Banks' Disclosure of Information and Financial Stability Regulations

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Abstract

This study proposes a model that analyzes the interaction between a bank and its creditors. The bank uses short-term wholesale funding and the creditors decide whether to roll over their loan by using information about the bank. The model shows that, when the creditors become more reluctant to roll over their loans since the bank heavily depends on such a debt, the bank does not issue the short-term debt excessively and its privately optimal amount of the debt in this situation corresponds to the socially desirable one. This implies that a regulation requiring banks to disclose information about their capital structures can by itself contribute to stabilizing the financial system. However, the model also shows that in order to ensure the result we need an additional regulation that bridges the information gap between banks and creditors.

Key words: Short-term debt, Rollover risk, Macroprudential, Fire sales

JEL classification: C21, E50, D80

1 Introduction

Since the 2007 global financial crisis occurred and the risk-free financial system turned out to be an illusion, many economists have developed the models of financial system to examine the causes of instability. These models showed that the system encouraging free competition tends to reach unequal allocation for various reasons, and therefore, the models emphasize the need for government intervention, that is, macroprudential regulations.

There is a growing literature analyzing the financial stabilities after the crisis, and some of them focus on the large share of short-term wholesale debt in financial intermediaries' liabilities, which causes the "maturity mismatch". Moreover, it is argued that the large share of short-term debt makes the intermediaries illiquid and then makes the financial system unstable. In the years preceding the crisis, banks played an important role in the financial markets and one could implicitly assume that the banks could absorb losses and their creditors were protected. However, the crisis revealed that banks underestimated the risk to which they were exposed and their equity was not enough to absorb the unexpected losses. After the crisis, therefore, the Basel Committee developed a new regulatory framework on banks, Basel Ⅲ, to make the financial system stable. Basel Ⅲ is based on three pillars: "minimal capital requirements and liquidity requirements", "supervisory review process", and "enhanced disclosure".

Although enhancing disclosure was one of the pillars in Basel Ⅱ, we should pay more attention to how information about banks affects their creditors' decision to withdraw funds. This is because one no longer always regards banks as safe after the crisis. In the arguments of the effectiveness of Basel Ⅲ, however, the creditors are usually assumed to take into account the macroeconomic circumstance, such as good or bad state solely. Therefore, the analyses of the effect of information disclosed by banks on the stability of financial system have not been sufficiently analyzed yet.

To address these issues in more depth, we develop a theoretical model in which a bank uses wholesale funding and discloses information about its capital structure. In the model, the bank issues both short-term and long-term debt and uses the funds to long-term investment, and subsequently its short-term creditors decide whether or not to roll over their loan. Analyses of such a model show that without any regulations the privately optimal amount of short-term debt for the bank exceeds the socially desirable one (Stein, 2012). If the bank discloses information that indicates its soundness truly and its creditors decide to withdraw funds only when they do not consider the bank to be safe based on the information, then the bank voluntarily would decide to issue less amount of short-term debt than the amount the bank issues without disclosure. This is because the creditors would refuse to roll over if the bank is heavily dependent on the short-term debt. It implies that there is a probability that the financial system can be stabilized by requiring banks to disclose information and requiring their creditors to use the information. Therefore, the aim of this paper is to analyze whether the regulation of the banks' disclosure of information is effective for the stability of financial system.

In the years preceding the crisis, the short-term debt gained popularity since it was considered to be a relatively cheap source of funding,[1] as a result of which banks began to rely more on the short-term debt than ever. Before the crisis, in the literature the maturity mismatch of intermediaries' balance sheets caused by short-term debt was viewed as playing a disciplining role to address incentive problems of banks (Calomiris and Kahn, 1991; Diamond and Rajan, 2001), therefore such a debt of banks was thought to contribute to the stability of financial system. Moreover, it was implicitly assumed that banks could control the rollover risk[2] of short-term wholesale debt properly.

After the crisis, therefore, many theoretical models of banks (or financial intermediaries) using short-term funding are developed. Acharya et al.(2011) shows that a small change in the fundamental value of bank's collateral assets can cause a catastrophic decrease in the amount that the bank can borrow. Morris and Shin (2010) separates liquidity risk and solvency one, and shows that relying on the short-term funding increases the former risk. Moreover, Stein (2012) points out that using short-term funding causes fire-sale of assets and that the fire-sale exacerbates the credit-crunch. These models analyze the banks' ability to repay short-term debt with reference to estimation and change of the value of their assets.

In contrast, there are only a few analyses in which banks' creditors decision-making processes are considered. Some of them analyze the interaction between banks and their creditors by using global game approach (Eisenbach, 2013; Chen, 2015) and show that short-term debt does not always work as the discipline when both banks and their creditors need to estimate other's action. Since their purpose is to investigate the effects of banks' short-term funding in the stochastic process on the fragility, they do not analyze effect of banks' disclosure of information. Baek (2017) assumes that financial intermediaries can disclose costly information about the value of their assets and that the creditors' decisions about rolling over depend on the information. Then, he shows

[1] For example, Chernenko and Sunderam(2014) provide the evidence of the growing importance of short-term funding for European banks.

[2] The rollover risk is well documented for the asset-backed commercial paper market (Kacperczyk and Schnabl, 2010; Covitz, et al., 2013) and the market for repurchase agreements (Gorton and Metrick, 2012; Copeland, et al., 2014).

that the intermediaries' incentive to disclose information becomes weak when they can share solvency risk by holding securitized assets. Although he considers the creditors decision-making based on the information about financial intermediaries, he is interested in how much information is disclosed by the intermediaries with high leverage. Therefore, he pays little attention to how the disclosure affects the intermediaries' capital structure.

Our model aims to analyze the effect of disclosure of information by banks. As already mentioned, the main purpose is to examine the effects of the disclosure of information by banks on their capital structure.

In our model, when the bank does not disclose information about its capital structure, the creditors solely consider the success probability of the bank's long-term investment when they decide whether to roll over their short-term loan. In contrast, when the bank discloses information about its capital structure, the creditors take into account that the more the bank issues short-term debt the more risky rolling over their loan becomes. This is because the bank is likely to be illiquid and to fail to repay its debt when it is heavily dependent on short-term debt. This means that, when a bank discloses information about its capital structure, it must consider the effect of its capital structure on its creditors, which implies that the amount of short-term debt issued by the bank might differ from the amount it issues without disclosing information. Therefore, at first, we consider the model in which the bank does not disclose information about its capital structure, and subsequently compare the result with that we derive from the model with disclosure of the information .

