Designing Incentive-Compatible Regulation in Banking: The Role of Penalty in the Precommitment Approach

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1. Introduction

The purpose of this paper is to present a framework for incentive-compatible regulation that would enable regulators to ensure that riskier banks maintain higher capital holdings.

Under the precommitment approach, a bank announces the appropriate level of capital that covers the maximum value of expected loss that might arise in its trading account. If the actual loss (after a certain period) exceeds the announced value, the bank is penalised. This framework creates the correct incentive for banks: The banks choose the level of capital that minimises the total cost, which consists of the expected cost of penalty and the cost of raising capital.

Nevertheless, it is not certain that the regulator will always implement the mechanism through which banks accurately reveal their riskiness. To be more precise, the approach relies solely on the first-order condition of cost minimisation, in which the regulator need only offer a unique penalty rate and let each bank select the amount of capital that satisfies the first-order condition. This implies that the regulator needs no information ex ante with regard to the riskiness of each bank (that is, the regulator can extract private information ex post by observing how much capital each bank chooses to hold after setting the unique penalty rate).

It is, however, questionable whether riskier banks will always choose a higher level of capital. The choice of capital holding depends on the bank's private information, such as the shape of the density function of its investment return. Riskier banks may in fact choose smaller amounts of capital. Thus, the normative capital requirement dictating that riskier banks should hold higher levels of capital may not always be satisfied under the precommitment approach. With this in mind, we examine an alternative to the precommitment approach, in which the regulator is viewed as offering incentive-compatible contracts that consist of both the level of capital and the penalty rate, and see whether banks fulfill the normative capital requirement.

The paper is organised as follows: In the next section, we briefly review the precommitment approach and show that in some cases it may not be possible to determine each bank's riskiness by observing how much capital it decides to hold. In Section 3, we develop a model from the perspective of mechanism design whereby the regulator

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designs a menu of contracts. We then examine under different scenarios whether the regulator could achieve the norm where riskier banks decide to hold higher levels of capital. Section 4 summarises the paper's findings.

2. Outline of the Precommitment Approach

In this section, we briefly review the model set forth by Kupiec and O'Brien (1995), who first proposed the precommitment approach. We will examine the case where monetary fines are used as a penalty and will discuss how the fines work by letting banks hold optimal levels of capital, according to the innate qualities of the assets in their trading accounts.[1]

First, the net return of assets in banks' trading accounts is denoted by Δr, which follows the density function, $dF(\Delta r)$, and banks hold capital equivalent to k. In the model, there are two cost factors—the cost associated with raising capital and the expected cost of the penalty. The penalty is imposed if the actual net loss exceeds the precommitted amount (that is, if the net return is lower than $-k$, then the penalty is imposed). Assuming the penalty is imposed proportional to the excess loss, the total cost function is written as follows:

$$(1) \qquad C(k,\rho) = \eta k - \rho \int_{-\infty}^{-k} (\Delta r + k) dF(\Delta r),$$

where η is the marginal cost of capital, and ρ is the penalty rate. The first term represents the cost of raising capital. The second term shows the total expected cost of the penalty. Taking the first derivative with respect to k, we have

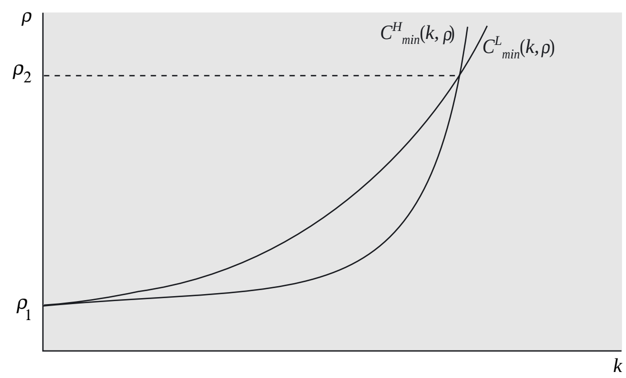
$$(2) \qquad \frac{\partial C(k,\rho)}{\partial k} = \eta - \rho F(-k) = 0.$$

Given the rate of penalty, banks choose their optimal levels of capital, which satisfy equation 2.[2]

