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How Can Leverage Regulations Work for the Stabilization of Financial Systems?

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HOW CAN LEVERAGE REGULATIONS WORK FOR THE STABILIZATION OF FINANCIAL SYSTEMS?[*]

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【ABSTRACT】

The purpose of this paper is to analyze the leverage ratio requirement as currently considered by the Basel Committee on Banking Supervision from both theoretical and empirical perspectives. The key concept in this paper is the *asset quality index*, which is obtained by dividing the risk-based capital ratio by the gearing ratio (i.e., the inverse of the leverage ratio). Using this concept in the microeconomic framework, we can describe the behavior of banks as an optimal choice of a gearing ratio and an asset quality index. We derive theoretical implications from this model and compare them with the data on the G10 and Asian commercial banks. In so doing, we find that the leverage ratio requirement has a number of side effects, if introduced as a uniform international rule. In light of the theoretical and empirical results thus obtained, we discuss desirable uses of leverage ratios from the perspective of maintaining the stability of financial systems.

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【Non-Technical Summary】

In this paper, we analyze the leverage ratio requirement as currently considered by the Basel Committee on Banking Supervision (the Basel Committee) from both theoretical and empirical perspectives. The focus is on the side effects that may arise if the leverage ratio requirement is introduced in addition to the current risk-based capital requirement. We also discuss desirable uses of leverage ratios from the perspective of maintaining the stability of financial systems. The main results of our discussion are summarized as follows.

(1) Results of Theoretical Analysis

- The key concept in this paper is the *asset quality index*, which is obtained by dividing the risk-based capital ratio by the gearing ratio (i.e., the inverse of the leverage ratio). The name comes from the fact that this index has the averaged risk-weights of assets in its denominator. Using this index in the microeconomic framework, we can describe the behavior of banks as an optimal choice of a gearing ratio and an asset quality index.

$$\text{Risk-based capital ratio} = \frac{\text{total capital}}{\text{risk assets}}.$$

$$\text{Gearing ratio} = \frac{\text{Tier 1 capital}}{\text{total assets}}.$$

$$\text{Asset quality index} = \frac{\text{total capital/Tier 1 capital}}{\text{weighted average of risk - weights}}.$$

Note: The total capital is the sum of Tier 1, Tier 2, and Tier 3 capital.

- When the risk-weight assigned to a certain asset has been underestimated, a bank can "improve" an asset quality index and at the same time increase a leverage ratio by changing its asset portfolio. Clearly, this "improvement" is superficial and not matched by any real improvement in the quality of bank assets. Before the onset of the financial crisis, many banks engaged in this type of *regulation arbitrage* by using trading accounts and increased leverage to a variety of degrees.

- To eliminate this regulation arbitrage, the Basel Committee has announced that it will increase the risk-weights assigned to trading accounts. This measure is expected to close one of the *regulatory loopholes* that have already been identified.

Regulation arbitrage, however, may reappear under different guises. To resolve this problem, the Basel Committee plans the introduction of leverage regulations that are designed to directly restrict the level of leverage.

- We should note, however, that the leverage ratio requirement has a number of *side effects*. First, while the leverage ratio requirement reduces bank leverage effectively, it deteriorates the quality of bank assets simultaneously. The reason is that banks will react to the leverage ratio requirement by shifting their asset portfolio from safer assets to riskier assets in order to maximize their expected utility. This risk-taking behavior will undermine the soundness of bank management eventually.

- The second *side effect* is that the leverage ratio requirement narrows the scope of banking business and introduces inefficiencies in asset portfolio management. The model implies that gearing ratios and asset quality indices may vary from country to country, depending on financial environment and business models. The leverage ratio requirement will be restrictive particularly to those banks characterized by low gearing ratios and high asset quality and have significant detrimental effects on the efficiency of their asset portfolio management.

(2) Results of Empirical Analysis

- We analyze gearing ratios and asset quality indices of the leading commercial banks of the G10 countries and find that there is a significant variation in their levels. In Germany, asset quality indices are high, while gearing ratios are low. In the United States, the opposite holds: gearing ratios are high, while asset quality indices are low. In Switzerland, there is a notable variation among banks.

- In the United States, leverage regulations have already been in place. This explains why the U.S. banks have high gearing ratios. Clearly, the leverage ratio requirement will have no notable impacts on the U.S. banks, unless it is sufficiently strong. Such a strong requirement would, however, unavoidably have serious negative impacts on the banks in other countries that maintained relatively stable business conditions even during the crisis.

- The Asian banks, excluding the Japanese, resemble their U.S. counterparts in that they have high gearing ratios and low asset quality indices. They differ significantly from their U.S. counterparts, however, in that they maintained relatively stable business conditions even during the crisis. This hints at the fact that a gearing ratio, if calculated only from on-balance-sheet items, is far from a perfect indicator for the soundness of bank management. This suggests that off-balance-sheet items should be included in the computation of gearing ratios.

- The behavior of banks increasing leverage ratios while superficially "improving" asset quality indices can be decomposed into *trend* and *cyclical* components. We use the trend components to identify the regulation arbitrage. A sharp increase in leverage ratios often indicates that risk-management measures lag behind innovation in regulation arbitrage. Thus, the trend components are useful in detecting the signs of financial instability. Among the G10 countries, trend components were the largest for the U.K. banks. One of the Swiss banks also has huge trend components. The Japanese banks registered the lowest trend components among the G10 countries.

(3) Using Leverage Ratios in Maintaining the Stability of Financial Systems

- In light of the preceding analysis, we examine how leverage ratios should be used in maintaining the stability of financial systems. The main points of our discussion are summarized as follows.

(i) Extreme increases in leverage due to regulation arbitrage pose serious problems. At the same time, however, we should pay close attention to the deterioration in bank asset quality, which may arise from the introduction of the leverage ratio requirement.

(ii) Given the significant differences in financial environment and business models, the adoption of uniform international standards regulating leverage levels will result in the inefficiency of asset portfolio management. One of the feasible leverage regulations is such that individual countries set their own minimum requirements, taking their local conditions into account.

(iii) Changes in the risk-taking behavior of banks have conspicuous impacts on changes in leverage. Therefore, supervisory effectiveness will be enhanced by focusing on *changes* in leverage rather than on the *level* of leverage.

(iv) It is essential that both on-balance-sheet and off-balance-sheet items be included in the computation of leverage ratios. To accomplish this, we must examine extensively what off-balance-sheet items are to be included and in what form.

1. INTRODUCTION

The recent financial crisis prompted the Basel Committee on Banking Supervision (the Basel Committee) to engage in a comprehensive reform of financial regulations, centered on a revision of its risk-based capital requirement. As part of these discussions, attention has been given to the use of leverage ratios as a supplementary measure. Specific proposals are being studied in the direction of imposing a ceiling on the level of leverage.[1]

The risk-based capital requirement not only failed to suppress risk-taking behavior of banks, but it also allowed them to engage in *regulation arbitrage*. Here regulation arbitrage refers to the bank behavior of compiling illiquid assets in trading accounts to which low risk-weights were assigned, while increasing their leverage simultaneously.[2] The leverage ratio requirement is proposed in response to this criticism and is expected to *directly* control excessive leverage, which contributed to the recent crisis. The side effects of the leverage ratio requirement, however, have not yet been examined extensively. Furthermore, no full investigation has been conducted into the feasibility of adopting uniform international numerical standards for leverage ratios.

The purpose of this paper is to analyze leverage regulations from both theoretical and empirical perspectives. We start with a simple theoretical model and use it to examine the impacts of the introduction of the leverage ratio requirement on the asset portfolio management by banks. Next, we use data on a risk-based capital ratio of commercial banks of leading countries and decompose it into a gearing ratio

[1] In December 2009, the Basel Committee released for consultation two packages of proposals regarding the strengthening of capital adequacy and liquidity regulations. Leverage regulations are considered in Basel Committee on Banking Supervision (2009a), while Basel Committee on Banking Supervision (2009b) is dedicated to the proposals on liquidity regulations.

[2] Various types of *regulation arbitrage* are said to have figured in the recent financial crisis, one of which took place through the use of trading accounts. To prevent such arbitrage, the Basel Committee decided to raise the risk-weights assigned to trading accounts. This change is scheduled to go into effect at the end of 2010 (at the end of March 2011 for Japanese commercial banks) together with revisions in capital requirements for re-securitized products and the treatment of counterparty credit risks. These changes will be adopted ahead of other regulatory revisions being considered.

(i.e., the inverse of a leverage ratio) and an *asset quality index*. The latter is an indicator of the quality of bank assets, since it has *averaged risk-weights* in its denominator. In this paper, we examine the distribution and changes in gearing ratios and asset quality indices to characterize the behavior of the world's leading commercial banks since the second half of the 1990s.

The remainder of this paper is organized as follows. Section 2 presents a theoretical model for analyzing asset portfolio management by banks, based on a gearing ratio and an asset quality index. This model is used to theoretically examine the consequences of the introduction of the leverage ratio requirement. In Section 3, we use data on leading commercial banks of the G10 countries and five Asian economies since the second half of the 1990s in order to obtain their gearing ratios and asset quality indices. We use these results to investigate how the world's leading commercial banks have responded to the risk-based capital requirement. We also discuss to what extent the world's leading commercial banks are affected by the introduction of the leverage ratio requirement. In Section 4, we summarize the main results of our analysis and conclude by discussing how leverage ratios can be used in maintaining the stability of financial systems.

2. THEORETICAL MODEL

(1) The *Asset Quality Index*

The risk-based capital ratio has in its denominator the risk-based assets (i.e., the sum of assets, each weighted with a corresponding *risk-weight*). The numerator consists of common stock and other Tier 1 capital, while subordinated bonds and other Tier 2 and Tier 3 capital can also be included in the numerator up to an allowable amount. Meanwhile, the simple capital ratio obtained by dividing Tier 1 capital by total assets is referred to as a *gearing ratio*.

This paper defines the *asset quality index* as the value obtained by dividing the risk-based capital ratio by the gearing ratio. Letting γ denote a gearing ratio and ϕ an asset quality index, we decompose a risk-based capital ratio ($\overline{\beta}$) as follows.

$$\overline{\beta} \equiv \phi \cdot \gamma \quad \Leftrightarrow \quad \phi \equiv \frac{\overline{\beta}}{\gamma}. \tag{2-1}$$

In the empirical analysis below, we compute the asset quality index by substituting the risk-based capital ratio and the gearing ratio into the second representation of equation (2-1).[3]

We use a two-asset model to examine the properties of an asset quality index. Denote holdings of asset i by A_i ($i = 1,2$), total assets by A ($= A_1 + A_2$), the investment share of asset i by s_i ($\equiv A_i / A$), Tier 1 capital by C, and total capital (the sum of Tiers 1 to 3 capital) by C'. Then we have

$$\frac{C'}{A_1\omega_1 + A_2\omega_2} \equiv \phi \frac{C}{A}. \tag{2-2}$$

The left-hand side describes the risk-based capital ratio, where ω_i denotes the risk-weight assigned to asset i, while the gearing ratio is represented by C/A on the right-hand side of the equation.

Next, we assume that $C' = \delta C$ ($\delta \geq 1$). In other words, δ represents the ratio of total capital to Tier 1 capital. Because commercial banks are subject to a regulatory requirement whereby Tier 1 capital must account for no less than one half of total capital, there is relatively little room for a change in δ. For this reason, in the analysis below we assume that banks take δ as an exogenous variable.

We can derive the asset quality index from equation (2-2) as follows.

$$\phi = \frac{\delta}{s_1\omega_1 + s_2\omega_2}. \tag{2-3}$$

The denominator is the averaged risk-weights of bank assets. Therefore, the asset quality index increases, when low-risk assets increase, i.e., when the *quality of assets* improves.

The asset quality index is not a perfect indicator of the quality of bank assets. The numerator of equation (2-3) represents the *ratio of total capital to Tier 1 capital*. Thus, the asset quality index increases, when the Tier 1 share in total capital declines, i.e., when the *quality of capital* declines. In other words, the asset quality index is distorted by the capital structure. Nonetheless, we can say safely that the asset quality index indicates the quality of bank assets quite closely, since there is little room for a change in δ, as mentioned above.

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[3] A similar measure of the quality of bank assets was previously proposed by Van Roy (2008).

(2) Utility Function of Banks

In this paper, we employ the framework of microeconomics to conduct a theoretical investigation into asset portfolio management by banks. We describe banks as optimizing their expected utility under the twin constraints of the risk-based capital requirement and the leverage ratio requirement.