If the bank does not provide any information about its capital structure and the cost of short-term debt is sufficiently cheap, then the amount of short-term debt issued by the bank exceeds the socially desirable amount as Stein(2012) shows. In contrast, if it discloses the information and its creditors use the information in their decision-making processes, the model shows that the amount of short-term debt issued by the bank is equal to the amount socially desired. However, the model also shows that this result cannot be obtained unless the bank can correctly estimate the creditors' risk-aversion parameter. This is because there is the asymmetry of information between the creditors and the bank in that the former have the information about the latter while the latter has no information about the former. These results imply that the regulation requiring banks to provide more information about their capital structures could be effective to make the financial system stable. In order to ensure the effectiveness of the regulation, however, we need another regulation that enables banks to have information about the degree of risk aversion of the creditors.

The remainder of this paper is organized as follows. Section 2 presents the model in which a bank dose not disclose information about its capital structure. Section 3 presents the model in which a bank discloses information, and section 4 examines the results obtained. Section 5 discusses the implication of regulation suggested by the model. Section 6 presents our conclusion.

2 The Model without Information

In this section, based on Stein(2012), we develop a model in which a bank does not disclose information about its capital structure.

2.1 Environment

There are three types of actors in the economy: a bank, its creditors, and investors. The bank raises funds from the creditors, and if it needs more funds to repay its debt, it sells its asset to the investors.

The period includes three points of time: 0, 1, and 2. It is only the creditors at time 0 who have the endowment. At time 2, there are two possible states, good and bad, and each state occurs with probability p and $1 - p$, respectively. Assume that at time 1, there is a public signal indicating the time-2 state and all actors can receive this signal. Moreover, suppose that the output of the bank's investment at the good state is sufficient to pay off all of its debt but at the bad state it is not enough. Thus, there is no probability of the bank to be insolvent when the public signal indicates the good state, while there is a positive probability that the bank is insolvent when the bad state is indicated.

2.2 Bank

In the economy, there is a bank which has an investment opportunity at time 0 and the return of the investment is delivered at time 2. Since the bank has no initial endowments, as already mentioned, it needs to raise funds externally. It can issue two types of financial debt to the creditors in order to raise funds: short-term (maturing at time 1) or long-term (maturing at time 2) debt. There is a positive probability that the bank will be insolvent at time 2, which implies that long-term debt has risk. By contrast, we assume that the bank pledges its assets for the short-term debt, and that the repayment for short-term debt is prior to that for long-term ones. Therefore, if the bank refrains from excessively issuing there is little risk in short-term debt. This is because the bank can raise funds to repay the debt by selling its assets at time 1. In addition, we assume that holding a short-term debt provides the creditors with higher utility than holding a long-term one, and therefore, the (gross) real return on a short-term debt, denoted by R^M, is lower than the (gross) real return on a long-term one, R^B.[3] Moreover, we suppose that these rates are fixed.

An investment by the bank at $t = 0$ delivers its output at time 2. If the amount I is invested, the total output in the good state is denoted by the concave function $f(I)$, and the total output is $\pi^r I < f(I)$ in the bad state. For simplicity, we assume that $f''(I) = 0$.

Suppose that the bank raises a fraction m of its investment I by issuing short-term debt. Then, the repayments the bank owes to its short-term and long-term creditors are mIR^M and $(1-m)IR^B$, respectively. Recall that the bank does not hold any cash. Therefore, if some of the short-term creditors refuse to roll over their loan at $t = 1$, it needs to acquire funds by selling its physical assets in the asset markets at the fire-sale prices.

The bank's physical assets are the bank's claim on the returns of its investment and the total value of them is equal to their expected returns. If fraction η of the assets is sold, the total proceed to the bank is $\eta k \pi^r I$ in the bad state or $\eta k f(I)$ in the good state. Thus, k is a measure of the discount on asset sales at $t = 1$. Since the returns in the good state are large enough to raise sufficient funds, we focus on the bad state. From the above arguments, we have

$$mIR^M = \eta k \pi^r I, \tag{1}$$

and then,

$$\eta = \frac{mR^M}{k\pi^r}.$$

Since $\eta \leq 1$, there is an upper bound on m, the maximum of which (m^{MAX}) is defined as,

$$m \leq \frac{k\pi^r}{R^M}. \tag{2}$$

$$m^{\mathrm{MAX}} \equiv \frac{k\pi^r}{R^M}$$

[3] The assumption that holding liquid claims yields additional utility is also used in Diamond and Dybvig(1983) and Gorton and Metrick(2010). Klimenko(2016) puts forward such an alternative interpretation that the interest rate of repo is exogenous (e.g., a 1-year LIBOR) but the interest rate of long-term debt is chosen endogenously. Therefore, the higher risk of long-term debt makes its rate higher than the repo ones.

This is the constraint on m in the model.[4]

2.3 Banks' creditors

Creditors are actors who lend funds to the bank by buying the bank's short-term and/or long-term debt by means of their initial endowment. We are interested in whether or not the disclosure of information can encourage the bank to refrain from the excessive issuing of short-term debt even though it can do so. Therefore, we assume that the creditors are always willing to buy the bank's debts in both Section 2 and Section 3. In addition, we assume that the number of the (potential) creditors is so large that the market clearing of both debts are guaranteed. Since the long-term creditors do not make any decisions in the model after buying the debt, we focus on the behavior of the short-term creditors.

As mentioned above, when the public signal indicates the good state, there is no need to secure repayment to short-term debt at $t = 1$. However, when the signal indicates that the bad state is coming, the short-term creditors need to decide whether to roll over the loan or not. Since there is no information about the bank's capital structure in the model, the probability that they refuse to roll over solely depends on their private properties. To keep the analysis simple, we focus on the extreme case in which all the creditors refuse to roll over and the bank knows their decisions. The model shows that there is still a probability that the bank chooses the socially undesired amount of short-term debt as the privately optimal one.

2.4 Investors

Investors are actors who have another late-arriving investment opportunities at $t = 1$. Since they have no endowment, however, the investors also need to issue debt to raise funds at $t = 0$. Suppose that the debt is long-term. Then the investors' cost of funding is R^B. The investors need to decide the optimal level of their funding, denoted by W, which equates the expected return on their investment to the cost of capital. Since this process does not affect the qualitative results of the model, we treat W as an exogenous variable in Section 2. We will return to this point later.