Although Kupiec and O'Brien do not go beyond this point, let us extend the model in such a way that it incorporates the riskiness of banks.[3] Suppose now that two types of banks exist: banks with riskier assets (H-type banks), whose density function is denoted by $dF^H(\Delta r)$, and banks with less risky assets (L-type banks), whose density function is denoted by $dF^L(\Delta r)$. We assume the variance of $dF^H(\Delta r)$ is larger than that of $dF^L(\Delta r)$. Then, we can imagine one example of the minimum cost curves, for

Chart 1

One Example of Minimum Cost Curves for High-Risk and Low-Risk Banks



H-type and L-type banks, on which the first-order condition is always satisfied (Chart 1).

$C^H_{min}(k,\rho)$ is the minimum cost curve for H-type banks, and $C^L_{min}(k,\rho)$ is the minimum cost curve for L-type banks. The higher the penalty rate offered by the regulator, the higher the capital requirement for banks to satisfy the first-order condition. The figure also generalises the case where H-type banks have a gentle curve when k is low, while they have a steep curve when k is high. This occurs because when k is low (that is, close to the mean of the density function), an additional increase in the penalty rate requires H-type banks to add more capital than L-type banks must add to retain the first-order condition. The magnitude of changes in the density function per one-unit increase in capital level is less for H-type banks (whose variance is larger) than for L-type banks. On the contrary, when k is high (that is, close to the tail of the density function), an additional increase in the penalty rate may require L-type banks to add more capital than H-type banks to reestablish the first-order condition. The reason is that the magnitude of changes in its density function per one-unit increase in capital level is less for L-type banks. The following two situations could arise:

- If the regulator charges a penalty rate higher than ρ_2, then L-type banks choose to hold higher levels of capital.
- If the regulator charges $\rho \in [\rho_1 \rho_2]$, then H-type banks choose to hold higher levels of capital.

A summary of these situations follows.

Kupiec and O'Brien assume that the regulator, without knowing the banks' riskiness, can allow banks to reveal their riskiness by charging a unique penalty rate.[4] Each bank, given the penalty rate, voluntarily chooses the level of capital that minimises the total cost. The authors further claim that the choice of capital level is incentive compatible for every bank. But without knowing where the minimum cost curves lie, the regulator cannot assess banks' riskiness just by observing the levels of capital (that is, high-risk banks sometimes hold more capital, sometimes less). In this situation, we are not sure whether the regulator can overcome private information (that is, the riskiness of each bank) just by penalising at the uniform rate.

Next, we suggest a general model in which the regulator offers contracts that consist of the level of capital and the penalty rate and lets banks select a contract—an arrangement that enables the regulator to assess the riskiness of each bank correctly. We will see how we could satisfy the normative requirement that high-risk banks hold higher levels of capital.

3. The Model

The following model is designed to establish whether the regulator could determine banks' riskiness by offering banks a menu of contracts and letting each select one. We are interested in two points: How incentive compatibility can be satisfied in both the precommitment approach and the model presented below, and whether the normative standard of capital requirements—whereby banks with riskier assets choose to hold higher levels of capital than those with less risky assets—is fulfilled.

3.1. Setup of the Model

Two players participate in the game: the regulator and the banks. The banks are categorised according to the innate qualities of the assets in their trading accounts. For simplicity, we assume there are two types of banks—H-type (a bank whose portfolio consists of high-risk, or large-variance, assets) and L-type (a bank whose portfolio consists of low-risk assets). Although the banks know their own types, the regulator does not know ex ante which bank belongs to which type. One may argue, however, that the regulator can learn each bank's type through monitoring or from the records of on-site supervision. Nevertheless, we assume that most of the assets in the trading accounts are held short term and that banks can form the portfolios with different levels of riskiness. The assessment of the riskiness of a portfolio at the time of on-site supervision may therefore not be valid for a long time. Hence, it is reasonable to assume that the regulator is uninformed about the types. Remember, we are concerned with the quality of the banks' assets in their *trading accounts*. It may not be appropriate to extend the same interpretation to the assets in their banking accounts. Because these assets are held for much longer periods, the information obtained through monitoring is valid longer. The scope for private information is therefore much more limited.