We assume that the utility function of a bank is given by the following quadratic function of return on equity (*r*).[4]

$$U = r - \theta \cdot r^2 . \tag{2-4}$$

Then the expected utility of a bank can be expressed in terms of the *mean* and *standard deviation* of return on equity, which are denoted by μ and σ, respectively. That is,

$$E(U) = \mu - \theta(\mu^2 + \sigma^2) , \tag{2-5}$$

where θ represents the parameter that characterizes the utility function of a bank. The implication of equation (2-5) can be easily seen, when it is rearranged as follows.

$$E(U) = -\theta\left\{\left(\mu - \frac{1}{2\theta}\right)^2 + \sigma^2 - \frac{1}{4\theta^2}\right\} . \tag{2-6}$$

Let us consider a two-dimensional plain, where the horizontal and vertical axes measure σ and μ, respectively. Equation (2-6) indicates that an indifference curve of a bank takes the shape of a circle, the center of which is located on the vertical axis. The parameter θ in the above equation represents the height of the center of the circle and thus determines the height of the indifference curve.

Letting r_i denote the rate of return on asset i, we can express return on equity as follows.

$$r \equiv \frac{A_1 r_1 + A_2 r_2}{C} = \frac{A(s_1 r_1 + s_2 r_2)}{C} = \ell(s_1 r_1 + s_2 r_2) , \tag{2-7}$$

[4] This utility function is one of the standard functions, as used in Tobin (1998). When θ takes a small positive value, marginal utility is positive within the normal range of r . Specifically, marginal utility is positive when $r < 0.5/\theta$. Furthermore, marginal utility diminishes when θ takes a positive value.

where $\ell\,(\equiv A/C)$ represents the leverage ratio. Denote the expected rate of return on asset i by μ_i, the standard deviation of the rate of return on asset i by σ_i, and the correlation coefficient of the rates of return on the two assets by ψ. Then we can express the average and standard deviation of return on equity as follows.

$$\mu = \ell(s_1\mu_1 + s_2\mu_2), \tag{2-8}$$

$$\sigma = \ell\sqrt{\sigma_1^2 s_1^2 + 2\psi\sigma_1\sigma_2 s_1 s_2 + \sigma_2^2 s_2^2}\,. \tag{2-9}$$

We combine the above relationships to show that the expected utility of a bank is a function of γ and ϕ. Substitute the equality $s_2 = 1 - s_1$ and equations (2-8) and (2-9) into equation (2-5). Then the expected utility of a bank becomes a function of only ℓ and s_1. It is easily seen that ℓ and s_1 are both functions of γ and ϕ. That is,

$$\ell \equiv \frac{1}{\gamma};\ s_1 = \frac{\omega_2 - \dfrac{\delta}{\phi}}{\omega_2 - \omega_1}. \tag{2-10}$$

The second equation is derived by rearranging equation (2-3) and using $s_2 = 1 - s_1$. Utilizing the relationships in (2-10), we find the expected utility of a bank to be a function of γ and ϕ.[5]

Below, the expected utility of a bank is expressed as $U^e(\gamma,\phi)$. This function enables us to draw indifference curves on the γ-ϕ plain. Chart 1 is a schematic diagram of the indifference curves, where the horizontal and vertical axes represent the gearing ratio (γ) and asset quality index (ϕ), respectively. The indifference curves can be drawn as contours around the bliss point H. If there were no regulations, banks would opt for this point.

(3) Behavior of Banks under the Risk-Based Capital Requirement

In the presence of regulations, there is no guarantee that banks can opt for the bliss point *H*. To begin with, we consider the effects of the current risk-based capital requirement. Here, we assume that banks target a specific level of the risk-based

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[5] The expected utility function of a bank is a function of γ and ϕ, even when there are three or more assets. To show this, we maximize the expected utility with regard to s_i under the constraint of $\delta/\phi = \Sigma_i \omega_i s_i$ ($\Sigma_i s_i = 1$) with each of γ and ϕ fixed at some discretionary level. Then, s_i becomes a function of γ and ϕ. Using this result, we see that the expected utility of a bank can be expressed as a function of γ and ϕ.

capital ratio, which is denoted by $\overline{\beta}$ below. Then the current risk-based capital requirement is interpreted as the enforcement of a minimum level on this target ratio. We also assume that banks hold some extra capital to prepare for an accidental dip of the risk-based capital ratio. This assumption implies that the target ratio exceeds the minimum requirement of 8 percent by this *safety margin* (i.e., $\overline{\beta} \geq 0.08$). Therefore, under the current risk-based capital requirement, banks solve the following constrained optimization problem.[6]

$$\max_{\gamma,\phi} U^e(\gamma,\phi) \text{ s.t. } \overline{\beta} \leq \gamma \cdot \phi . \tag{2-11}$$

Chart 2 represents the optimizing behavior of a bank under the current risk-based capital requirement diagrammatically. Curve MM is a rectangular hyperbola defined by $\overline{\beta} = \phi \cdot \gamma$. Under this regulatory regime, a bank must opt for a point either on the MM curve or to the right of and above the curve (the shadowed portion in the chart). To maximize its expected utility, a bank opts for the point of tangency between its indifference curve and the MM curve. In the chart, the optimal point is given by point E_0, the point of tangency between the indifference curve $I_0 I_0$ and the MM curve.[7]

The optimal point of a bank depends on various parameters: expected rates of return on assets, their volatility, and so on. Among them are the risk-weights applied in the calculation of the risk-based capital ratio. This is an important observation, when we consider the causes of the recent financial crisis. It is well known that a number of banks enlarged leverage by exploiting the underestimated risk-weights assigned to securitized products held in trading accounts.

Our model can treat this case as follows. That is, some portion of assets that should have been counted as *high risk-weight assets* (asset 2) was actually counted as *low risk-weight assets* (asset 1). Given that $\omega_1 < \omega_2 = 1$, let τ denote the portion of total

[6] More formally, it should be assumed that the selection of $\overline{\beta}$ (i.e., the selection of the safety margin) is made simultaneously to the determination of γ and ϕ. To simply the model, however, we assume that $\overline{\beta}$ is determined independently of γ and ϕ.

[7] While the constraint curve is convex toward the point of origin, the indifference curve is not necessarily concave toward the point of origin. Therefore, the determination of the optimal point must be done carefully, for instance, by using graphs and other means.

assets that has been transposed from asset 1 to asset 2. Then, the asset quality index is rewritten as follows.

$$\phi = \frac{\delta}{s_1\omega_1 + s_2\omega_2 + \tau(\omega_1 - \omega_2)} \quad \Leftrightarrow \quad s_1 = \frac{\omega_2 - \dfrac{\delta}{\phi}}{\omega_2 - \omega_1} - \tau \ . \tag{2-12}$$

Rows 1 to 3 of Chart 3 show how bank behavior is affected by the values of τ . We observe a definite increase in leverage, as τ rises from 0 percent to 10 percent. As the risk-weights of certain assets are lowered, the asset quality index undergoes superficial "improvement." This relaxes the constraint imposed by the risk-based capital requirement and allows banks to increase their leverage.[8]

The level of leverage is also affected by other factors, such as cost of capital, risk-return structures of assets, and other features of financial environment. These factors are often specific to individual countries. In an economy where cost of capital is high, banks tend to aim at a high rate of return. In this case, θ takes a small value. Rows 4 to 6 of Chart 3 show how bank behavior is affected by the values of θ. The chart shows that leverage increases as the value of θ declines. The level of leverage also depends on other parameters, such as the expected rates of return on assets, the standard deviation of the rates of return on assets, and the correlation coefficient of the rates of return of the two assets. As expected, there is a general tendency for leverage to increase along with declines in the risk-weights of assets and decreases in the minimum capital requirement. These examples indicate that the level of leverage is affected by the financial environment and business models of the banks as well as by the shape of utility functions.

(4) Introduction of the Leverage Ratio Requirement

The Basel Committee has announced changes in the risk-weights assigned to trading accounts to encounter the related regulation arbitrage. We expect this measure to

[8] A huge expansion in trading accounts may result in a reduction in leverage. For instance, in Chart 3, leverage declines, as τ rises from 10 percent to 20 percent. This emerges as follows. As τ climbs, $s_2\ (=1-s_1)$ rises, and thus high-risk high-return assets increase in the account of a bank. When high-risk assets increase beyond a certain amount, the bank opts for a lower level of leverage regardless of regulations. In this case, the constraints imposed by the risk-based capital requirement are no longer binding so that the bank will opt for the bliss point H in Chart 1. As shown here, a monotonic relation does not necessarily exist between an expansion in trading accounts and increased leverage.

close one of the *regulatory loopholes* effectively. Regulation arbitrage, however, may reappear under different guises. To avoid the recurrence of similar problems of regulation arbitrage, the leverage ratio requirement is designed to directly restrict the level of leverage. As discussed below, however, we should bear in mind that the leverage ratio requirement has a number of *side effects*.

Under the two forms of regulations—the risk-based capital requirement and the leverage ratio requirement—banks solve the following optimization problem that is subject to two constraints.

$$\max_{\gamma,\phi} U^e(\gamma,\phi) \text{ s.t. } \bar{\beta} \le \gamma \cdot \phi \text{ and } \bar{\gamma} \le \gamma . \tag{2-13}$$

The second constraint represents the leverage ratio requirement, which specifies a minimum level for a gearing ratio. As shown diagrammatically below, it is unlikely for the second constraint to become binding by itself. Therefore, two possibilities arise concerning the optimal choice of a bank. The first is such that at the optimum only the first constraint is satisfied with equality; the second possibility is that an optimum point is located at the intersection of the two boundaries of the constraints, i.e., at $(\bar{\gamma}, \bar{\beta}/\bar{\gamma})$.

Chart 4 describes this situation in a diagram. To satisfy the risk-based capital requirement, a bank must opt for a point that lies on the MM curve or to the right of and above the curve. Additionally, in order to satisfy the leverage ratio requirement, a bank must opt for a point that lies on the straight line GG or to the right of the line, which is perpendicular to the horizontal axis. Therefore, if simultaneously subject to both the requirements, a bank would have to opt for a point located within the shadowed area of the diagram. In the typical case, the indifference curve would shift from I_0I_0 to I_1I_1, making it highly probable that a bank would opt for point E_1, the intersection of the MM curve and the straight line GG.[9]

The implications of our model are clear. The leverage ratio requirement has two main *side effects*. First, while the leverage ratio requirement reduces leverage effectively, it deteriorates the quality of bank assets simultaneously. In doing so, a

[9] The introduction of leverage regulations is likely to change bank behavior and thereby may cause changes in the mean and volatility of return on assets. Notwithstanding, the conclusion is still untouched that banks are highly likely to opt for point E_1.

bank reacts to the leverage ratio requirement by shifting its asset portfolio from safer to riskier assets in order to maximize its expected utility. This type of risk-taking behavior will undermine the soundness of bank management eventually. Second, the leverage ratio requirement narrows the scope of banking business and introduces inefficiency in asset portfolio management. Gearing ratios and asset quality indices vary widely from country to country, depending on the financial environment and business models. The leverage ratio requirement has particularly strong and restrictive impacts on those banks that are characterized by a low gearing ratio and a high asset quality index. These impacts will have significant detrimental effects on the efficiency of asset portfolio management.

To prevent asset quality from deteriorating, it would be an effective way to raise the level of the risk-based capital requirement. As previously explained, the intersection of the boundaries of the two requirements provides a benchmark to predict the behavior of banks. Let us consider the following question: How should the two requirements be combined to prompt banks to opt for an asset quality index of three times and a gearing ratio of 4 percent? First of all, note that these targets can be restated as $\bar{\gamma} = 4$ and $\bar{\beta} = 12$. Next, we need to take into account a safety margin that banks provide to avoid dipping below a regulatory level due to unforeseen events. Because the United States has already introduced a similar leverage regulation, the U.S. data can provide an idea of how large this safety margin is.[10] As seen in the empirical analysis below, the safety margin amounts to about 2 percent. The safety margin for the risk-based capital requirement is also about 2 percent.[11] Therefore, the following combination of two regulations gives us a desired solution: a

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[10] Under the U.S. leverage regulations, "strong" banks are required to maintain a minimum Tier 1 capital to total asset ratio of 3 percent, while other banks are required to maintain a ratio of no less than 4 percent. The Swiss authority applied to a few banks the following requirements, which came into effect at the end of 2008: minimum consolidated and non-consolidated Tier 1 capital to (total asset ratio – outstanding domestic lending) ratios of 3 percent and 4 percent, respectively. The Canadian authority has also introduced a new regulation system similar to leverage regulations.

[11] Theoretically, the optimal safety margin for a risk-based capital ratio would be expected to be larger than that for a gearing ratio. This is because the greater complexity of a risk-based capital ratio gives rise to greater uncertainty. In practice, however, the U.S. data indicate that safety margins for the two ratios are roughly equivalent.

minimum of 10 percent for the risk-based capital requirement and a minimum of 2 percent for the leverage ratio requirement as expressed in terms of a gearing ratio. Needless to say, however, such an increase in the capital requirements would undermine the efficiency of asset portfolio management by banks.