[4] Although Stein(2012) argues that this constraint is a pecuniary externality and makes the financial market fragile, it is subtle as stated in Hanson, et al.(2011).

At $t = 1$, the investors use their funds to invest in their opportunities, and if the bank sells its assets they use a part of their funds to buy the assets. Suppose that the investors' return of their investments is determined by an increasing and concave function $g(\cdot)$. If they spend M amount on asset purchases, the amount they invest is $W - M$, and the return obtained from their investments is $g(W - M)$. Thus, the marginal return on new projects must be the same as the marginal return from buying assets. In addition, suppose that in the asset markets the investors have bargaining power and they can change the discount factor k. Since the investors' payments to the bank must be equal to the bank's repayments to their creditors, $M = mIR^M$ holds. Then, we have

$$\frac{1}{k} = g'(W - \sigma mIR^M). \tag{3}$$

2.5 Bank's problem

The bank's expected net returns at time 2 are given as follows (the subscript ni means "no information").

$$\Pi_{ni} = \{pf(I) + (1-p)\pi^r I - IR^B\} + m(R^B - R^M)I - (1-p)z\, mIR^M, \tag{4}$$

$$\text{where} \quad z = \frac{1-k}{k}.$$

The terms in equation (4) can be interpreted in the following three parts. The first three terms denote the net present value of the investment when the bank solely issues a long-term debt. The fourth term is the financing cost that the bank can save by using the fraction m of short-term debt. Finally, the fifth term is the expected loss at time-1 asset sale.

Suppose that the bank can arbitrarily choose k (and therefore, z). It implies that the bank does not know the decision mechanism of k used by the investors.

By differentiating (4) with respect to m and I, respectively, we have

$$\frac{\partial \Pi_{ni}}{\partial m} = (R^B - R^M)I - (1-p)z\, IR^M, \tag{5}$$

$$\frac{\partial \Pi_{ni}}{\partial I} = \{pf'(I) + (1-p)\pi^r - R^B\} + m(R^B - R^M) - (1-p)z\, mR^M. \tag{6}$$

Thus, we have the following proposition.

Proposition 1. *Define I_B as the amount of the investment that satisfies $\partial\Pi_{ni}/\partial I = 0$ when $m = 0$. Suppose that $(R^B - R^M)$ is sufficiently large and the bank chooses z with $\partial\Pi_{ni}/\partial m \geq 0$. Then, there are two cases in which the bank chooses (m_{ni}, I_{ni}).*

1. *When z satisfies $\partial\Pi_{ni}/\partial m > 0$, the bank chooses the maximum of m_{ni}, denoted by $\bar{m}_{ni}$, and we have $\bar{m}_{ni} = m^{MAX}$. In this case, the amount of investment I_{ni} that the bank chooses satisfies $I_{ni} > I_B$.*

2. *When z satisfies $\partial\Pi_{ni}/\partial m = 0$, the bank chooses m unless it is smaller than $\bar{m}_{ni}$. In this case, I_{ni} associated with $\bar{m}_{ni}$ always satisfies $I_{ni} = I_B$.*

Next, suppose that there is a social planner whose purpose is to maximize the sum of the bank's and investors' returns by choosing the optimal level of m. Then, his objective function is given by

$$\begin{aligned} U_{ni} &= \{pf(I) + (1-p)\pi^r I - IR^B + m(R^B - R^M)I \\ &\quad + pg(W) + (1-p)\{g(W - mIR^M) + mIR^M\} - WR^B. \end{aligned} \tag{7}$$

The first four terms in equation (7) are the same for the bank's objective function and the rest denote the expected return for the investors. By differentiating (7) with respect to each m and I, respectively, we have

$$\frac{\partial U_{ni}}{\partial m} = (R^B - R^M)I + (-IR^M)(1-p)\{g'(W - mIR^M) - 1\}, \tag{8}$$

$$\begin{aligned} \frac{\partial U_{ni}}{\partial I} &= \{pf'(I) + (1-p)\pi^r - R^B\} + m(R^B - R^M) \\ &\quad -(1-p)(mR^M)\{g'(\cdot) - 1\}. \end{aligned} \tag{9}$$

Suppose that m satisfies $\partial U_{ni}/\partial m \geq 0$. Then, we have the following condition for m.

$$\{g'(W - mIR^M) - 1\} \leq \frac{r}{1-p},$$

Let us define m^*_{ni} as the maximum level of m that satisfies the following condition.

$$\{g'(W - m^*_{ni}IR^M) - 1\} = \frac{r}{1-p}. \tag{10}$$

If $m = m^*_{ni}$ and $\partial U_{ni}/\partial I = 0$ are satisfied, we have (see the Appendix with respect to the derivation)

$$pf'(I) + (1-p)\pi^r - R^B = 0. \tag{11}$$

Therefore, if m_{ni}^* can be chosen, the socially optimal amount of investment is $I_{ni}^* = I_B$. It implies that the bank is required to choose $m = 0$ in spite of $m = m_{ni}^* \neq 0$. Thus, there is no need to use short-term funding from the point of view of the social planner. However, it is noteworthy that the bank can increase the amount of its investment by using short-term funding, and in this case, obviously $I_{ni}^* < I_{ni}$. That is, the bank chooses larger amount of investment than the socially optimal level if it issues short-term debt.

Next, we focus on the case in which the bank cannot choose m_{ni}^*, that is, $m^{\text{MAX}} < m_{ni}^*$. Suppose that the social planner chooses I that satisfies $\partial U_{ni}/\partial I = 0$ and $\partial \Pi_{ni}/\partial I = 0$. Then, equations (6) and (9) can be rewritten as follows.

$$\{pf'(I) + (1-p)\pi^r - R^B\} = m(R^B - R^M) - (1-p)(mR^M)\, z, \tag{12}$$

$$\{pf'(I) + (1-p)\pi^r - R^B\} = m(R^B - R^M) - (1-p)(mR^M)\{g'(\textit{MAX}) - 1\}, \tag{13}$$

where we define $g'(\textit{MAX}) = g'(W - m^{\text{MAX}} I R^M)$.