Next, let us explain the sequence of events in the model. In each of the game's three periods, the following events take place.

Period 0

1. Banks collect one unit of deposits, whose rate of interest is normalised to zero. The deposit has to be paid back to depositors at the end of the game (that is, in Period 2).
2. The banks then invest the money in financial assets.

Period 1

1. The regulator offers a menu of contracts consisting of different levels of required capital and penalty rates corresponding to each capital requirement level.
2. Banks choose a contract from the menu. For them, accepting a contract means that they hold $k_i \in (0, 1)(i = H, L)$ as capital.

Period 2

1. The return on investment, $\tilde{r}$, is realised.
2. If the return fails to achieve the precommitted level, the regulator penalises the bank.

Let the return on investment be a stochastic variable in the range of $[r^-, r^+]$, and it follows a density function, $dF(\tilde{r})$. We denote the return on investment by $dF_H(\tilde{r})$ for an H-type bank, and $dF_L(\tilde{r})$ for an L-type bank. We assume that the variance of $dF_H(\tilde{r})$ is larger than that of $dF_L(\tilde{r})$, but we do not assume any specific shape of distribution functions.[5]

The regulator penalises the bank if the net loss from the investment, $-(\tilde{r}-1)$, exceeds the precommitted value k_i; hence the penalty is imposed if $1-k_i \geq \tilde{r}$. Let the penalty rate be denoted by $p_i (i = H,L)$, so that the amount of penalty is $p_i \times [(1-k_i)-\tilde{r}]$.

We analyse the three following cases according to the relative size of the cumulative density:[6]

Case 1: $F_H(1-k_i) \geq F_L(1-k_i)$ for $k_i \in (0,1)$

The cumulative density for H-type banks is always larger than the one for L-type banks.[7]

Case 2: $F_H(1-k_i) \geq F_L(1-k_i)$ for k_i close to 0

$F_H(1-k_i) < F_L(1-k_i)$ for k_i close to 1

The cumulative density for H-type banks is larger when the level of capital is close to 0; it is smaller when the level of capital is close to 1.

Case 3: $F_H(1-k_i) \leq F_L(1-k_i)$ for k_i close to 0

$F_H(1-k_i) > F_L(1-k_i)$ for k_i close to 1

The cumulative density for H-type banks is smaller when the level of capital is close to 0; it is larger when the level of capital is close to 1.[8]

We now write the bank's cost function as follows:

$$C_H^H \equiv \int_{\bar{r}}^{1-k_H} p_H[(1-k_H)-\tilde{r}]dF_H(\tilde{r}) + \eta k_H, \quad (3)$$

where C_j^i represents the cost function of the bank that has an innate riskiness of j but announces the riskiness i. The first term in this cost function is the expected cost of a penalty. The second term is the cost associated with raising capital equivalent to k_H, where η is the marginal cost of capital. Likewise, the cost function of an L-type bank is as follows:

$$C_L^L \equiv \int_{\bar{r}}^{1-k_L} p_L[(1-k_L)-\tilde{r}]dF_L(\tilde{r}) + \eta k_L. \quad (4)$$

3.2. Regulator's Programme

Let us now analyse how the regulator designs the mechanism in which the H-type and L-type banks reveal their types truthfully. The following programme is a starting point:[9]

$$\min_{\begin{Bmatrix} k_L, k_H \\ p_L, p_H \end{Bmatrix}} L = \delta \times \left[d\left[k_L - \left(1 - F_L^{-1}\left(\frac{\eta}{P_L}\right)\right)\right]^2 + \left[k_H - \left(1 - F_H^{-1}\left(\frac{\eta}{P_H}\right)\right)\right]^2\right]$$

$$+ (1-\delta) \times max(0, k_L - k_H), \text{ where } k_L \neq k_H$$

$$(\text{IC}_\text{H}) \quad C_H^H = \int_{\bar{r}}^{1-k_H} p_H[(1-k_H)-\tilde{r}]dF_H(\tilde{r}) + \eta k_H$$

$$\leq \int_{\bar{r}}^{1-k_L} p_L[(1-k_L)-\tilde{r}]dF_H(\tilde{r}) + \eta k_L \equiv C_H^L$$

$$(\text{IC}_\text{L}) \quad C_L^L = \int_{\bar{r}}^{1-k_L} p_L[(1-k_L)-\tilde{r}]dF_L(\tilde{r}) + \eta k_L$$

$$\leq \int_{\bar{r}}^{1-k_H} p_H[(1-k_H)-\tilde{r}]dF_L(\tilde{r}) + \eta k_H \equiv C_L^H.$$

