B(\theta_S)$) is chosen and that when project G

[11] When a bank proposes a contract in $\mathcal{A}^E(B)$ and $\theta = 1$, this contract is always fulfilled. In other cases, however, zero profit in period 2 implies default. As is the same as the case in the previous section, the bank does not propose a contract in $\mathcal{A}^E(B)$ and $\theta = 1$. Hence, the terms zero profit in period 2 and default are used as a synonymously in this section.

$(\pi^S(\theta_S))$ is chosen. Hence, when $\pi^S(\theta_S) \geq \pi^B(\theta_S)$, that is, when $C(\theta_S) \leq \hat{C}_L \equiv 1 - \{Q\chi(\theta_S)B + D(\theta_S)\}\frac{1}{G}$, a bank will choose project G and social welfare will be improved.[12]

However, proposition 5 is not fulfilled in all the areas of $C(\theta_S)$ in which the bank's profit is opposed to the social welfare. The important case is the case when $\hat{C}_L < \hat{C}_H$. (It is clear that $\hat{C}_L > \hat{C}$.) By rewriting this we have the following.

$$H > \{Q\chi(\theta_{\mathcal{L}})B + D(\theta_{\mathcal{L}})\} - \{Q\chi(\theta_S)B + D(\theta_S)\}. \tag{14}$$

In this case, a regulation cannot make a bank choose project G. Since a high bankruptcy cost implies a high value of $\hat{C}_H$, a bank's profit is likely to be opposed to social welfare. The above equation (14) shows that when the expected bankruptcy cost H is high enough, the disclosure regulation cannot make a bank choose project G. In this case, it may be necessary to combine the disclosure regulation with other policies, such as a capital regulation. These issues are not discussed in this paper. We consider these as future topics.[13]

Proposition 5 says that a disclosure regulation has the potential to improve efficiency. However, when a bankruptcy cost is high or a signaling cost is high $(\hat{C}_L < C(\theta_S) \leq \hat{C}_H)$, it is not effective.

Recent arguments about bank's disclosure have stressed the importance of inducing banks to hold safer assets and making banks more solvent, which, in turn, would contribute to a more stable financial system. Our paper justifies these arguments based on a rigorous model, and warns against disclosure requirements without due consideration of the costs and benefits. The disclosure level θ_S, as derived from our model, has an important implication in the disclosure regulation. In Calomiris and Kahn (1991), some of the depositors monitor banks, at a cost, in order to prevent bank's moral hazard. Market discipline does not always require monitoring by all investors. The disclosure level θ_S and information transmission cost in our model are equivalent to some of the investors and the monitoring costs in the model of Calomiris and Kahn (1991) respectively. When we request that banks disclose information, we should argue the amount and the quality of information that will be necessary for effective and efficient discipline.

6 Summary

In this paper, we have theoretically analyzed the effects of the information disclosure of banks on resource allocations. When banks hold safe assets, information disclosure becomes wasteful. On the other hand, when banks hold risky assets, information

[12]The regulation which forces a bank to disclose at a level other than θ_S cannot be socially better than the regulation with the disclosure level θ_S. See the Appendix (the proof of proposition 5) for a treatment of this issue.

[13]In our model, if the disclosure regulation at the level of θ_S and the interest regulation at the level of $(R', R) = (r, r)$ are imposed, a bank always chooses project G.

disclosure contributes to the efficiency of allocations. Further, we can specify two roles played by the information disclosure of banks. First, the disclosure serves as a device to liquidate bad loans efficiently. Second, it serves as a device to prevent inefficient liquidation of good loans. The results of this paper show that the use of the former disclosure is efficient. Importantly, they also imply that the market discipline toward banks is inefficient when it is too strict or too soft.

When banks can choose between safe assets and risky assets, disclosure may be used to signal the safety of the bank's assets. When a signaling cost is relatively small, banks use disclosure as a signal and hold safe assets. On the other hand, when a signaling cost is relatively large, banks use disclosure as a device to liquidate inefficient assets and hold risky assets.

Furthermore, the disclosure level banks choose has the following property. When the expected payment to depositors increases due to an increase in the depositors' power, the disclosure level chosen by banks increases regardless of whether the assets of the bank are safe or not. Moreover, the condition under which banks hold safe assets, the signaling condition, becomes more restrictive, and then banks are likely to hold risky assets.

When bankruptcy costs of banks are considered, project choices of banks may be inconsistent with social efficiency. In such cases, an adequate level of disclosure regulation can improve the social welfare. However, when the expected bankruptcy cost is high enough, the disclosure regulation may not be effective. In this case, it may be necessary to combine the disclosure regulation with other policies, such as a capital regulation.

A crucial implication of the results of this paper is that disclosure has several different roles, and that the adequate level of disclosure differs depending on the role being played. Therefore, if we recklessly request information disclosure from banks without due consideration of the roles and levels, the disclosure will be socially inefficient.