3. Empirical Analysis

(1) International Comparison

In this section, we empirically examine the leverage ratios and asset quality indices chosen by commercial banks since the mid-1990s. The analysis targets the top five commercial banks (measured in terms of total value of Tier 1 capital as of the end of fiscal 2006) of each of the G10 countries and five Asian economies.[12] The sample period covers the 1997–2008 fiscal years. It should be noted that some portions of data are missing for a number of banks. We exclude those banks for which large portions of data are missing from the sample.[13]

In Chart 5, equation (2-1) was used to decompose a risk-based capital ratio of G10 commercial banks into a gearing ratio and an asset quality index. The solid and dotted lines appearing in the graphs represent the combinations of a gearing ratio and an asset quality index necessary for achieving risk-based capital ratios of 8 percent and 12 percent, respectively. In the case of the G10 countries, a relatively large number of banks are seen congregating around a gearing ratio of 4 percent and an asset quality index of three times. Hence, this combination can be viewed as the average pattern of G10 commercial banks.

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[12] The G10 comprises the 10 countries (i.e., Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom, and the United States) plus Switzerland, which changed from an associate member to a full member in 1984. Notwithstanding the increase in membership, the group continues to be called the "G10." The five Asian economies refer to China, Hong Kong, South Korea, Taiwan, and Thailand.

[13] The data were collected from various issues of *The Banker* (Financial Times Business Limited). In cases where a large-scale merger was expected to influence the continuity of data, the authors calculated a gearing ratio and an asset quality index for the merged banks, aggregating their individual gearing ratios and asset quality indices with their total assets used as weights.

It is also true, however, that there are considerable variations among the countries. The three particular examples are Germany, the United States, and Switzerland. In the German case, high asset quality indices are combined with low gearing ratios. The opposite holds in the United States, where gearing ratios are high and asset quality indices are low. Switzerland is characterized by a wide variation among banks.

Let us conduct a thought experiment where a minimum gearing ratio of 2 percent is required in addition to the current risk-based capital requirement. As mentioned in Section 2, we assume that banks have a safety margin of 2 percent to cope with unexpected fluctuations in their gearing ratios. Thus, effective leverage regulations would require a gearing ratio of 4 percent, that is, the sum of a nominal requirement of 2 percent and a safety margin of 2 percent. Judging from Chart 5, we find that this leverage ratio requirement would be binding for many of the G10 countries. In particular, activities of most German banks would be seriously restricted by this requirement. Swiss and Japanese banks would also be significantly impacted.

In contrast, the same leverage ratio requirement would not be binding for the U.S. commercial banks. This is because the United States has already introduced stricter leverage regulations than what is assumed here. This leads us to the following conclusion immediately: in order to restrict the activities of U.S. commercial banks that committed obvious management errors in the process leading to the recent crisis, we must introduce regulations which are significantly stricter than the current U.S. standards. These leverage regulations would have serious negative impacts on commercial banks of other countries, even though they maintained relatively stable business conditions even during the crisis.

Chart 6 summarizes the results for Asian economies other than Japan. Here again, a risk-based capital ratio is decomposed into a gearing ratio and an asset quality index. In comparison to the benchmark combination, that is, a gearing ratio of 4 percent and an asset quality index of three times, all of the Asian economies in this study can be characterized by low asset quality indices and high gearing ratios. In terms of these measures, Asian commercial banks are categorized into the same group as their U.S. counterparts. Nonetheless, this does not imply that U.S. and Asian commercial banks retain similar levels of soundness of bank management. On the contrary, it is believed that during the recent crisis Asian commercial banks succeeded in maintaining a higher degree of stability than their U.S. counterparts.[14] A natural interpretation of the above-mentioned similarity between the U.S. and Asian commercial banks is that a gearing ratio is far from a perfect measure of the soundness or resiliency of bank management in the face of external shocks.

In discussing differences between the financial systems of Asia and those of the United States and Europe, a critical issue is how deeply the U.S. and European commercial banks engaged in dealing with complex financial products. For instance, it is well known that the major U.S. commercial banks took huge risks by investing aggressively in securitized products through structured investment vehicles (SIVs), for which they promised to provide huge supplementary liquidity. In contrast, with a fresh memory of the Asian currency crisis during 1997–1998, Asian commercial banks and supervisory authorities remained cautious on taking risks, and took a particularly conservative stance toward investing in securitized products and other complex financial instruments. These observations suggest to us that the design of a leverage ratio requirement should cover off-balance-sheet items as well as on-balance-sheet items.[15]

It is far from simple, however, to design leverage regulations by taking into account off-balance-sheet transactions. In Appendix A, we examine the size of off-balance-sheet transactions of the Japanese and U.S. banks and calculate leverage ratios that reflect both off-balance-sheet and on-balance-sheet items. Note that data on off-balance-sheet transactions are scarcely available. Thus, this exercise is based on

[14] The stability of Asian commercial banks relative to their U.S. and European counterparts may be inferred from the quick recovery in financial sector stock prices and the low and stable ratio of nonperforming loans.

[15] Basel Committee on Banking Supervision (2009a) also devotes attention to the introduction of leverage regulations that take off-balance-sheet items into consideration. The Canadian experience with leverage regulations provides a reference on the usefulness of off-balance-sheet items. In 1982, Canada introduced leverage regulations that included certain off-balance-sheet items in assets as well as on-balance-sheet items. Bordeleau, Crawford, and Graham (2009) point out that Canada's leverage regulations were effective in stabilizing the leverage ratio which included off-balance-sheet items. It should be noted that Canadian commercial banks had no need of government capital injection during the recent crisis (as of the end of 2009).

those data that are disclosed for the purpose of computing the risk-based capital ratios. Analyzing the results, we find that the gearing ratio of the U.S. commercial banks is only slightly lower than that of the Japanese banks. This result is not sufficiently eloquent to explain the relative stability of Japanese commercial banks in the recent crises, even when off-balance-sheet transactions are included. A number of factors may contribute to the result: the limited coverage of off-balance-sheet transactions included in the computation of the risk-based capital ratios, the suitability of the *credit conversion factors* used in converting off-balance-sheet transactions into amounts equivalent to lending, and so on. These factors must be examined widely and closely in order to calculate a gearing ratio that properly and accurately reflects the soundness of management of commercial banks.

(2) Time-Series Analysis

There is a wide consensus about the increased leverage in the recent crisis being caused by the unfairly low risk-weight assigned to trading accounts. In the preceding section, we provided the numerical examples to justify this argument. As shown there, the regulation arbitrage by banks is expected to manifest itself through a combination of an increasing leverage ratio and an improving asset quality index. In the remainder of this section, we combine this theoretical proposition with actual data to show that the regulation arbitrage by banks was a phenomenon observable all over the world before the onset of the recent financial crisis.

A time-series perspective is quite important in dealing with this problem. As explained in the preceding section, the level of leverage ratios and the quality of bank assets vary across countries, reflecting each country's financial environment and systems. Hence, even if its leverage ratio is high, we cannot conclude immediately that the bank runs an unsound business. In contrast, a sharp increase in leverage often indicates that risk-management measures lag behind innovation in regulation arbitrage. Therefore, we can detect the signs of financial instability by observing movements in leverage ratios from a time-series perspective.

In Charts 7 to 22, we trace the movements of a gearing ratio and an asset quality index for individual banks since fiscal 1997. In each graph, the two numbers indicate the starting and ending year of the sample. The empty squares indicate years for which data were missing and thus linearly interpolated.

Charts 15 and 16 cover British and Swiss commercial banks, respectively. During fiscal 1997–2008, many British commercial banks and one of the Swiss commercial banks enlarged their leverage ratios (lowered their gearing ratios) aggressively. To maintain risk-base capital ratios, these banks increased an asset quality index. Yet, these "improvements" in the asset quality index turned out to be superficial. Furthermore, we find more or less similar patterns of bank behavior in other countries. This shows that the regulation arbitrage was a worldwide phenomenon.[16]

Here, we introduce a quantitative method of analyzing movements in a gearing ratio and an asset quality index. Chart 23 shows that bank behavior can be decomposed into the following two basic patterns. The first is represented by unit vector *p*, which is tangent to a rectangular hyperbola. In this pattern, a gearing ratio and an asset quality index substitute for each other, while the risk-based capital ratio remains constant. The second pattern is denoted by unit vector *q*, which is perpendicular to vector *p* and describes the most efficient path for raising the risk-based capital ratio.

The above argument can be summarized in a matrix form as follows. Let v denote a change in a gearing ratio and an asset quality index of banks that takes place between fiscal year $t-1$ and t. Suppose that v stands for a and b units of movement along vectors p and q, respectively. Then the following relationship holds.

$$v_t = a_t \cdot p_{t-1} + b_t \cdot q_{t-1}, \tag{3-1}$$

where

$$p_t \equiv \frac{1}{\Delta_t}\begin{pmatrix} -\gamma_t \\ \phi_t \end{pmatrix},\ q_t \equiv \frac{1}{\Delta_t}\begin{pmatrix} \phi_t \\ \gamma_t \end{pmatrix},\ \Delta_t \equiv \sqrt{\gamma_t^2 + \phi_t^2}\ . \tag{3-2}$$

Solving for a and b yields the following equation.

---

[16] In some countries, no signs of regulation arbitrage are observed. For instance, Chart 22 shows that top commercial banks in Thailand improved their gearing ratios and the quality of assets simultaneously before the financial crisis.

$$\begin{pmatrix} a_t \\ b_t \end{pmatrix} = \frac{1}{\Delta_{t-1}} \begin{pmatrix} -\gamma_{t-1} & \phi_{t-1} \\ \phi_{t-1} & \gamma_{t-1} \end{pmatrix} v_t . \tag{3-3}$$

In this paper, we are interested in the time-series properties of a thus obtained and especially in the average value of a. As discussed in the preceding section, the unfairly low risk-weights assigned to trading accounts enabled commercial banks to improve the asset quality index superficially and thereby to increase leverage ratios before the financial crisis. We think this regulation arbitrage affected the trend behavior of banks, which is captured in the values of a averaged over time.[17] Chart 24 (1) presents the average value of a for individual countries. The countries appear in descending order. Among the G10 countries, the United Kingdom shows the largest degree of regulation arbitrage, while Japan registers the lowest value.[18]

Let us define the cumulative values of a over time (a^{cum}) as follows.

$$a_t^{cum} = \sum_{i=1998}^{t} a_i , \tag{3-4}$$

Then the regulation arbitrage is reflected in the *trend* component of a^{cum}. Chart 25 presents the time series of a^{cum} for individual banks. Note the rapid increase in the thick solid line in Chart 25 (9). This shows clearly that one of the Swiss leading banks engaged in considerable regulation arbitrage during fiscal 1997–2008. Similarly, Chart 25 (10) indicates the possibility that the British leading banks all engaged in regulation arbitrage, although at a lower level than the Swiss bank.

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[17] As explained in the preceding section, regulation arbitrage is one of many factors affecting trends in bank behavior. Therefore, it should be noted that the results of this analysis are only approximations.

[18] The standard deviation of a indicates a cyclical behavior of banks. Among the G10 countries, Switzerland registers the largest *cyclical* components, followed by Japan. It has been argued that *pro-cyclicality of regulations* contributes to economic cycles (e.g., Kashyap and Stein [2004]). In the framework of Basel II, during periods of economic boom, the amount of risk, for example, credit risk, declines as the probability of business failure recedes. As a result, the quality of bank assets improves; and thus banks are able to take advantage of this improvement to increase leverage, which provides a further stimulus to economic activities. The opposite mechanism operates during periods of recession. This pro-cyclicality provides a rationale for *capital buffers*, whereby capital is built up during booms and drawn down during recession. In this context, it is extremely interesting to examine whether pro-cyclicality of regulations is actually observable. This question, however, goes beyond the scope of the present paper and must await future empirical research.

4. CONCLUDING REMARKS

In this paper, we analyzed the leverage ratio requirement as is currently considered by the Basel Committee from both theoretical and empirical perspectives. In this concluding section, we summarize the main results of our analysis and discuss how leverage ratios can be used in maintaining the stability of financial systems.

Our theoretical analysis shows that leverage regulations have two side effects. First, the introduction of leverage regulations restricts the scope of banking business, thereby undermining the efficiency in asset portfolio management. Second, in return for high leverage ratios, leverage regulations often result in deterioration in the quality of bank assets. An extremely high leverage, if induced by regulation arbitrage, certainly poses serious problems for the stability of financial systems. At the same time, however, we should pay close attention to the associated inefficiency in asset portfolio management and the deterioration in the quality of bank assets.

In Section 2, we explained how we could stop the quality of assets from deteriorating by raising the risk-based capital requirement. An alternative method to gain a similar effect is simply to introduce a minimum requirement for the asset quality index. We discuss this method in Appendix B. We also introduce there a general method of regulating extreme drops in both gearing ratios and asset quality indices.