The loss function of the regulator consists of both the deviation of capital from the level specified by the first-order condition and the difference between capital holdings of banks with different risk levels. The term in parentheses after δ represents any capital holding that is not equivalent to the optimal level. Such a case is regarded as costly for the regulator. This applies to both L-type and H-type banks. The term after $(1-\delta)$ shows that the regulator is willing to let high-risk banks hold more capital. As long as high-risk banks hold more capital, the regulator does not incur any loss. This is consistent with the norm specifying that the level of capital holding should increase with riskiness.

The two inequalities after the regulator's objective function are called incentive-compatibility constraints for H-type and L-type banks. We denote them by IC_H and IC_L, respectively. These constraints guarantee that each bank will select the contract appropriate to its type. By choosing the wrong contract, a bank will have to pay a higher cost. Any pair of contracts that satisfy the incentive-compatibility constraints is one of a number of possible solutions.

Case 1: $F_H(1-k_1) \geq F_L(1-k_1)$ for $k_1 \in (0, 1)$

In this case, the minimum cost curve—where the first-order condition is satisfied—for H-type banks is always below the curve for L-type banks (Chart 2).

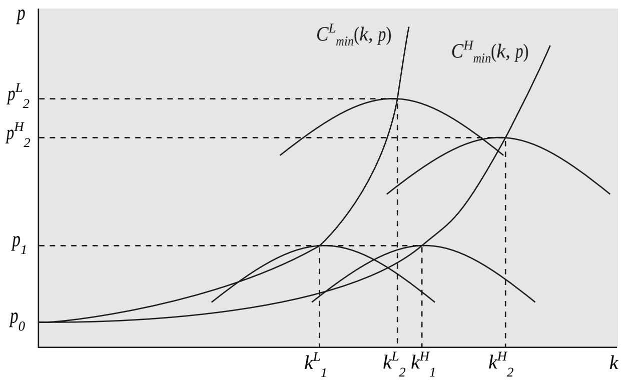
Chart 2 also depicts the iso-cost curve, where the total cost remains constant (reverse U-shaped function). The curvature of the iso-cost curve is easily verified. The slope of the curve is always 0 when it crosses the minimum cost curve. The reason is that, in the case of H-type banks,

$$\left.\frac{dp}{dk}\right|_{C = const} = \frac{F_H(1-k_H)-\eta}{\int_{\bar{r}}^{1-k_H}[(1-k_H)-\tilde{r}]dF_H(\tilde{r})}$$

is zero whenever the first-order condition is satisfied.

Chart 2

Minimum Cost Curve: Case 1



Next, we check the marginal cost. Additional capital will influence the total cost through two different channels. First, it will reduce the range of $\tilde{r}$ in which the penalty is imposed (*penalty cost-saving effect*), so that the more capital the bank holds, the less expected cost it will incur. Second, more capital means the total cost of raising capital increases (*capital cost effect*). On the right-hand-side of the minimum cost curve, the iso-cost curve is downward sloping because the marginal cost is positive. In other words, the capital cost effect exceeds the penalty cost-saving effect, so that the more capital the bank holds, the more costly it is. Hence, to retain the same level of cost, the penalty rate needs to be reduced. On the left-hand-side of the minimum cost curve, the iso-cost curve is upward sloping because the marginal cost is negative. In other words, the penalty cost-saving effect exceeds the capital cost effect, so that the more capital the bank holds, the less costly it is. Hence, to retain the same level of cost, the penalty rate needs to be raised.