In this paper, we have focused on the decision-making of banks for which disclosure is important, and theoretically analyzes the determinants and mechanism of disclosure, as well as the influence of disclosure on resource allocation. By extending the model in this paper, for example, by introducing bank capital and/or multiple banks, we will be able to perform comprehensive analyses of the regulation and institutional arrangements with regard to information disclosure in the future. In Japan, the Financial Services Agency tries to impose quarterly disclosure requirements on all public companies and to unify the disclosure standard currently implemented with self-rule of each securities exchange. Although such policies for disclosure require revisions of the Securities Exchange Law, the Financial Services Agency plans to enforce these from 2005. It is important that the effects of such regulations are analyzed theoretically.

References

[1] Alonso, I., 1996. On avoiding bank runs. J. Monet. Econ. 37, 73-87.

[2] Calomiris, C.W., Kahn, C.M., 1991. The role of demandable debt in structuring optimal banking arrangements. Amer. Econ. Rev. 81, 497-513.

[3] Chari, V.V., Jagannathan, R., 1988. Banking panics, information, and rational expectations equilibrium. J. Finance 43, 749-763.

[4] Chen, Y., 1999. Banking panics: The role of the first-come, first-served rule and information externalities. J. Polit. Economy 107, 946-968.

[5] Cordella, T., Yeyati, E.L., 1997. Public disclosure and bank failures. International Monetary Fund Working Paper, No. 97-96.

[6] Diamond, D.W., Dybvig, P.H., 1983. Bank runs, deposit insurance, and liquidity. J. Polit. Economy 91, 401-419.

[7] Gorton, G., 1985. Bank suspension of convertibility. J. Monet. Econ. 15, 177-193.

[8] Grossman, S.J., 1981. The informational role of warranties and private disclosure about product quality. J. Law Econ. 24, 461-483.

[9] Jacklin, C.J., Bhattacharya, S., 1988. Distinguishing panics and information-based bank runs: Welfare and policy implications. J. Polit. Economy 96, 568-592.

[10] Milgrom, P., 1981. Good news and bad news: Representation theorems and applications. Bell J. Econ. 12, 380-391.

[11] Park, S., 1991. Bank failure contagion in historical perspective. J. Monet. Econ. 28, 271-286.

[12] Verrecchia, R., 2001. Essays on disclosure. J. Acc. Econ. 32, 97-180.

A Appendix

A.1 Section 3: a contract in $\mathcal{A}^E(B)$

Here, we examine a contract which a bank offers when $R'(\theta_E)$ does not satisfy the range constraint $r \geq R'(\theta_E) > \frac{Qr}{Q+(1-Q)p\theta_E} \equiv \underline{R}'(\theta_E)$.

First, when $R'(\theta_E) > r$, for R' which satisfies the range constraint, (6) becomes $\frac{\partial \pi_E^B}{\partial R'} < 0$. Hence, we have $R' = \frac{Qr^+}{Q+(1-Q)p\theta}$.[14] By substituting this for the profit function, we have $\pi_E^B(\theta) = Q\chi(\theta)B - \frac{\left\{\left(\frac{QB}{L}-1\right)-p\left(\frac{B}{L}-1\right)\theta\right\}Qr^+}{Q+(1-Q)p\theta} - r$. By differentiating this with respect to θ, we have

$$-Q\chi'(\theta)B = \frac{p\left\{\frac{QB}{L}(2-Q)-1\right\}Qr^+}{(Q+(1-Q)p\theta)^2}.$$

Express θ which satisfies this equation as $\underline{\theta}_E$. In this case, $R' = \frac{Qr^+}{Q+(1-Q)p\underline{\theta}_E} \equiv \underline{R}'(\underline{\theta}_E)$ and $R = \frac{r^-}{Q+(1-Q)p\underline{\theta}_E} \equiv \underline{R}(\underline{\theta}_E)$ hold.

Second, when $R'(\theta_E) \leq \underline{R}'(\theta_E)$, for R' which satisfies the range constraint, (6) becomes $\frac{\partial \pi_E^B}{\partial R'} > 0$. Hence, we have $R' = r$. By substituting this for (8), we have $\theta = -\gamma\left(\frac{p\left(\frac{B}{L}-1\right)}{QB}r\right) \equiv \bar{\theta}_E$.