The levels of leverage vary widely from one country to another, depending on differences in financial environment and business models. If we ignore these differences and introduce uniform international standards for leverage ratios, banks suffer from serious inefficiencies in asset portfolio management.[19] Therefore, when leverage regulations are introduced, it seems more feasible that individual countries set their own minimum leverage ratios, taking local conditions into account.

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[19] Bank of England (2009) undertakes an international comparative analysis similar to that of the present paper. While stating that it is desirable to adopt uniform international standards for regulating leverage, it also points to difficulties of such a unified approach. Although not discussed in this paper, differences in national accounting standards can also obstruct the introduction of leverage regulations.

Changes in the risk-taking behavior of banks have conspicuous impacts on changes in leverage. This suggests that we can obtain more useful information on changes in bank behavior by focusing on *changes* in leverage rather than on the *level* of leverage. The adoption of *speed limits* to leverage growth is a policy measure in this spirit. Moreover, instead of regulating changes in leverage, we can use them as important signals in the supervision process in order to identify changes in the incentive structure of banks.

In the recent financial crisis, major U.S. and European commercial banks suffered massive losses due to the failure of SIVs and other instruments. If we focused on simple leverage regulations based only on on-balance-sheet items, we would fail to capture increases in off-balance-sheet leverage again in the future. Therefore, we must include off-balance-sheet items as well as on-balance-sheet items in developing leverage regulations. In so doing, we must examine extensively what off-balance-sheet items are to be included in the calculation of leverage ratios and in what form.

APPENDIX A. LEVERAGE RATIOS REFLECTING OFF-BALANCE-SHEET TRANSACTIONS

As shown in Section 3, it is impossible to develop leverage regulations that include only on-balance-sheet items and satisfy the following two conditions: First, the regulations should be so restrictive that the U.S. commercial banks that were at the epicenter of the recent financial crisis cannot enlarge their leverage anymore. Second, the regulations should be not so restrictive as to distort asset portfolio management by those banks in other countries that maintained relatively stable business conditions even during the crisis.

A promising method to overcome the above problem is to take into account off-balance-sheet items in the calculation of leverage ratios. In this appendix, we give a brief description of off-balance-sheet transactions and calculate leverage ratios, taking into account these off-balance-sheet items. Due to the limited availability of data, however, we focus on the U.S. and Japanese commercial banks and confine ourselves into the investigation of the off-balance-sheet transactions that are disclosed for the computation of the risk-based capital ratio.

Chart A1 (1) compares the size of on-balance-sheet transactions with that of off-balance-sheet transactions. The horizontal axis plots the ratio of face value or notional amounts of off-balance-sheet transactions to the total value of on-balance-sheet assets. Next, these face value or notional amounts are converted into credit equivalents so that they can be combined with on-balance-sheet transactions. The vertical axis plots the ratio of these credit equivalents of off-balance-sheet transactions to the total value of on-balance-sheet assets. The graph shows that face value or notional amounts of off-balance-sheet transactions are larger for Japanese commercial banks than for the U.S. counterparts, while credit equivalents are larger for the U.S. commercial banks than for the Japanese counterparts.

In Chart A1 (2), the horizontal axis plots a simple gearing ratio based solely on on-balance-sheet transactions, while the gearing ratio plotted on the vertical axis is computed using the sum of the credit equivalents of off-balance-sheet transactions and the total value of on-balance-sheet assets as its denominator. The graph indicates that even when off-balance-sheet transactions are taken into account, the gearing ratio for the Japanese commercial banks is only slightly higher than that of the U.S. counterparts.

In the recent financial crisis, the leading Japanese banks maintained stable business conditions, relative to the U.S. and European counterparts. It appears, however, that gearing ratios that take into account off-balance-sheet transactions do not fully reflect this difference between the Japanese and U.S. commercial banks. The analysis suggests that we should examine extensively what off-balance-sheet items are to be included in the calculation of leverage ratios and in what form, before we set a leverage ratio that is useful in maintaining the stability of financial systems.

APPENDIX B. REGULATIONS USING CES FUNCTIONS

Thus far, we have only dealt with regulations on leverage. Here we consider similar regulations on the quality of assets. The simplest way to regulate the quality of assets is to establish a minimum level for the asset quality index. This would entail the following form of regulation.

$$\bar{\phi} \leq \phi . \tag{B-1}$$

We have discussed the three regulations so far: the risk-based capital requirement, the leverage ratio requirement, and the asset quality requirement. Next we show that these regulations can be unified into a general form of regulation with the help of the CES function. This general form of regulation is so flexible that we can design well-balanced regulations that prevent both a gearing ratio and an asset quality index from deteriorating extremely.

We use the following CES function.[20]

$$1 \leq \left\{ \alpha \left(\frac{\phi}{\lambda_\phi} \right)^{-\rho} + (1-\alpha) \left(\frac{\gamma}{\lambda_\gamma} \right)^{-\rho} \right\}^{-\frac{1}{\rho}} . \tag{B-2}$$

This function is meaningful only when $\rho \geq -1$, $0 \leq \alpha \leq 1$ and takes various forms, depending on the value of ρ.

(a) The function converges to a linear function, as $\rho \to -1$.

$$1 \leq \alpha \frac{\phi}{\lambda_\phi} + (1-\alpha) \frac{\gamma}{\lambda_\gamma} . \tag{B-3}$$

(b) The function converges to the Cobb-Douglas function, as $\rho \to 0$.

$$1 \leq \left(\frac{\phi}{\lambda_\phi} \right)^{\alpha} \left(\frac{\gamma}{\lambda_\gamma} \right)^{1-\alpha} . \tag{B-4}$$

(c) The function converges to the Leontief function when $\rho \to \infty$.

$$1 \leq \min \left[\frac{\phi}{\lambda_\phi}, \frac{\gamma}{\lambda_\gamma} \right] . \tag{B-5}$$

---

[20] CES is an abbreviation for constant elasticity of substitution. In the case of production functions, elasticity of substitution refers to the percent change in the ratio of production factors for every 1 percent change in the slope of isoquant curves. For the CES production function, this elasticity of substitution remains constant. Elasticity of substitution can be computed as $1/(1+\rho)$. Therefore, the value of the elasticity of substitution will be infinitely large for a linear CES function, equal to 1 for a Cobb-Douglas production function, and equal to zero for a Leontief production function.

When $\alpha = 0.5$ and $\lambda_\phi = \lambda_\gamma = \sqrt{\beta}$, equation (B-4) above coincides with the risk-based capital requirement. When $\lambda_\gamma = \bar{\gamma}$ and $\lambda_\phi = \bar{\phi}$, equation (B-5) corresponds to a case in which the leverage ratio requirement and the asset quality requirement are both imposed. We set α at a positive value of less than 1 and ρ at any finite positive value in order to introduce "moderate" regulations that satisfy the following two requirements (Chart B1). First, the regulations are stricter than the risk-based capital requirement, preventing both the leverage ratio and asset quality index from taking extreme values; second, they are less severe than the simultaneous implementation of a leverage ratio requirement and an asset quality requirement. Admittedly, the drawback is that the simplicity of leverage regulations is lost in this scheme.

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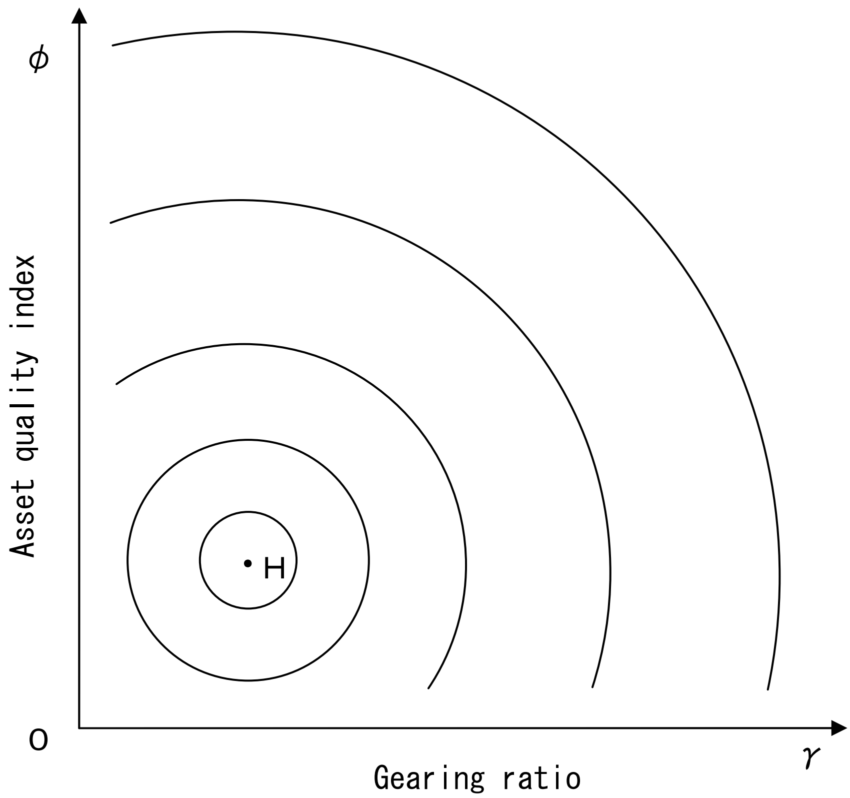
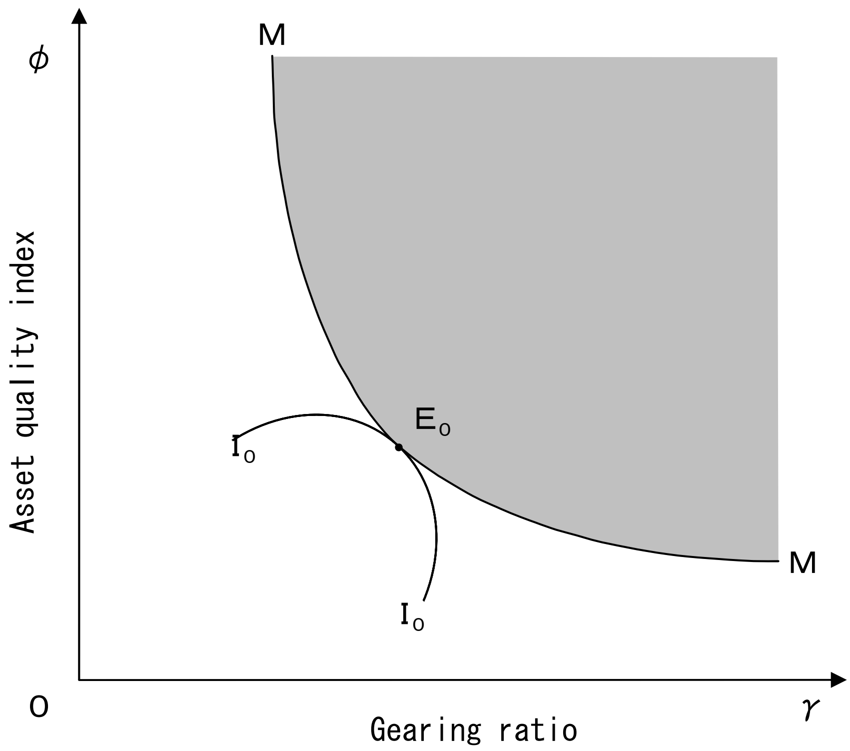
(Chart 1)

Indifference curves of a bank



Bank behavior under the risk-based capital requirement



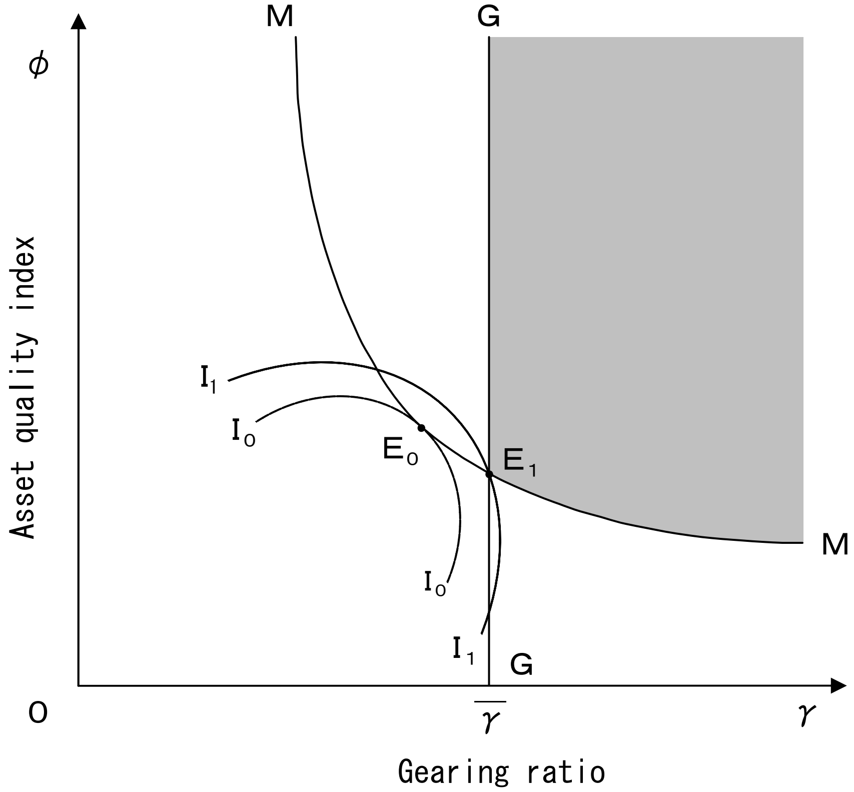
Changes in optimal choice by banks (numerical examples)