It implies that the values of $f'(I)$ in equations (6) and (9) are determined by m. Thus, when the right-hand side of (12) is larger than that of (13), that is, $z < g'(\textit{MAX}) - 1$, we have $f'(I_{ni}) < f'(I_{ni}^*)$, which implies $I_{ni} > I_{ni}^*$. This condition cannot always be satisfied, however, because there are many choices regarding z that satisfy $\partial \Pi_{ni}/\partial m \geq 0$, while there is only one choice for $g'(\textit{MAX}) - 1$, which is determined by m^{MAX}.

Suppose that $\hat{m}$ satisfies $m^{\text{MAX}} < \hat{m} < m_{ni}^*$. Since $g'(\cdot)$ is a decreasing function, we have

$$(g'(\textit{MAX}) - 1) < (g'(\hat{m}) - 1) < (g'(m^*) - 1).$$

Thus, if the bank chooses z that satisfies $z = (g'(\hat{m}) - 1)$, we have $I_{ni} < I_{ni}^*$. Then, the bank chooses a smaller amount of investment than the socially optimal level.

From the above arguments, we have the following proposition.

Proposition 2. *When $m^{MAX} \geq m_{ni}^*$, m_{ni}^* is determined by equation (10) and the socially optimal amount of investment is $I_{ni}^* = I_B$ that satisfies $I_{ni}^* < I_{ni}$.*

When $m^{MAX} < m_{ni}^*$, m^{MAX} is chosen, whether or not I_{ni} is larger than I_{ni}^* depends on z solely. The bank excessively invests when $z < g'(\textit{MAX}) - 1$ and insufficiently invests when $z > g'(\textit{MAX}) - 1$.

In conclusion, when the privately optimal amount of short-term debt for the bank is relatively larger than the socially optimal one or the bank is sufficiently optimistic, the amount of short-term debt issued by the bank always exceeds the socially desirable one.

3 The Model with Disclosure of Information

This section explains the model in which a bank discloses information about its capital structure.

3.1 Disclosure of information and its effects

Suppose that a bank discloses the true ratio of the short-term debt to its total funds to its creditors. Moreover, we assume that this announcement dose not entail any cost.

The bank's creditors lend funds to the bank at $t = 0$ and decide at $t = 1$ whether or not to roll over their loan, as they do in the model in Section 2. However, when the bank discloses information about its capital structure, the creditors can use this information when they decide whether to roll over. In fact, since the creditors think of the information about the bank's m as the guarantee for its repayment at time 2, m determines the fraction of creditors who accept the rolling over at $t = 1$.[5]

However, why shall m be regarded as a guarantee for the bank's repayment? Suppose that all the short-term creditors of the bank agree to roll over, that is, $\sigma = 0$, though they know that the bad state is coming. The return on investment expected at time 1 that the bank will receives at time 2 is given as follows.

$$\pi^r I - mIR^M - (1-m)IR^B$$

Recall that the repayment for the short-term debt is prior to that for the long-term debt. The larger m the bank chooses, the less likely the creditors are to receive exact repayment, R^M. Therefore, the fraction σ of creditors who refuse the roll over can be defined as a function of m. In this model, for simplicity, it is defined as follows.

$$\sigma(m) = \alpha m \qquad (\alpha > 0)$$

[5]Baek(2017) assumes that information provided by a financial intermediary also increases the value of its assets. This is because he assumes that the assets of the financial intermediary are asset-backed securities that the intermediary creates by pooling its projects. Therefore, the value of the securities can be increased by providing detailed information about the projects. In our model, however, both the creditors and the investors know the exact values of the bank's assets. In addition, although Baek (2017) is interested in the optimal amount of information disclosed by the intermediary, we are interested in whether or not the disclosure of information itself can be effective in stabilizing the economy. Thus, we do not consider the effects of information on the prices of the bank's assets in our model.

If α is larger, the creditors respond more sensitively to the increase in m, and therefore, α can be defined as the parameter indicating the degree of risk aversion of the creditors.

3.2 Changes in banks

In the model with bank's disclosure of information, as already mentioned, the fraction σ denotes the share of the creditors who refuses to roll over their loan. Therefore, the amount of funds the bank must repay is denoted by σmIR^M. As in Section 2, we assume that $f(I)$ is so large that all of the creditors receive the exact repayment if the economy is in the good state at time 2. Thus, $\sigma = 0$ is satisfied at time 1 when the public signal indicates that the good state is coming.

By contrast, if the public signal reveals bad news, we have $\sigma \neq 0$. Then, the bank must sell their assets as it does in Section 2, and we have

$$\sigma mIR^M = \eta k \pi^r I.$$

If all of the creditors refuse to roll over, $\sigma = 1$, we have

$$mIR^M = \eta k \pi^r I.$$

Since this is the same equation as (1), the constraint on the bank's short-term funding and its maximum fraction, m^{MAX}, are the same as those in the model without disclosure of information.

4 Results when Information is Disclosed

4.1 Bank's problem

As mentioned above, when the public signal indicates a good state, there is no difference in the results obtained in Section 2. Therefore, we focus on a situation in which everyone knows that the state at time 2 is the bad one.

If $\sigma \neq 1$, the bank does not need to sell all of its assets. At time 1, since the bank must pay σmIR^M to the creditors, it sells its assets until it raises enough funds. If assets are remained after the repayment, the bank retains the assets and receives return of the investment in proportion to the assets remained at time 2. After receiving the return, the bank preferentially repays the fraction $(1 - \sigma)$ of its short-term debt, then it repays all of its long-term debt. Therefore, the expected return of the bank is given by

$$\Pi = \{pf(I) + (1-p)\pi^r I - R^B I\} \quad + \quad m(R^B - R^M)I - (1-p)z\,\alpha m^2 I R^M. \quad (14)$$

In this section, we assume that the bank arbitrarily chooses k. This assumption is discussed later.

By differentiating equation (14) with respect to m, we have

$$\frac{\partial \Pi}{\partial m} = (R^B - R^M)I - 2\alpha(1-p)z\,mIR^M. \quad (15)$$

Suppose that $\partial\Pi/\partial m \geq 0$ is satisfied, we have the following condition with respect to m:

$$m \quad \leq \quad \frac{r}{2\alpha\,z(1-p)}, \quad (16)$$

$$\text{where} \quad r \quad = \quad \frac{R^B - R^M}{R^M}.$$

We define $\bar{m}$ as the maximum m, which is given by

$$\bar{m} = \frac{r}{2\alpha\,z(1-p)}. \quad (17)$$

The condition for $m^{\text{MAX}} \geq \bar{m}$ is given by

$$\alpha \geq \frac{R^B - R^M}{1-k} \cdot \frac{1}{2(1-p)}. \quad (18)$$

If the expected loss of the fire sale is larger than the the financing cost saved by using short-term funding when $m = m^{\text{MAX}}$, then $\bar{m} \leq m^{\text{MAX}}$ and the bank chooses $\bar{m}$ as the optimal level.