Here, the menu of contracts can be incentive compatible. One example of the menu is depicted in Chart 2. If the regulator provides (k_2^L, p_2^L) and (k_2^H, p_2^H), L-type banks will choose the former and H-type banks will choose the latter. The menu options minimise the loss function of the regulator (that is, the menu identifies the level of capital that satisfies the first-order condition, and H-type banks are offered a higher level of capital). The menus also satisfy incentive compatibility, namely that

$$\int_{r-}^{1-k_2^H} p_2^H[(1-k_2^H)-\tilde{r}]dF_H(\tilde{r}) + \eta k_2^H$$
$$< \int_{r-}^{1-k_2^L} p_2^L[(1-k_2^L)-\tilde{r}]dF_H(\tilde{r}) + \eta k_2^L$$

for an H-type bank and

$$\int_{r-}^{1-k_2^L} p_2^L[(1-k_2^L)-\tilde{r}]dF_L(\tilde{r}) + \eta k_2^L$$
$$< \int_{r-}^{1-k_2^H} p_2^H[(1-k_2^H)-\tilde{r}]dF_L(\tilde{r}) + \eta k_2^H$$

for an L-type bank.

At the same time, the regulator offering the unique penalty rate also guarantees incentive compatibility because the penalty rate minimises the loss function. To see this point, suppose that the regulator offers p_1 in Chart 2. The pairs of (k_1^L, p_1) and (k_1^H, p_1) are incentive compatible, namely that

$$\int_{r-}^{1-k_1^L} p_1[(1-k_1^H)-\tilde{r}]dF_H(\tilde{r}) + \eta k_1^H$$
$$< \int_{r-}^{1-k_1^L} p_1[(1-k_1^L)-\tilde{r}]dF_H(\tilde{r}) + \eta k_1^L$$

for an H-type bank and

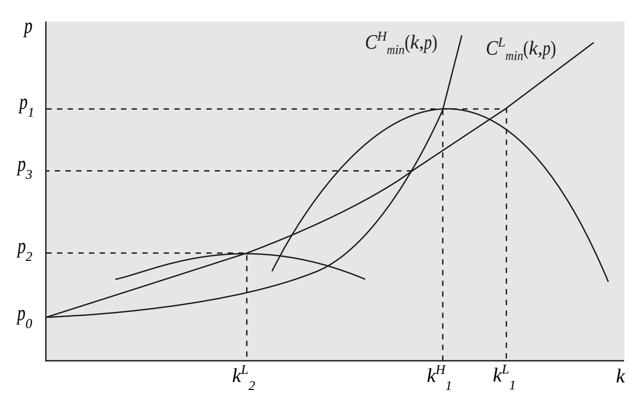
$$\int_{r-}^{1-k_1^L} p_1[(1-k_1^L)-\tilde{r}]dF_L(\tilde{r}) + \eta k_1^L$$
$$< \int_{r-}^{1-k_1^H} p_1[(1-k_1^H)-\tilde{r}]dF_L(\tilde{r}) + \eta k_1^H$$

for an L-type bank.

Because this model and the original approach satisfy both incentive compatibility and the requirement that riskier banks hold more capital, the menu of contracts with different penalty rates may not be necessary: As long as the single penalty rate is offered by the regulator, the regulator's objective is fulfilled.[10]

Chart 3

Minimum Cost Curve: Case 2



Case 2: $F_H(1-k_i) \geq F_L(1-k_i)$ for k_i close to 0

$F_H(1-k_i) < F_L(1-k_i)$ for k_i close to 1

In case 2, the minimum cost curves intersect at $k > 0$ (Chart 3).

In the precommitment approach, any penalty rate that lies between p_0 and p_3 will yield the same result as in case 1. A problem arises, however, when a penalty rate above p_3 is imposed. Here, the regulator can no longer achieve its objective: Although the capital levels chosen by the banks are incentive compatible, the regulator incurs an additional loss by letting L-type banks hold more capital than H-type banks. Our approach, however, may be able to overcome this problem. Suppose that in Chart 3 the regulator offers two contracts, k_2^L, p_2 and k_1^H, p_1. It is indeed the case that L-type banks choose the first contract and H-type banks choose the second (incentive compatibility is satisfied). Moreover, the regulator achieves its objective by minimising the loss: an additional loss is not incurred as long as H-type banks choose to hold more capital than L-type banks.