	Regulation arbitrage through trading accounts			Cost of capital (lower values mean higher costs)			Mean return on assets			Standard deviation of return on assets		
τ	0	0.1	0.2	0	0	0	0	0	0	0	0	0
θ	0.2	0.2	0.2	0.18	0.2	0.22	0.2	0.2	0.2	0.2	0.2	0.2
μ_1	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.05	0.07	0.05	0.05	0.05
μ_2	0.1	0.1	0.1	0.1	0.1	0.1	0.08	0.1	0.12	0.1	0.1	0.1
σ_1	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.04
σ_2	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.07
ϕ	0	0	0	0	0	0	0	0	0	0	0	0
ω_1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
$\bar{\beta}$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ℓ	31.48	32.29	31.78	34.91	31.48	28.68	30.00	31.48	26.96	38.57	31.48	26.26
s_1	0.85	0.76	0.67	0.89	0.85	0.81	0.83	0.85	0.79	0.93	0.85	0.77
γ	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04
ϕ	3.15	3.23	3.26	3.49	3.15	2.87	3.00	3.15	2.70	3.86	3.15	2.63

	Correlation coefficient of asset returns			Risk-weights of safe assets			Target ratio of risk-based capital requirement		
τ	0	0	0	0	0	0	0	0	0
θ	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
μ_1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
μ_2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
σ_1	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
σ_2	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
ϕ	−0.05	0	0.05	0	0	0	0	0	0
ω_1	0.2	0.2	0.2	0.15	0.2	0.25	0.2	0.2	0.2
$\bar{\beta}$	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.1	0.11
ℓ	31.45	31.48	31.51	32.31	31.48	29.93	31.55	31.48	31.43
s_1	0.85	0.85	0.85	0.81	0.85	0.89	0.81	0.85	0.89
γ	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
ϕ	3.15	3.15	3.15	3.23	3.15	2.99	2.84	3.15	3.46

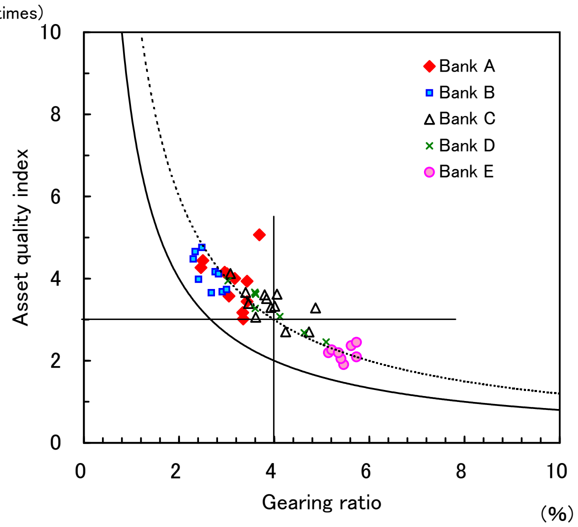
(Note) $\omega_2 = 1$; $s_2 = 1 - s_1$.

Bank behavior under an additional regulation on a leverage ratio

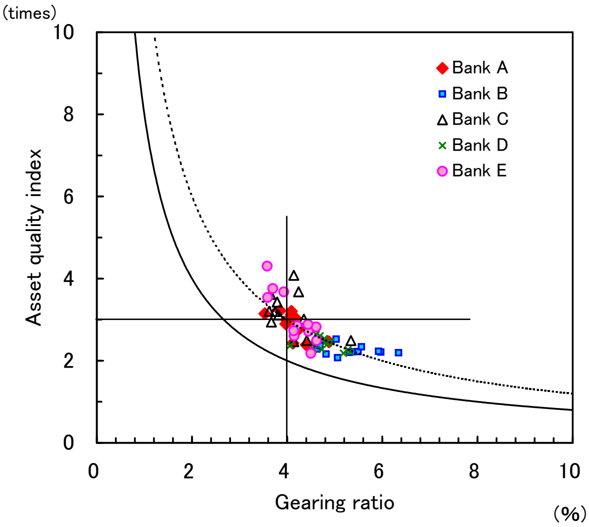


Gearing ratios and asset quality indices of G10 commercial banks

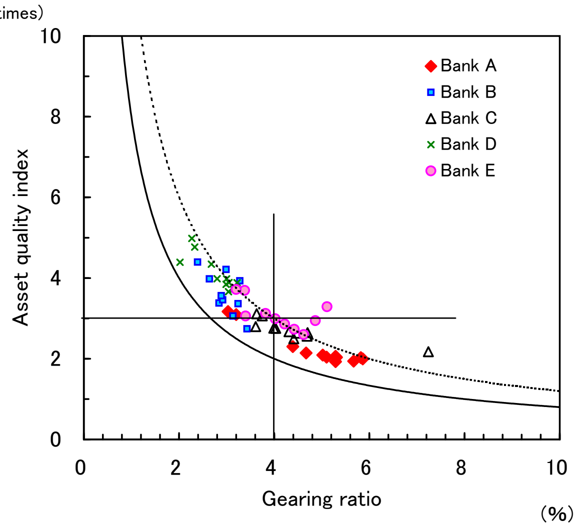
(1) Belgium



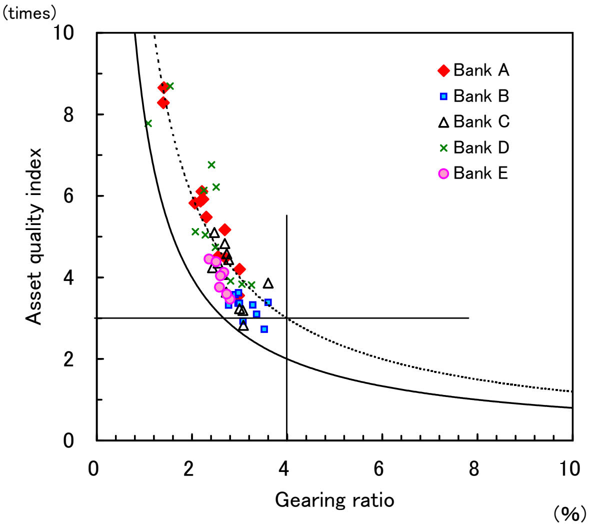
(2) Canada



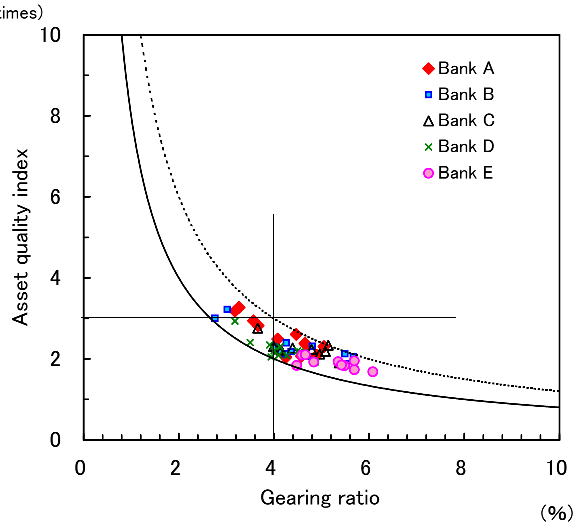
(3) France



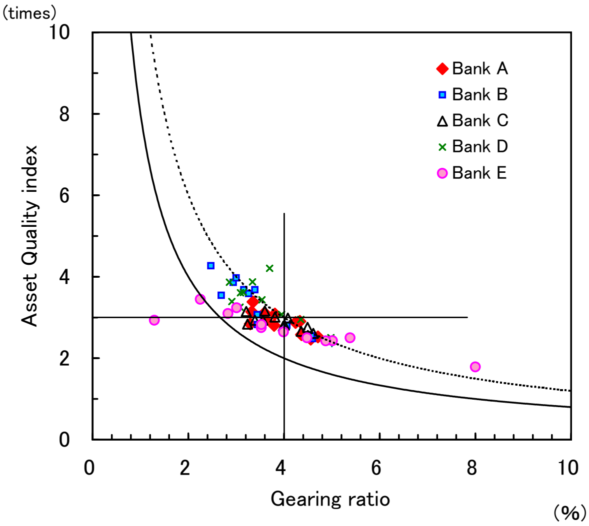
(4) Germany



(5) Italy



(6) Japan



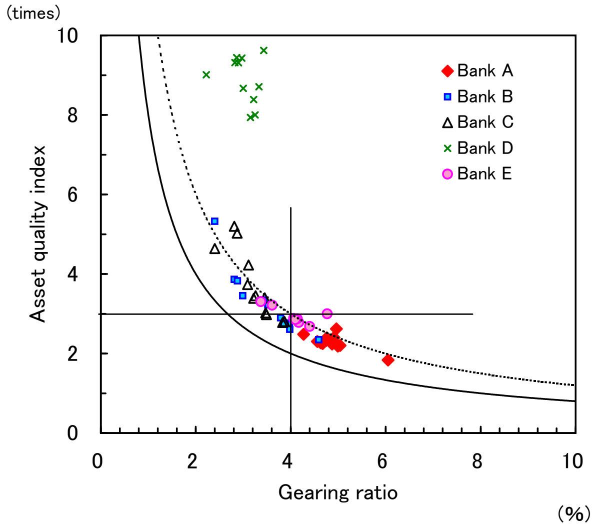
(Source) "The Banker" and the authors' calculation.

(Note) —— : Target ratio of risk-based capital requirement = 8%

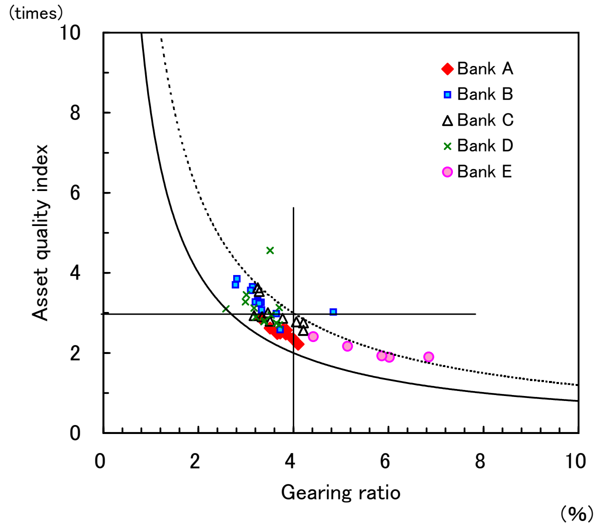
- - - - : Target ratio of risk-based capital requirement = 12%

(Chart 5 continued)