By differentiating equation (14) with respect to I, we have

$$\frac{\partial \Pi}{\partial I} = \{pf'(I) + (1-p)\pi^r - R^B\} + m(R^B - R^M) - (1-p)z\,\alpha m^2 R^M. \quad (19)$$

Suppose that $\partial\Pi/\partial I = 0$. Then we can rewrite equation (19) as follows.

$$m(R^B - R^M) - (1-p)z\,\alpha m^2 R^M = \{R^B - (1-p)\pi^r\} - pf'(I) \quad (20)$$

Let us denote the left-hand side of equation (20) as P. Then, we can rewrite P as the function of m as follows.

$$\begin{aligned} P \quad &= \quad m(R^B - R^M) - (1-p)z\,\alpha m^2 R^M \quad (21) \\ &= \quad -\alpha(1-p)zR^M \left(m - \frac{r}{2\alpha\,z(1-p)}\right)^2 + \frac{(R^B - R^M)r}{4\alpha(1-p)z} \end{aligned}$$

The relationship between m and P is shown in Figure 1, where P reaches the maximum when $m = \bar{m}$.

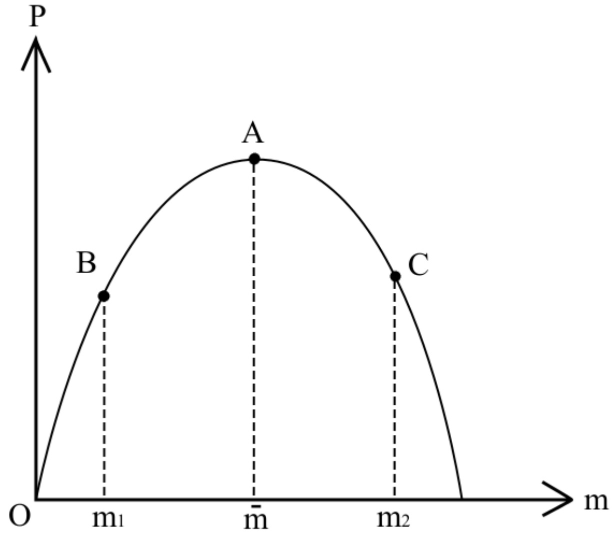

Figure 1: Relationship between m and P

On one hand, if m^{MAX} is equal to m_2, the bank chooses $\bar{m}$, and thus, P is determined by Point A. On the other hand, if m^{MAX} is equal to m_1, the bank chooses m^{MAX}, and thus, P is by Point B.

Once the value of P is determined, we can calculate the optimal amount of investment by using equation (20). Since $f(I)$ is the concave function and $f'(I)$ is decreasing with respect to I, the amount of I can be determined from $f'(I)$. This relationships between m, P, $f'(I)$, and I are shown in Figure 2.

From the above arguments, we have the following proposition.

Proposition 3. *If α is small enough to satisfy $m^{MAX} = m_1 < \bar{m}$ in equation (18), m is equal to m_1 and P is given by Point B. Then, the bank chooses I_1.*

If α is large enough to satisfy $\bar{m} < m^{MAX} = m_2$, m is equal to $\bar{m}$ and P is given by Point A, and then the bank chooses $\bar{I}$.

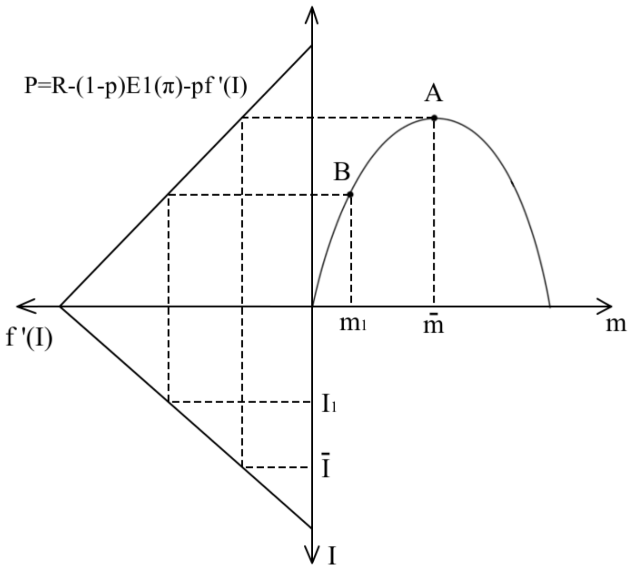

Figure 2: Relationship between m and I

Furthermore, suppose that $m = \bar{m}$ in equation (21). Then, we have

$$P = \frac{1}{2}\bar{m}(R^B - R^M). \tag{22}$$

Defining L as a line given by (22), we get Figure 3.

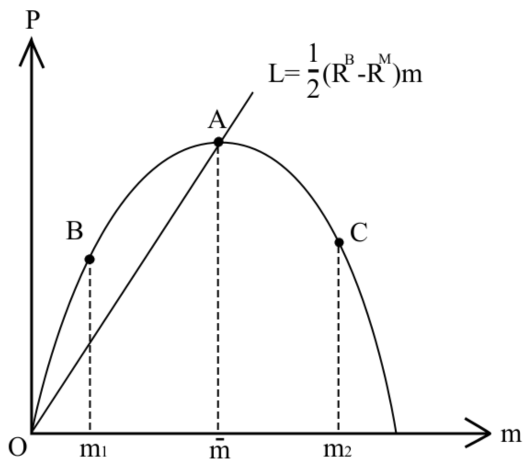

Figure 3: Relationship between line L and Point A

It is noteworthy that α, z and p have no effect on the slope of L, as shown in equation (22). In addition, even if the value of $\bar{m}$ changes, P always satisfies equation (22) as far as $\bar{m}$ satisfies equation (17) (see the Appendix with respect to the derivation). In other words, L in Figure 3 indicates the locus of P with the respect to the change in $\bar{m}$.