We therefore propose two modifications to the precommitment approach. First, the regulator collects necessary information concerning banks' risk characteristics so that it will not impose a penalty rate above p_3. Any penalty rate between p_0 and p_3 will achieve the objective: the regulator will be able to assess each bank's riskiness by observing the level of capital that the bank chooses to hold. Second, the regulator again collects necessary information on banks' riskiness and provides banks with two contracts having different penalty rates. Note that both modifications would require regulators to gather extensive information about banks' risk characteristics.

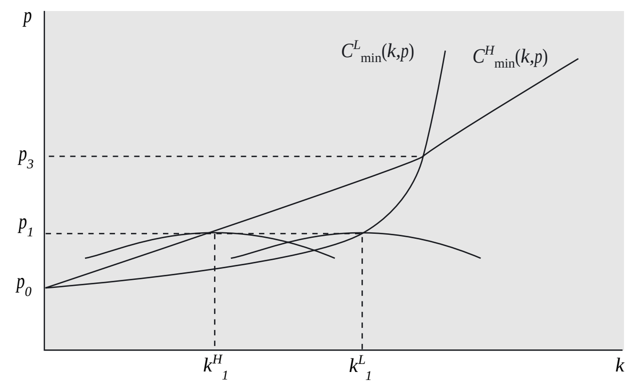
Case 3: $F_H(1-k_i) \leq F_L(1-k_i)$ for k_i close to 0

$F_H(1-k_i) > F_L(1-k_i)$ for k_i close to 1

Our final case is the opposite of case 2 (Chart 4). In the precommitment approach, any penalty rate above p_3 will yield the same result as in case 1, but $p \in (p_0, p_3)$ must be avoided. Unfortunately, our approach may not be able to overcome this difficulty. When one of a pair of contracts deals with a penalty rate below p_3, the regulator's objective cannot be achieved, because H-type banks are

Chart 4

Minimum Cost Curve: Case 3



permitted to hold less capital. To achieve the normative capital requirement, two contracts must thus be offered with penalty rates above p_3. The regulator's objective can also be achieved by offering the single penalty rate as in the precommitment approach, under the condition that the regulator knows p_3, the penalty rate at which the two minimum cost curves intersect. Perhaps it would be simpler to rely on the single penalty rate above p_3—in which case incentive compatibility is automatically satisfied—rather than to design a menu of contracts that requires the regulator to ensure that incentive compatibility is satisfied.

4. Conclusion

In this paper, we developed a model from the perspective of mechanism design and demonstrated that, in some cases, the penalty also plays an important role in persuading riskier banks to hold more capital than less risky banks.

In the original precommitment approach framework, the regulator can allegedly discover a bank's riskiness by offering a unique penalty rate. Nonetheless, the appropriate level of capital for each bank depends on the bank's private information, such as the shape of its investment return's density function. Thus, it is not certain that riskier banks always choose to hold more capital than less risky banks.

We then developed a model of mechanism design in which the regulator offers a menu of contracts representing different levels of capital and the corresponding penalty rates. We found that the regulator can implement incentive-compatible contracts in which banks with one level of riskiness voluntarily separate themselves from banks with other levels of riskiness.

We examined three cases. In case 1, if the cumulative density for H-type banks is always greater than the cumulative density for L-type banks, then both the precommitment framework and our approach achieve the regulator's objective: The level of capital holding is equivalent to the amount specified by the first-order condition. In addition, the level of capital holding increases as the bank's riskiness goes up. In this case, it would probably be easier for the regulator to implement the original approach rather than to offer contracts with various penalty rates. In case 2, the cumulative density for H-type banks is greater than the cumulative density for L-type banks for small amounts of capital; the cumulative density is smaller for large amounts of capital. In this instance, our model may be able to achieve the regulator's objective. By contrast, in the precommitment approach, the penalty rate must fall within a particular range; otherwise, the regulator's objective is not completely fulfilled in that incentive compatibility is satisfied but the normative capital requirement is not achieved. In case 3, we examined an instance in which the cumulative density for H-type banks is smaller than the cumulative density for L-type banks for small amounts of capital, whereas cumulative density is greater for large amounts of capital. In case 3, neither approach achieves the regulator's objective as long as either one or two penalty rates take the value where the cumulative density for H-type is smaller. To avoid this, the penalty rate must be set in the range where the cumulative density for H-type is larger. Then, both the precommitment approach and our modification of this approach achieve the regulator's objective. In this instance, it would probably be easier, as in case 1, to implement the original approach.