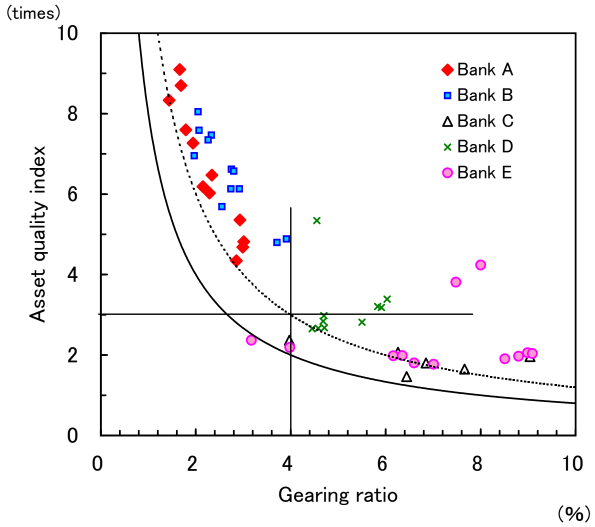
(7) Netherlands



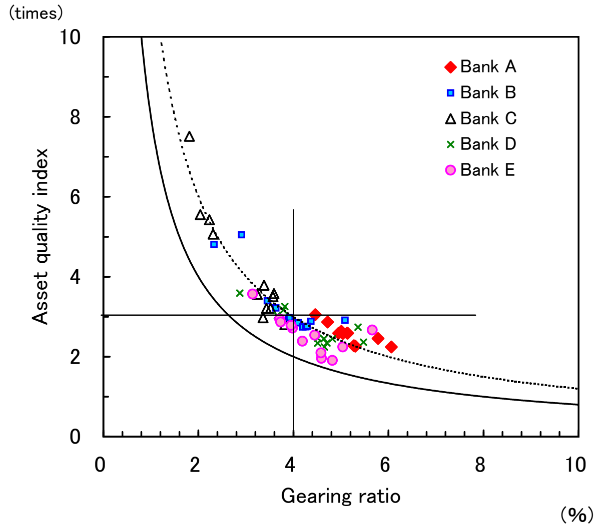
(8) Sweden



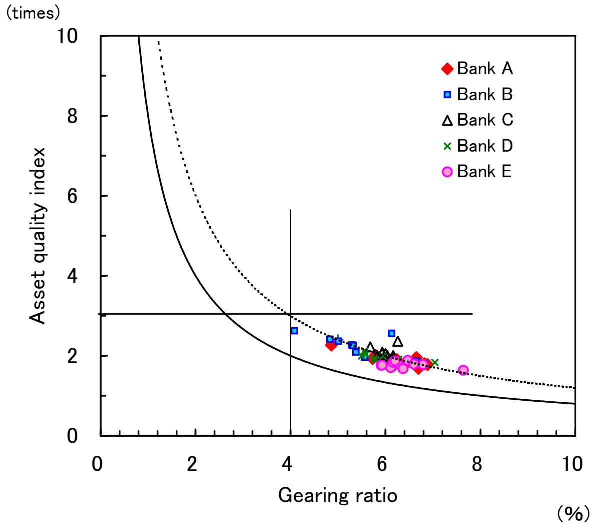
(9) Switzerland



(10) U.K.



(11) U.S.



(Source) "The Banker" and the authors' calculation.

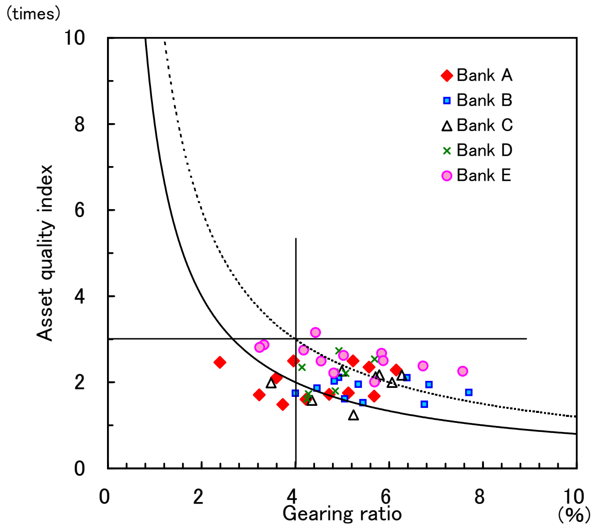
(Note) ——— : Target ratio of risk-based capital requirement = 8%

- - - - - : Target ratio of risk-based capital requirement = 12%

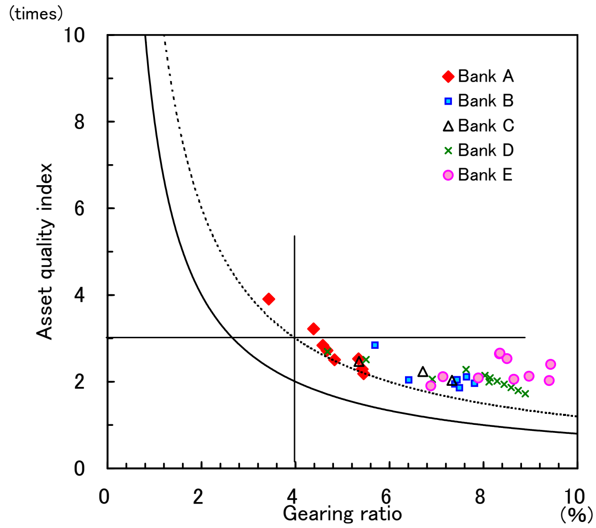
(Chart 6)

Gearing ratios and asset quality indices of Asian commercial banks

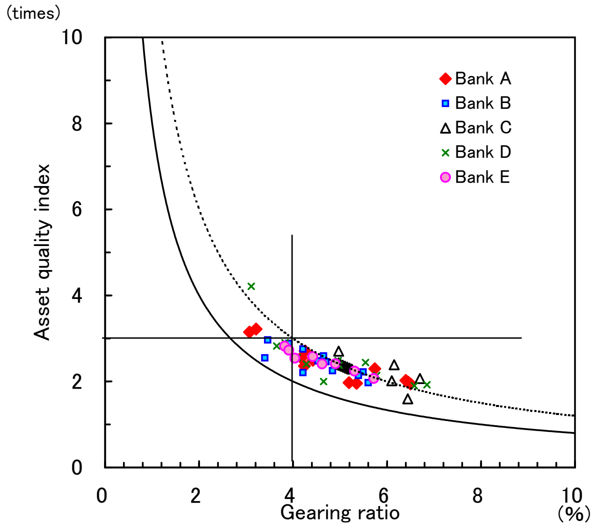
(1) China



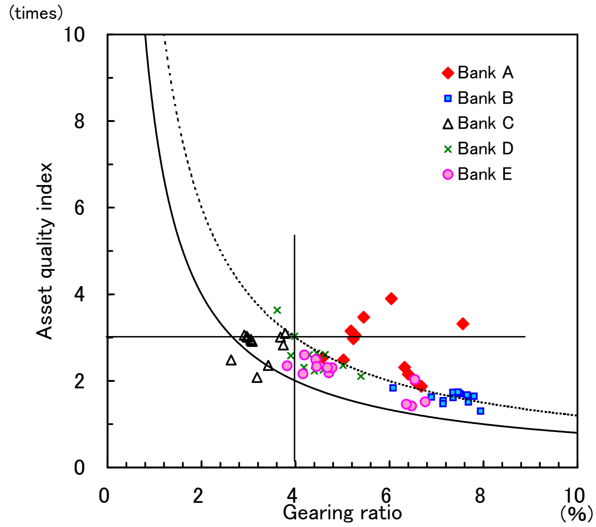
(2) Hong Kong



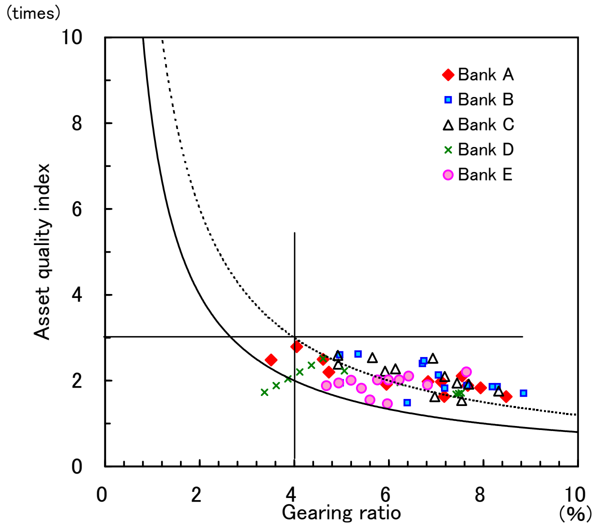
(3) Korea



(4) Taiwan



(5) Thailand



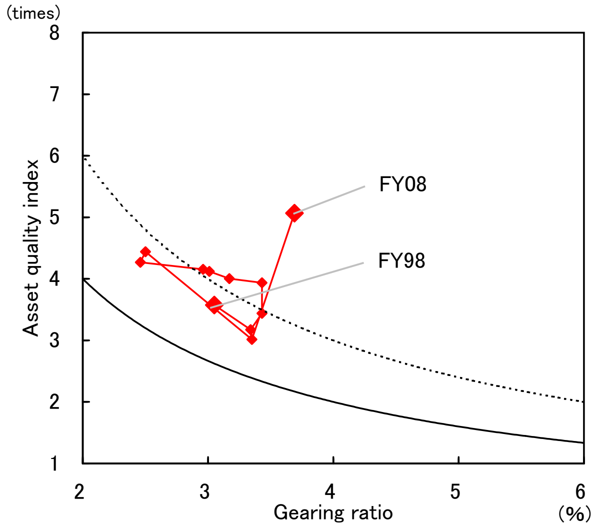
(Source) "The Banker" and the authors' calculation.

(Note) ――― : Target ratio of risk-based capital requirement = 8%

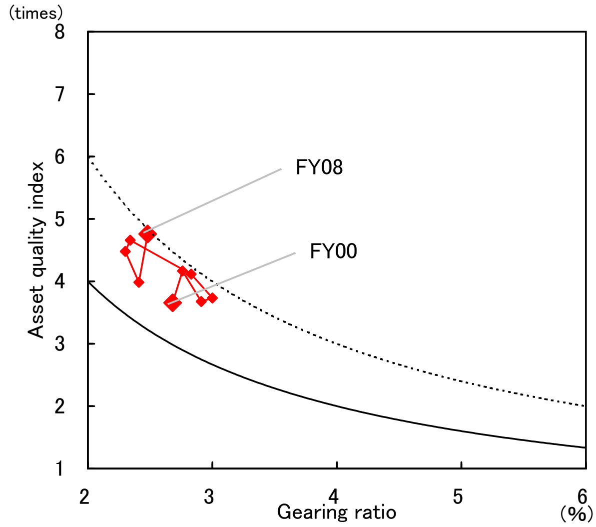
------ : Target ratio of risk-based capital requirement = 12%

Gearing ratios and asset quality indices of Belgian commercial banks

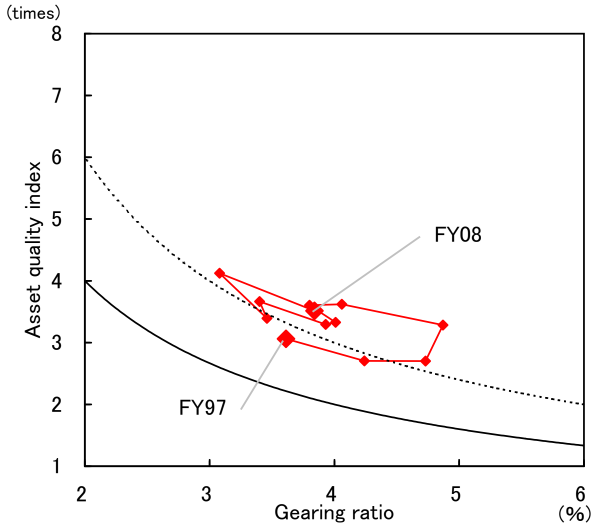
(1) Bank A



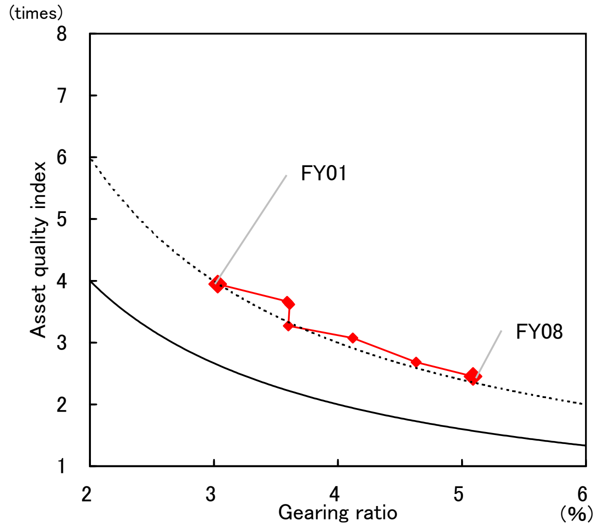
(2) Bank B



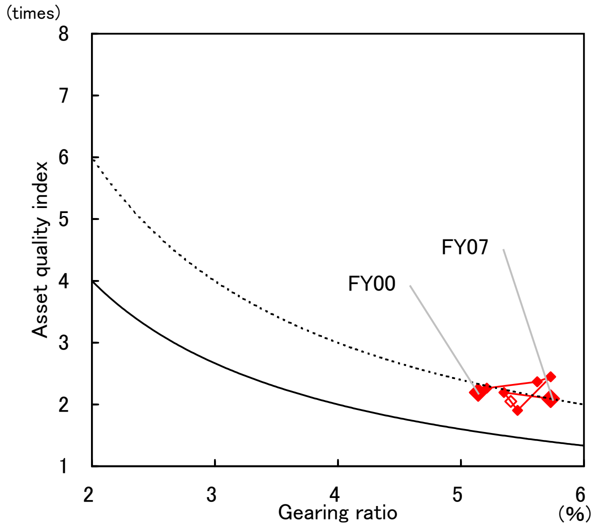
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