4.2 Social planner's problem and results

Next, we assume that the social planner determines the level of m to maximize the sum of bank's and investors' return. The total return is given by

$$\begin{aligned} U &= \{pf(I) + (1-p)\pi^r I - R^B I\} + m(R^B - R^M)I \\ &\quad + pg(W) + (1-p)\{g(W - \alpha m^2 I R^M) + \alpha m^2 I R^M\} - W R^B. \end{aligned} \tag{23}$$

By differentiating (23) with the respect to m, we have

$$\frac{\partial U}{\partial m} = (R^B - R^M)I + (-2\alpha m)(1-p)\{g'(W - \alpha m^2 I R^M) - 1\} I R^M. \tag{24}$$

Suppose that $\partial U/\partial m \geq 0$. Then the condition for m is given by

$$\{g'(W - \alpha m^2 I R^M) - 1\}\, m \leq \frac{r}{2\alpha(1-p)}. \tag{25}$$

Then, the condition for m on the bank in equation (16) is changed to

$$zm = \left(\frac{1}{k} - 1\right) m \leq \frac{r}{2\alpha(1-p)}. \tag{26}$$

By differentiating the left-hand side of equation (25) with the respect to m, we have

$$\frac{\partial}{\partial m}[\{g'(W - \alpha m^2 I R^M) - 1\}\, m] = \{g'(\cdot) - 1\} + (-2\alpha\, m R^M) g''(\cdot) m. \tag{27}$$

Even though the bank can choose k satisfying (3), m in equation (25) reaches $r/(2\alpha(1-p))$ faster than in equation (26). This is shown by $\partial g'(\cdot)/\partial m > 0$. Then, we have m^*, which is the maximum m in equation (25), is smaller than $\bar{m}$.

Next, by differentiating (23) with the respect to I, we have

$$\begin{aligned} \frac{\partial U}{\partial I} &= \{pf'(I) + (1-p)\pi^r - R^B\} + m(R^B - R^M) \\ &\quad + (1-p)(-\alpha m^2 R^M)\{g'(\cdot) - 1\}. \end{aligned} \tag{28}$$

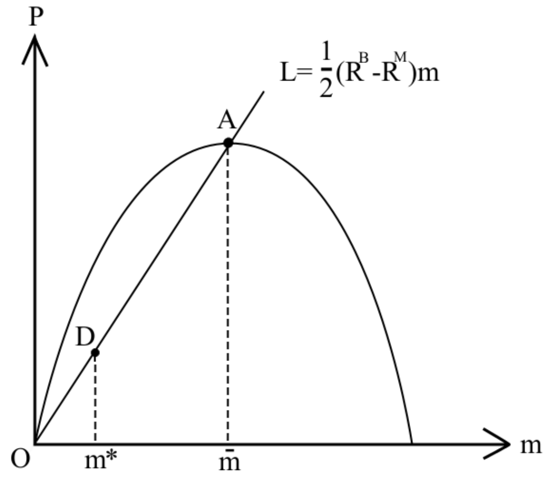

Figure 4: Relationship between line L and Point D

Let us define P^* as follows.

$$P^* = m(R^B - R^M) + (1-p)(-\alpha m^2 R^M)\{g'(\cdot) - 1\} \tag{29}$$

P^* is the part determined by m in equation (28). Just as in P, P^* can also be rewritten as follows by substituting m^* for m (see the Appendix with respect to the derivation).

$$P^* = \frac{1}{2}m^*(R^B - R^M)$$

Therefore, P^* is also located on line L in Figure 4. In other words, the socially optimal m^* is smaller than $\bar{m}$ and the socially optimal I^* is smaller than $\bar{I}$, as shown in Figure 5.

In conclusion, we have the following proposition.

Proposition 4. *The socially optimal m^* is always smaller than $\bar{m}$ and the socially optimal amount of the bank's investment, I^*, is always less than $\bar{I}$.*

In the model with disclosure of information, even if the bank chooses the same k as the creditors, it always invests too large amount as far as it does not take into account that the effect of m on the determination of k. This occurs when the constraint on m in Section 2 does not bind the bank, that is, $m < \bar{m}$. Furthermore, even when $m^* = m^{\mathrm{MAX}}$, P determined by the bank is higher than P^*.

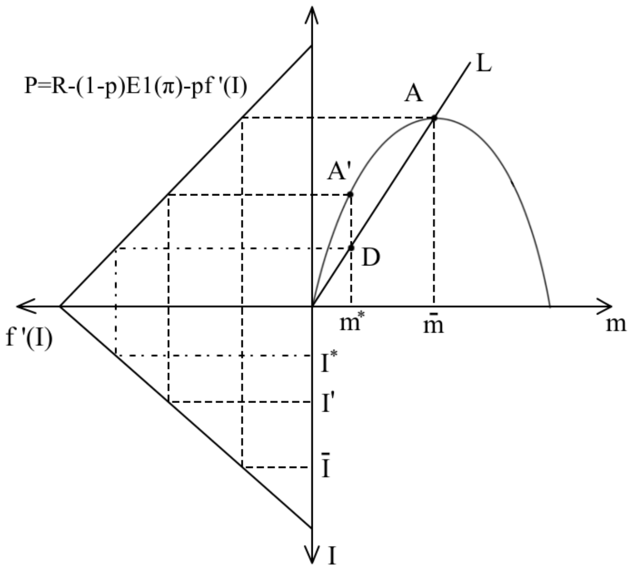

Figure 5: Relationship between m^* and $\bar{m}$

The result indicates that the bank always chooses an excessive amount of investment if the following conditions are satisfied, regardless of α. The first condition is that the bank does not know the process by which k is determined. The second is that the bank estimates smaller k than the value that the investors choose.

Thus, the excessive issuing of short-term debt and excessive investment are possible not only when $m = m^{\text{MAX}}$ but also when $m < m^{\text{MAX}}$. This means that forcing the bank to disclose information about its capital structures is not effective for the prevention of the bank's excessive issuing of short-term debt and investment unless it chooses the value of k properly.

4.3 Banks' selection process for the discount factor k

4.3.1 Process

As explained above, the bank's excessive issuing of short-term debt and investment are caused by its arbitrary selection of k. Therefore, in this section, we analyzes in detail the process through which the bank chooses the discount factor k.