Then, a contract $((R', R), \theta)$ which a bank offers in this area becomes

$$((R', R), \theta) = \begin{cases} ((r, r), \bar{\theta}_E) & \text{if } R'(\theta_E) \leq \underline{R}'(\theta_E) \\ \left(\left(R'(\theta_E), R(\theta_E)\right), \theta_E\right) & \text{if } r \geq R'(\theta_E) > \underline{R}'(\theta_E) \\ \left(\left(\underline{R}'(\underline{\theta}_E), \underline{R}(\underline{\theta}_E)\right), \underline{\theta}_E\right) & \text{if } R'(\theta_E) > r, \end{cases}$$

and the expected profit becomes

$$\pi_E^B = \begin{cases} Q\chi(\bar{\theta}_E))B + \left\{p\left(\frac{B}{L}-1\right)\bar{\theta}_E) - \left(\frac{QB}{L}-1\right)\right\}r - r & \text{if } R'(\theta_E) \leq \underline{R}'(\theta_E) \\ Q\chi(\theta_E)B - r & \text{if } r \geq R'(\theta_E) > \underline{R}'(\theta_E) \\ Q\chi(\underline{\theta}_E)B - \left\{\left(\frac{QB}{L}-1\right) - p(\frac{B}{L}-1)\underline{\theta}_E\right\}\frac{Qr^+}{Q+(1-Q)p\underline{\theta}_E} - r & \text{if } R'(\theta_E) > r. \end{cases}$$

A.2 The proof of lemma 1

Proof Both sides of (10) are decreasing functions of θ. And, when $\theta = 0$, the left-hand side is strictly less than the right-hand side. Hence, when $\theta = 1$, if the left-hand side is larger than the right-hand side, i.e.,

$$\chi(1)(G - QB) \geq (1-p)\left\{(1-s) - s\left(\frac{B}{L}-1\right)\right\}r,$$

[14] The superscript $+$ $(-)$ means that the value is marginally larger (smaller) than the value without it.

there exists a θ which satisfies (10).[15] Rewriting this equation with respect to $\chi(1)$, we have

$$\chi(1) \geq \frac{(1-p)\left(1-\frac{sB}{L}\right)r}{G-QB}.$$

(Q.E.D.)

A.3 The proof of proposition 5

Proof First, we will investigate the form of the contract offered under the disclosure level θ_S, given that a bank is choosing project B. As we have seen in section 3, for all θ, $\pi_L^B \geq \pi_N^B$ and $\pi_E^B \geq \pi_A^B$ hold. Here, we examine whether or not π_L^B is larger than π_E^B.

When a contract is offered in area $\mathcal{A}^L(B)$, a bank chooses a contract

$$((R',R),\theta) = \left(\left(\frac{Qr}{Q+(1-Q)p\theta_S}, \frac{r}{Q+(1-Q)p\theta_S}\right), \theta_S\right),$$

and the expected profit becomes $\pi_L^B(\theta_S) = Q\chi(\theta_S)B + D(\theta_S) - r$.[16]

Next, if a contract is offered in the area $\mathcal{A}^E(B)$, a bank chooses

$$((R',R),\theta) = \left(\left(\frac{Qr}{Q+(1-Q)p\theta_S}, \frac{r}{Q+(1-Q)p\theta_S}\right), \theta_S\right),$$

and receives an expected profit of

$$\pi_E^B(\theta_S) = Q\chi(\theta_S)B - \left\{\left(\frac{QB}{L}-1\right) - p(\frac{B}{L}-1)\theta_S\right\}\frac{Q}{Q+(1-Q)p\theta_S}r - r$$

when $\theta_S < \theta_E$, similar to the situation in the area $\mathcal{A}^E(B)$.[17] The sign of $\frac{\partial \pi_L^B}{\partial\theta} - \frac{\partial \pi_E^B}{\partial\theta}$ (for $\theta \in [0,\theta_E]$) does not depend on θ. From this fact, $\pi_L^B(0) > \pi_E^B(0)$, and $\pi_L^B(\theta_E) > \pi_E^B(\theta_E)$, we know that $\pi_L^B > \pi_E^B$ for $\theta \in [0,\theta_E]$.[18] Therefore, if there exists a θ which satisfies $\pi_L^B(\theta) \leq \pi_E^B(\theta)$, we obtain $\theta > \theta_E$. Here, in the area $\mathcal{A}^E(B)$, if $\theta_S > \theta_E$, then a bank offers a contract $((r,r),\theta_S)$. However, we have seen in section 4 that project G is chosen if this contract is offered. From these facts, we know that a bank never chooses project B in the area $\mathcal{A}^E(B)$ when a regulation with the level

[15] Even if this condition is not satisfied, a θ which satisfies (10) may exist. However, here, we will propose a condition that θ_S always exists.

[16] We have already seen, in section 3, that regardless of the value of θ imposed, a bank offers $(R',R) = \left(\frac{Qr}{Q+(1-Q)p\theta}, \frac{r}{Q+(1-Q)p\theta}\right)$ as a deposit rate.

[17] See section 3 (especially (6)) and Appendix $A.1$. Also see these explanations about the contract and expected profit in the case of $\theta_S > \theta_E$, which will be described below.