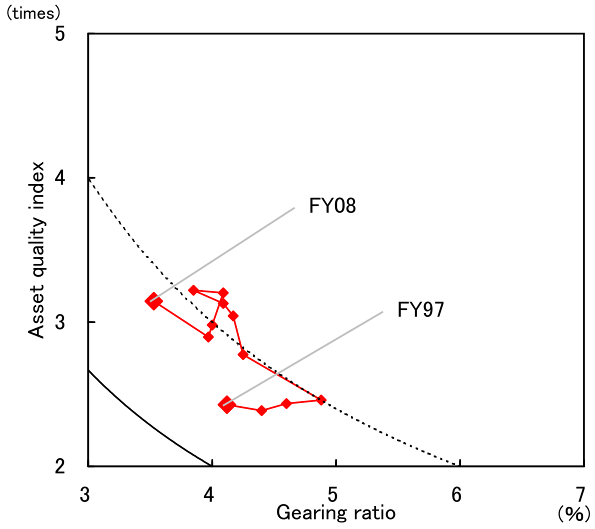
(Note1) ——— : Target ratio of risk-based capital requirement = 8%

- - - - - : Target ratio of risk-based capital requirement = 12%

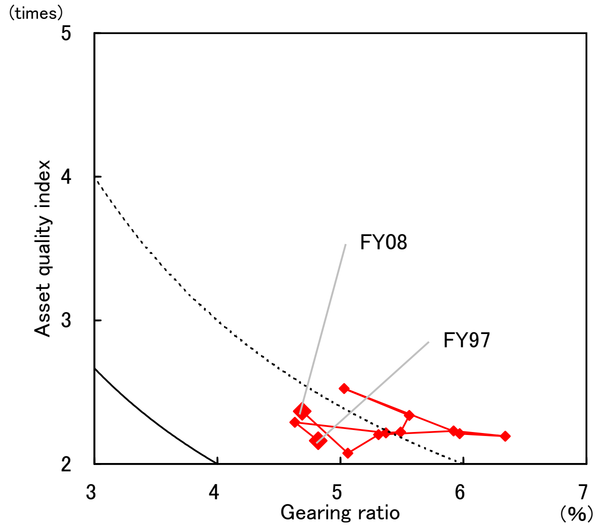
(Note2) The empty squares indicate data linearly interpolated.

Gearing ratios and asset quality indices of Canadian commercial banks

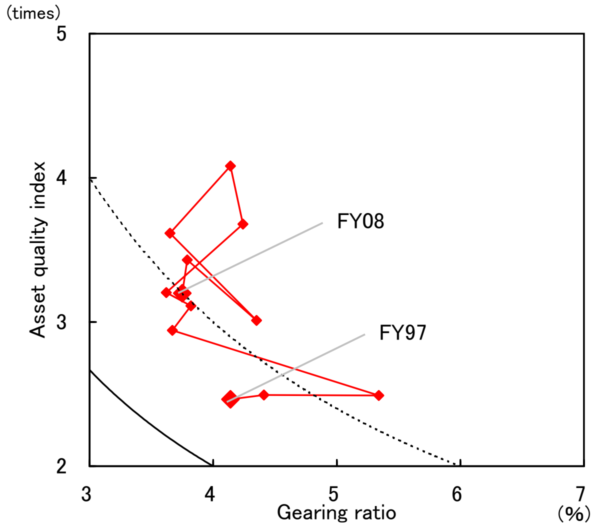
(1) Bank A



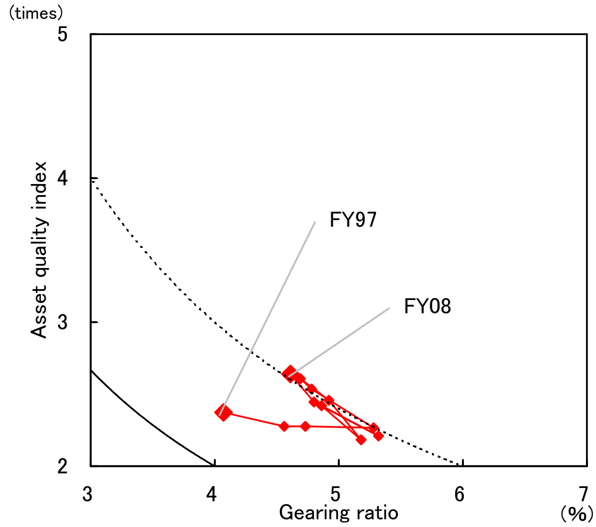
(2) Bank B



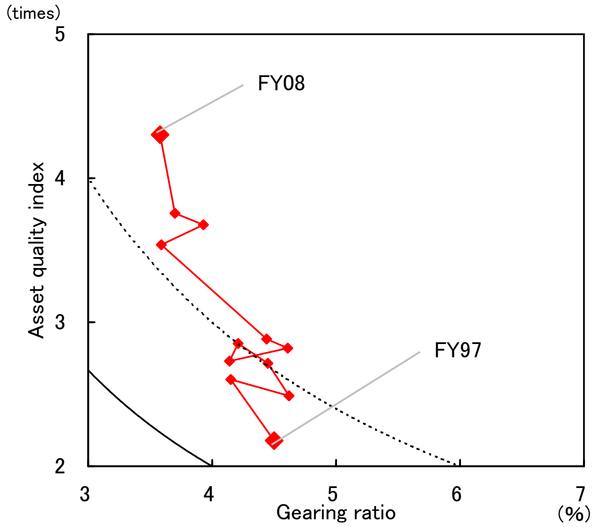
(3) Bank C



(4) Bank D



(5) Bank E



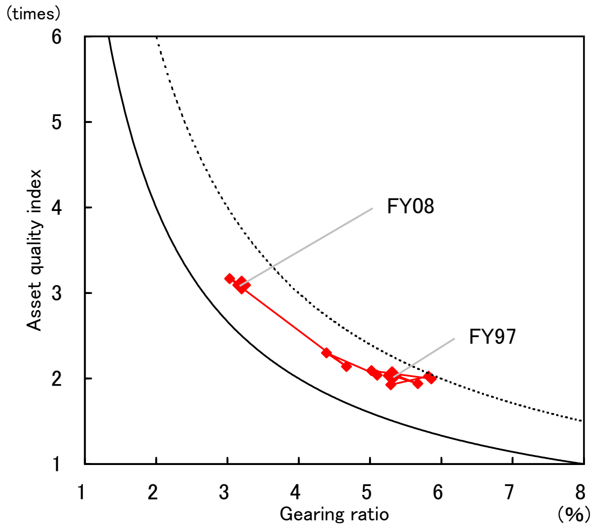
(Source) "The Banker" and the authors' calculation.

(Note) ——— : Target ratio of risk-based capital requirement = 8%

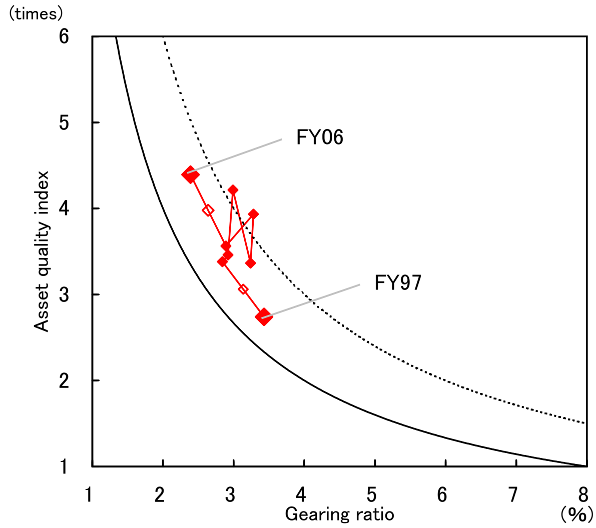
------ : Target ratio of risk-based capital requirement = 12%

Gearing ratios and asset quality indices of French commercial banks

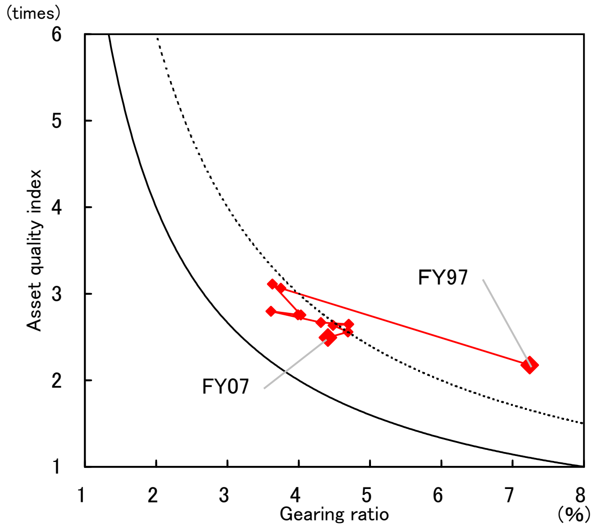
(1) Bank A



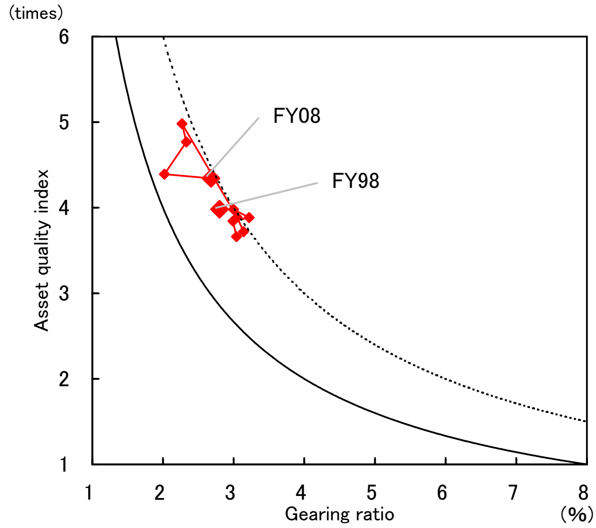
(2) Bank B



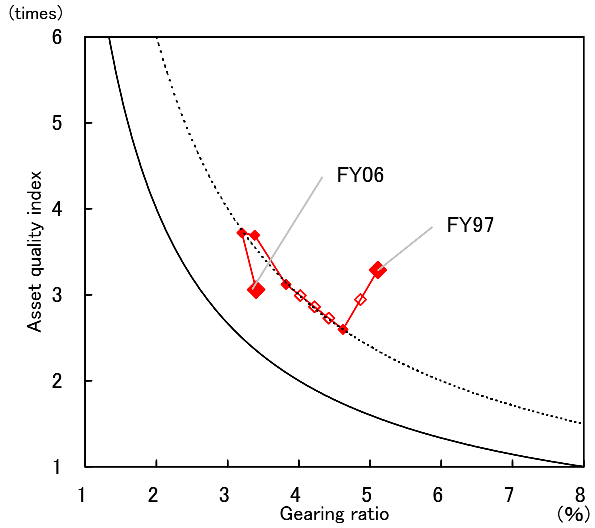
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

(Note1) ——— : Target ratio of risk-based capital requirement = 8%

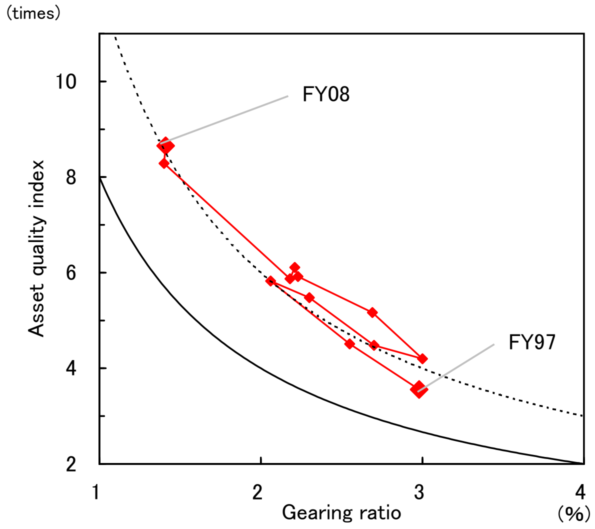
------ : Target ratio of risk-based capital requirement = 12%

(Note2) The empty squares indicate data linearly interpolated.