Since the choice of an inappropriate k results in a loss for the bank, it is not rational for the bank to continue to use the arbitrary selection process. Therefore, we assume that at time 0, the bank gathers information to perceive the true process used by the creditors. In the model with disclosure of information, the investors choose k in such way that it satisfies $k = 1/g'(A)$, where $A = W - \alpha m^2 I R^M$. A denotes the investors' funds remaining after buying the bank's assets. Suppose that the bank knows this process. Then, the question to address remains as to whether it perceives the shape of $g(\cdot)$. Even though $g(\cdot)$ is the return on the projects on which the bank does not invest, it would be valid to think that it can get information at time 0 about these projects because they are at the point where their return $g(\cdot)$ is fixed regardless of the state of the economy. Therefore, we assume that the bank knows $g(\cdot)$ at time 0.

This assumption is supported by the different viewpoint. The difference between k arbitrarily chosen by the bank and the one chosen by the investors is the difference in the values of m, P, and I. However, the difference in k can be reduced to the difference between z in equation (15) and $(g'(A) - 1)$ in equation (24). Thus, it is plausible to think that bank uses the same $g(\cdot)$ to choose k. The bank's expected amount of the investors' remaining funds, denoted as a, can be different from the true amount. It means $z = g'(a) - 1 \neq g'(A)$. It implies that whether the bank chooses appropriate k or not depends on whether the value of a is equals to A or not.

4.3.2 Bank's choice of a

Suppose that the bank knows the shape of $g(\cdot)$ and equation (3). As mentioned in Section 2, the value of W is endogenously determined by the investors in such a way that the expected return on their investment is equal to the cost of capital R^B. It is written by

$$pg'(W) + (1-p)g'(W - \alpha\, m^2 I R^M) = R^B. \tag{30}$$

Suppose that the bank knows equation (30) used by the investors. Therefore, the difference in k chosen by the bank and the investors implies that $a \neq A = W - \alpha\, m^2 I R^M$. It indicates that there is certain information that the bank cannot know about parameters included into $W - \alpha m^2 I R^M$. Suppose that the investors have information about I and have the same α as the creditors, denoted as α^*. In addition, let us denote W determined based on α^* as W^*. Since R^M is exogenous and m is disclosed by the bank, the variables unknown to the bank are α^* and W^*.

At first, suppose that the bank knows α^* but not W. However, since it knows equation (30), it can expect the same W^* as the investors thanks to the equation. Similarly, when the bank knows W^* alone, it understands the correct value of α^*, which the investors use to determine W^* from equation (30). Therefore, the difference between a and A implies that the bank understands neither α^* nor W^* used by the investors.

Let us define $\tilde{\alpha}$ as the value of α estimated by the bank and $\tilde{W}$ as the expected amount of funds determined from $\tilde{\alpha}$, respectively. In addition, we focus on the case where $\tilde{\alpha} < \alpha^*$ is satisfied. This case means that the bank estimates the degree of the investors' risk aversion is less than the actual degree.

Suppose that (α^*, W^*) is satisfying equation (30). When α^* is substituted with $\tilde{\alpha}$, the second term of (30) decreases due to $\tilde{\alpha} < \alpha^*$. Then, we have

$$pg'(W^*) + (1-p)g'(W^* - \tilde{\alpha}\, m^2 I R^M) < R^B.$$

Thus, to equate both sides of this inequality, W^* must be reduced. Therefore, we obtain $\tilde{W} < W^*$ such that

$$pg'(\tilde{W}) + (1-p)g'(\tilde{W} - \tilde{\alpha}\, m^2 I R^M) = R^B.$$

This equation can be rewritten as follows.

$$(1-p)g'(\tilde{W} - \tilde{\alpha}\, m^2 I R^M) \;=\; R^B - pg'(\tilde{W})$$

Similarly, by substituting (α^*, W^*) into equation (30) and by rewriting we have

$$(1-p)g'(W^* - \alpha^*\, m^2 I R^M) \;=\; R^B - pg'(W^*).$$

Since $\tilde{W} < W^*$ is satisfied, we have

$$g'(\alpha^*, W^*, m, I) \;>\; g'(\tilde{\alpha}, \tilde{W}, m, I), \tag{31}$$

where $g'(\alpha^*, W^*, m, I) \equiv g'(W^* - \alpha^*\, m^2 I R^M)$ and $g'(\tilde{\alpha}, \tilde{W}, m, I) \equiv g'(\tilde{W} - \tilde{\alpha}\, m^2 I R^M)$.

Suppose that the bank chooses $m = \tilde{m}$ and $I = \tilde{I}$. Letting us denote the bank's estimation of P based on $(\tilde{\alpha}, \tilde{W})$ as $\tilde{P}$, we have

$$\tilde{P} \;=\; \tilde{m}(R^B - R^M) + (1-p)(-\tilde{\alpha}\,\tilde{m}^2 R^M)\{g'(\tilde{W} - \tilde{\alpha}\,\tilde{m}^2 \tilde{I} R^M) - 1\}.$$

Moreover, by substituting (α^*, W^*) into equation (29), we have

$$P^* \;=\; \tilde{m}(R^B - R^M) + (1-p)(-\alpha^*\tilde{m}^2 R^M)\{g'(W^* - \alpha^*\tilde{m}^2 \tilde{I} R^M) - 1\}.$$

The difference between them is given by

$$\tilde{P} - P^* = (1-p)(\tilde{m}^2 R^M)[\alpha^*\{g'(\alpha^*, W^*, \tilde{m}, \tilde{I}) - 1\} - \tilde{\alpha}\{g'(\tilde{\alpha}, \tilde{W}, \tilde{m}, \tilde{I}) - 1\}]. \tag{32}$$

Since $\tilde{\alpha} < \alpha^*$ is assumed, we have by using equation (31)

$$\tilde{P} - P^* > 0.$$

Therefore, we have the following proposition.

Proposition 5. *If $\tilde{\alpha} < \alpha^*$,*

1. *for any set of (m, I), the bank always expects $\tilde{P}$, which is larger than P^*.*
2. *the amount of investment $\tilde{I}$ chosen by the bank is always larger than I^*.*

These results have some important implications. First, we find that the decision-making process about k itself does not significantly affect whether or not the bank can choose k properly. Thus, reforming the process used by banks has little influence if they continue to use inappropriately estimated values in the decision-making processes. In other words, the socially desired results can be achieved when information is complete, and banks and the creditors use the information properly.