[18] Differentiating π_L^B and π_E^B with respect to θ, respectively, we have $\frac{\partial \pi_L^B}{\partial\theta} = Q\chi'(\theta)B + \frac{(1-p)\left(1-\frac{sB}{L}\right)Q^2 r}{(Q+(1-Q)p\theta)^2}$ and $\frac{\partial \pi_E^B}{\partial\theta} = Q\chi'(\theta)B + \frac{p\left\{\frac{QB}{L}(2-Q)-1\right\}Qr}{(Q+(1-Q)p\theta)^2}$. Hence, we have $\frac{\partial \pi_L^B}{\partial\theta} - \frac{\partial \pi_E^B}{\partial\theta} = \frac{Qr}{(Q+(1-Q)p\theta)^2}\left[(1-p)\left(1-\frac{sB}{L}\right)Q - p\left\{\frac{QB}{L}(2-Q)-1\right\}\right]$. The sign of $\frac{\partial \pi_L^B}{\partial\theta} - \frac{\partial \pi_E^B}{\partial\theta}$ does not depend on θ. From this fact, $\pi_L^B(0) > \pi_E^B(0)$, and $\pi_L^B(\theta_E) > \pi_E^B(\theta_E)$, we have $\pi_L^B(\theta) > \pi_E^B(\theta)$ for $\theta \in [0,\theta_E]$.

θ_S is imposed. Hence, a bank chooses project G when the profit when project G is chosen, $\pi^S(\theta_S)$, is greater than the expected profit $\pi_L^B(\theta_S)$ from the contract offered in $\mathcal{A}^L(B)$. Rewriting $\pi^S(\theta_S) \geq \pi_L^B(\theta_S)$, we obtain

$$C(\theta_S) \leq 1 - \{Q\chi(\theta_S)B + D(\theta_S)\}\frac{1}{G}.$$

In this case, a regulation with the level θ_S is able to make a bank choose project G.

Next, we will show $\theta_R = \theta_S$. When $\theta_R < \theta_S$, the disclosure level which is less than θ_S cannot make investors believe that a bank chooses project G. Hence, we have $\eta^e = \eta = B$. (See section 4.) Therefore, we obtain $S = \pi_L^B(\theta_R) + r - H < S^B < S^G$, which is inefficient. When $\theta_R > \theta_S$, if project B is chosen, then a similar argument as before is applied. Even if project G is chosen, we have $S = \pi^S(\theta_R) + r < S^G$ $(C(\theta_R) > C(\theta_S))$, which is inefficient. Therefore, the optimal level of disclosure becomes $\theta_R = \theta_S$. (Q.E.D.)

B Tables

Area	Interest rate	Probability	State	Investor's behavior			
				with information		without information	
				Ratio	Behavior	Ratio	Behavior
$(R'R) \in \mathcal{A}^N(B)$	$R' \leq sR$	p	g	θ	wait	$1-\theta$	wait
		$1-p$	b		wait		wait
$(R'R) \in \mathcal{A}^L(B)$	$QR \geq R' > sR$	p	g	θ	wait	$1-\theta$	wait
		$1-p$	b		withdraw		wait
$(R'R) \in \mathcal{A}^E(B)$	$R \geq R' > QR$	p	g	θ	wait	$1-\theta$	withdraw
		$1-p$	b		withdraw		withdraw
$(R'R) \in \mathcal{A}^A(B)$	$R' > R$	p	g	θ	withdraw	$1-\theta$	withdraw
		$1-p$	b		withdraw		withdraw

Table 1: Investor's behavior (Project B)

Area	Project	Investor's Expectation	Economy's State	Investor's behavior: with information, Ratio	with information, Behavior	without information, Ratio	without information, Behavior
$(R'R) \in \mathcal{A}^N(G) \cup \mathcal{A}^N(B)$	G	G	g	θ	wait	$1-\theta$	wait
	B	B	g	θ	wait	$1-\theta$	wait
			b		wait		wait
	G	B	g	θ	wait	$1-\theta$	wait
	B	G	g	θ	wait	$1-\theta$	wait
			b		wait		wait
$(R'R) \in \mathcal{A}^N(G) \cup \mathcal{A}^L(B)$	G	G	g	θ	wait	$1-\theta$	wait
	B	B	g	θ	wait	$1-\theta$	wait
			b		withdraw		wait
	G	B	g	θ	wait	$1-\theta$	wait
	B	G	g	θ	wait	$1-\theta$	wait
			b		withdraw		wait
$(R'R) \in \mathcal{A}^N(G) \cup \mathcal{A}^E(B)$	G	G	g	θ	wait	$1-\theta$	wait
	B	B	g	θ	wait	$1-\theta$	withdraw
			b		withdraw		withdraw
	G	B	g	θ	wait	$1-\theta$	withdraw
	B	G	g	θ	wait	$1-\theta$	wait
			b		withdraw		wait

Table 2: Investor's expectation and behavior