We have demonstrated that both the precommitment approach and our approach have limitations that prevent them from achieving the optimal result as specified in the regulator's objective function. Here, the key element is how much information the regulator needs to assess banks' risk characteristics. In their recent paper, Kupiec and O'Brien (1997) also note the importance of information to regulators attempting to develop the incentive-compatible regulation. Future research must examine the amount of necessary information and the extent to which there may be a limit to the amount of pressure the regulator can place on banks to disclose their riskiness truthfully.

As we have observed, incentive-compatible contracts cannot be provided unless the regulator obtains certain information. In this sense, incentive-compatible regulation will not replace the traditional role of the regulator as an ex ante monitor of banks: The provision of incentive-compatible contracts and the monitoring by the regulator can be complementary. On a related matter, it has been proposed that the regulator's penalty be replaced by public disclosure. In other words, whenever a bank's actual loss exceeds its precommitted value, the regulator will inform the market of the fact. Such a proposal might be feasible if market participants have the necessary information to assess others' riskiness and if market participants can impose a penalty that satisfies incentive compatibility.

ENDNOTES

This is a revised version of the paper presented at the conference. The author thanks discussant Pat Parkinson and other participants in the conference, especially Jim O'Brien, for useful comments and criticisms. Any errors are the author's. The views expressed here are the author's and not necessarily those of the Bank of Japan.

1. Kupiec and O'Brien (1995) stress that since the regulator's objective is to let banks precommit levels of capital that satisfy the desired value-at-risk (VaR) capital coverage, it is incentive compatible as long as banks achieve the regulator's goal: Incentive compatibility is allegedly satisfied if they hold the amount of capital that is equivalent to the desired VaR capital requirement.

2. $F(-k)$ in equation 2 is the probability that losses exceed the level of capital, which represents the basis for a VaR capital requirement. In this interpretation of incentive compatibility, it does not matter whether banks with higher risk levels hold higher capital: As long as they hold the right amount of capital consistent with the desired VaR capital requirement, they are regarded as incentive compatible with the regulator's objective. We feel this interpretation is rather unique. Generally speaking, incentive compatibility may not be an instrument that ensures consistency with the principal's objective. There may be a case where a capital requirement is inconsistent with the principal's objective, which nevertheless does not satisfy incentive-compatibility constraints.

3. To be more precise, we take the riskiness of banks as exogenous. This may contradict what Kupiec and O'Brien maintain. The underlying idea of the precommitment approach claims that banks, after being offered a penalty rate, would either commit capital, adjust risk, or do both to satisfy the first-order condition. Here, the riskiness is taken as an endogenous strategy for the banks. Nonetheless, if we view both the risk adjustment and capital holding as endogenous variables, banks do not have any preference-ordering among the pairs of these variables as long as they satisfy the first-order condition. Then there may not be an incentive for banks to "separate." They can be pooled by choosing the same pair. Consequently, the regulator may not need to identify banks' characteristics.

4. To be fair, Kupiec and O'Brien's recent paper (1997) mentions that the regulator should collect information in order to assess banks' risk characteristics.

5. Kupiec and O'Brien are critical of such simplifying assumptions as first-order/second-order stochastic dominance.

6. These cases may not cover all the possibilities. As the bank portfolio becomes more complex, the shape of the distribution becomes more complex as well, and the cumulative densities for H-type and L-type banks may intersect repeatedly. Still, the fundamental idea developed in this section can be applied to more complex cases.

7. Note that the opposite case—in which the cumulative density for H-type is always smaller than the one for L-type—does not exist.

8. Note that we have implicitly assumed that all these events—from case 1 to case 3—take place in the feasible range for the level of capital holding.

9. We have neglected individual rationality constraints for H-type and L-type by simply assuming that the regulator will not offer contracts that exceed the reservation level of cost for both types.

10. This observation implies that the precommitment approach is a special case of our model, where $\rho^L = \rho^H$ (that is, the penalty rates offered to L-type and H-type banks are identical).

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