Second, even if market incompleteness has little influence, that is, the constraint on m does not bind banks, the incompleteness of information can cause inefficiencies. We confirm this result by checking that $\tilde{P}$ is larger than P^* even when m^* and $\tilde{m}$ are smaller than m^{MAX} under the assumption of $\tilde{\alpha} < \alpha^*$.

Third, these two implications indicate that a regulation requiring banks to disclose information is more effective in the prevention of their excessive activities than the relaxation of upper bound of m. In order to secure its effectiveness, however, we need another condition that enables the banks to understand the property of the creditors correctly.

5 Effective Regulation

In this section, we briefly examine effective regulations by using the model in Section 4.

In the model without disclosure of information, the constraint on m is always bound and the amount of the bank's investment is not always equal to the socially optimal amount. In order to equate the former to the latter, some exogenous constraints on m or I must be added. It implies that the social planner must know the shape of $f(I)$ to calculate the optimal values of m and I. From this viewpoint, Stein(2012) asserts the need of the regulations which enforce the banks to provide the social planner with information about the shape of $f(I)$.

In the model with disclosure of information, however, the value of m chosen by banks is not always fixed at m^{MAX}. Even if the social planner does not know the shape of $f(I)$, therefore, trivial problems are just arisen. This is because we assume that the difference between the bank's decision and the social planner's one are reduced to the difference in their choices with regard to m. In addition, and more importantly, there is a one-to-one correspondence between m and P, as shown in Figure 4. This means that the social planner can understand that the amount of the bank's investment $\tilde{I}$ differs from the socially optimal amount I^* by observing the difference between $\tilde{m}$ disclosed by the bank and m^*.

Furthermore, when the bank discloses information, an upper bound of m or I can be ineffective. As confirmed from equation (31) and Figure 5, even if $m = m^*$, the bank expects not Point A but Point D, and chooses excessive investment $\tilde{I}$ if the bank uses the estimated value $(\tilde{\alpha}, \tilde{W})$. Similarly, even if $I = I^*$, the bank chooses a smaller m than m^*.

From the above arguments, it is concluded that there are two types of effective regulations in the model with disclosure of information: to encourage the bank' decision to be consistent with the investors' decision or to encourage the investors' decision to be consistent with the bank's decision. Under the former regulation the bank thinks of α^* as the optimal choice. Under the latter regulation, by contrast, the investors think of $\tilde{\alpha}$ as the optimal choice. We think that the disclosure of $\tilde{m}$ by the bank is one of the latter regulations. This is because the disclosed $\tilde{m}$ indicates the value of $\tilde{\alpha}$, and then the investors would regard $\tilde{\alpha}$ as the optimal choice.

Let us compare these two regulations. In the former, the amount of investment I^* is chosen, and in the latter, $\tilde{I}$ is chosen. Suppose that the larger the optimal amount of investment the more desirable it is for the economy. Then, the latter regulation, under which the investors make a decision in accordance with the bank's estimation, is more effective regulation because $\tilde{I}$ is larger than I^*.

6 Conclusion

The main conclusions of this study are summarized as follows. If a bank does not provide any information about its capital structure and the cost of short-term debt is sufficiently cheap, then the amount of short-term debt issued by the bank exceeds the socially desirable amount.

In contrast, if it discloses the information and its creditors use the information in their decision-making processes, the amount of short-term debt issued by the bank is equal to the amount socially desired. However, this result cannot be obtained unless the bank can correctly estimate the creditors' risk-aversion parameter. This is because there is the asymmetry of information between the creditors and the bank in that the former have the information about the latter while the latter has no information about the former.

In order to prevent banks from excessively depending on short-term wholesale funding, therefore, the regulation of banks' disclosure of information could be effective. However, another regulation that can bridge the information gap between banks and creditors is necessary to secure the effectiveness.

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A Appendix

A.1 Derivation of equation (11)

$$\frac{\partial U_{ni}}{\partial I} = \{pf'(I) + (1-p)\pi^r - R^B\} + m^*_{ni}(R^B - R^M) - (1-p)(m^*_{ni}R^M)\{g'(\cdot) - 1\} = 0.$$

From $\{g'(m^*_{ni}) - 1\} = \frac{r}{1-p}$,

$$0 = \{pf'(I) + (1-p)\pi^r - R^B\} + m^*_{ni}(R^B - R^M) - (1-p)(m^*_{ni}R^M) \cdot \frac{r}{1-p}.$$

From $r = \frac{R^B - R^M}{R^M}$,

$$0 = \{pf'(I) + (1-p)\pi^r - R^B\} + m^*_{ni}(R^B - R^M) - m^*_{ni}(R^B - R^M 1).$$

Then, $0 = \{pf'(I) + (1-p)\pi^r - R^B$.

A.2 Derivation of line L (P→L)

$$P = \bar{m}(R^B - R^M) - \alpha\bar{m}(1-p)z\,\bar{m}R^M.$$

From $\bar{m} = \frac{r}{2\alpha\, z(1-p)}$,

$$\begin{aligned} P &= \bar{m}(R^B - R^M) - \alpha\bar{m}(1-p)z\,\frac{r}{2\alpha\, z(1-p)}R^M \\ &= \bar{m}(R^B - R^M) - \frac{1}{2}\bar{m}(R^B - R^M) \\ &= \frac{1}{2}\bar{m}(R^B - R^M) \end{aligned} .$$

If $\bar{m}$ satisfies equation (17), from $\bar{m} = \frac{r}{2\alpha\, z(1-p)}$, we always derive this result.

A.3 Derivation of line L ($P^* \to$ L)

$$m(R^B - R^M) + (1-p)(-\alpha m^2 R^M)\{g'(\cdot) - 1\}$$

$$= m^*(R^B - R^M) + (1-p)(-\alpha m^* R^M)\{g'(W - \alpha m^{*2} I R^M) - 1\}m^*.$$

From $\{g'(m^*) - 1\}m^* = \frac{r}{2\alpha(1-p)}$,

$$
\begin{aligned}
&= m^*(R^B - R^M) + (1-p)(-\alpha m^* R^M) \cdot \frac{1}{2\alpha(1-p)} \\
&= m^*(R^B - R^M) - \frac{1}{2}m^*(R^B - R^M) \\
&= \frac{1}{2}m^*(R^B - R^M).
\end{aligned}
$$

If m^* satisfies equation (25), from $\{g'(m^*) - 1\}m^* = \frac{r}{2\alpha\, z(1-p)}$, we always obtain this result.