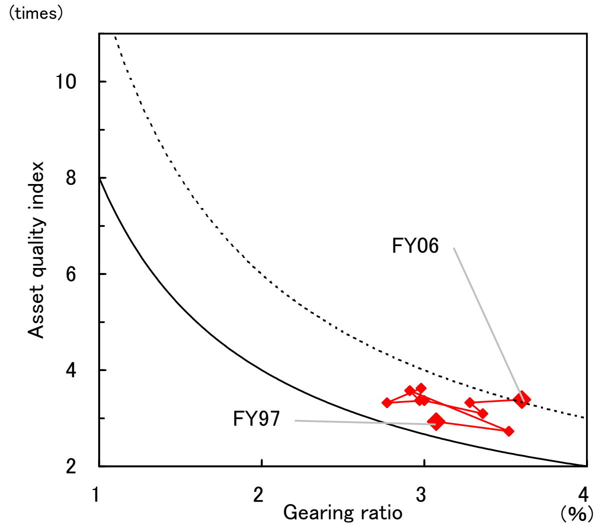
(Chart 10)

Gearing ratios and asset quality indices of German commercial banks

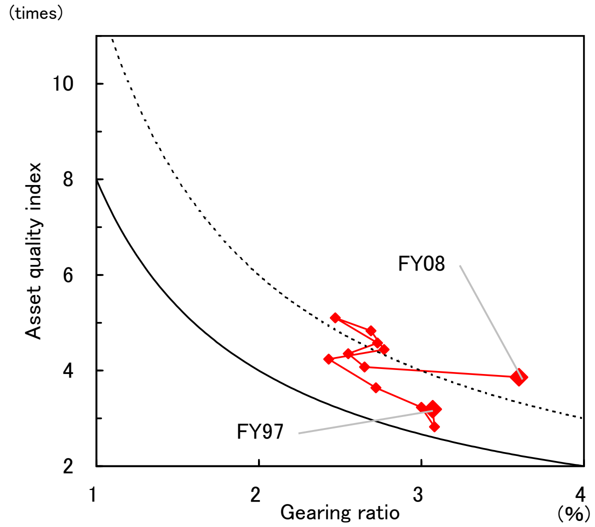
(1) Bank A



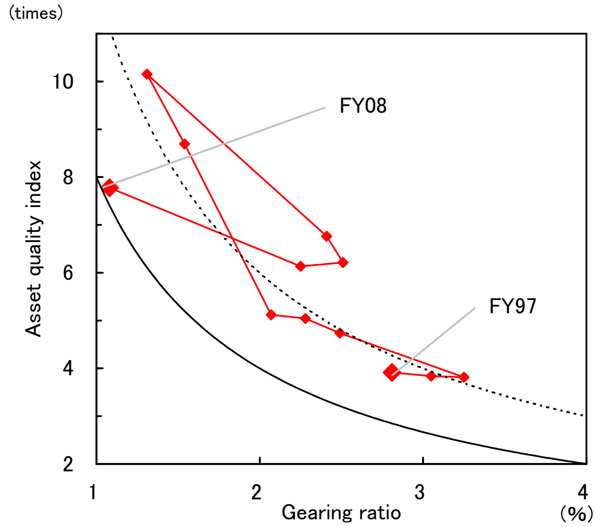
(2) Bank B



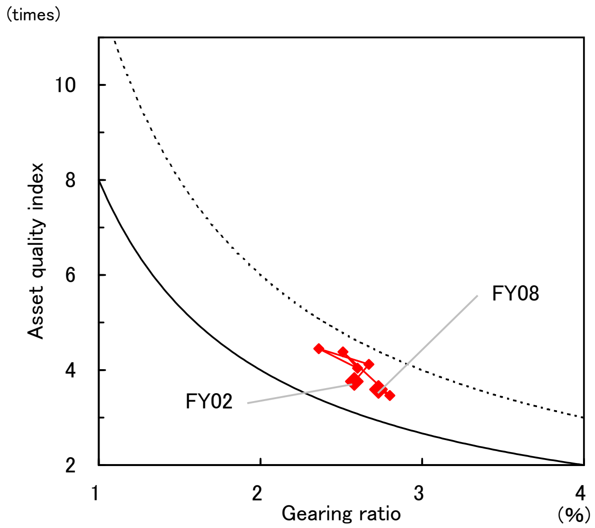
(3) Bank C



(4) Bank D



(5) Bank E



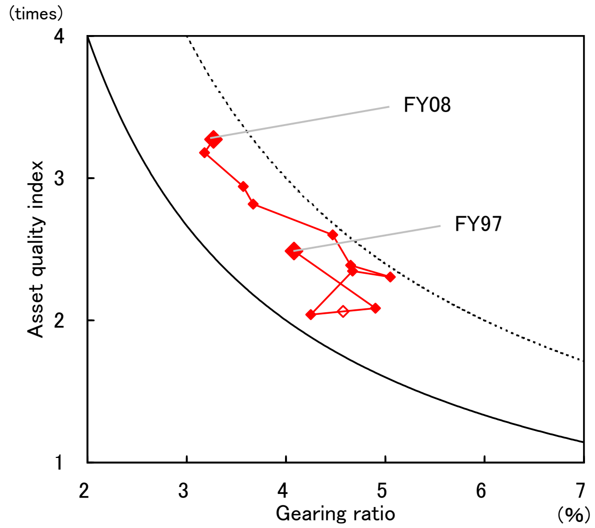
(Source) "The Banker" and the authors' calculation.

(Note) ——— : Target ratio of risk-based capital requirement = 8%

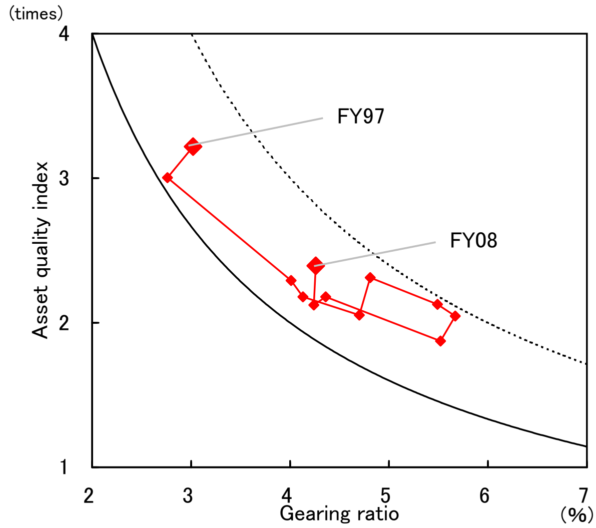
- - - - : Target ratio of risk-based capital requirement = 12%

Gearing ratios and asset quality indices of Italian commercial banks

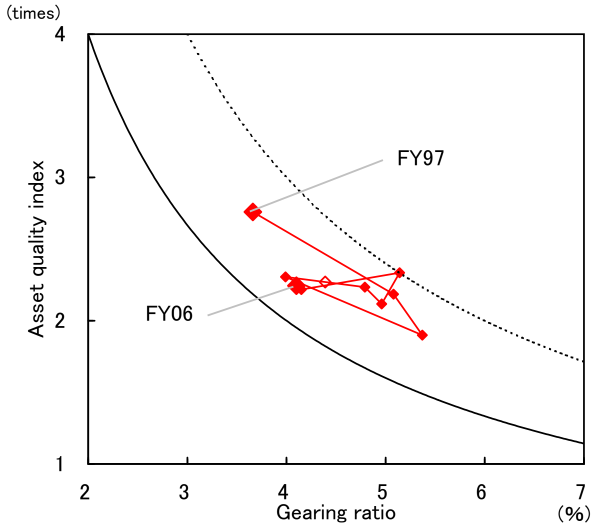
(1) Bank A



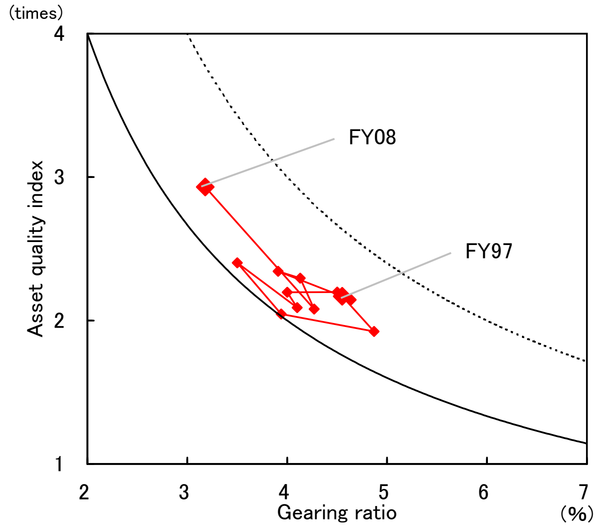
(2) Bank B



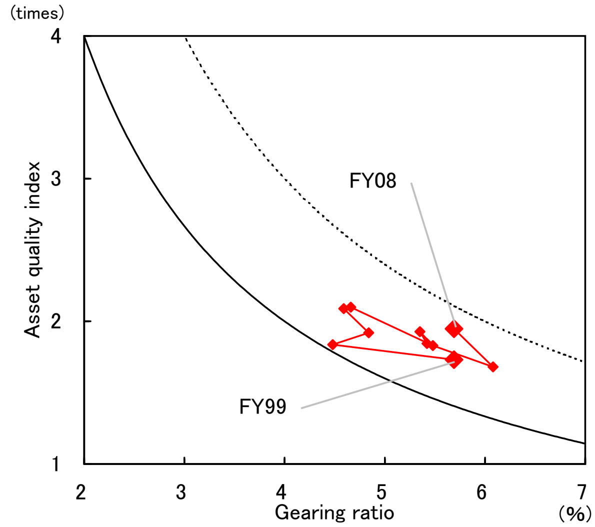
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

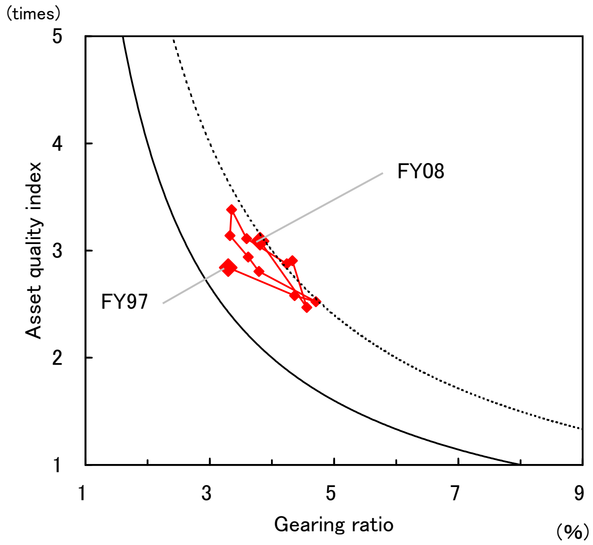
(Note1) ——— : Target ratio of risk-based capital requirement = 8%

----- : Target ratio of risk-based capital requirement = 12%

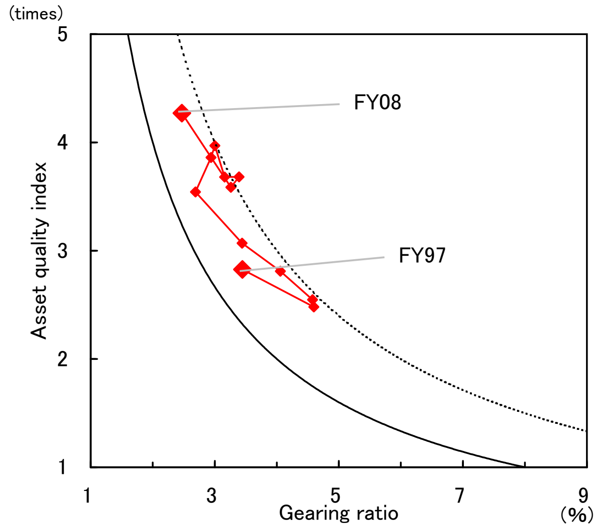
(Note2) The empty squares indicate data linearly interpolated.

Gearing ratios and asset quality indices of Japanese commercial banks

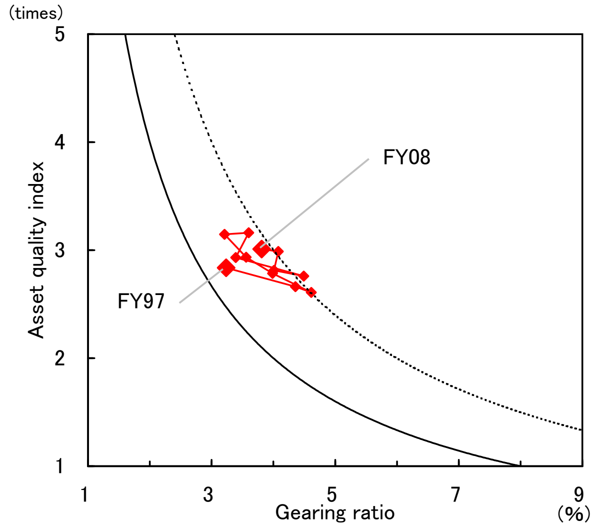
(1) Bank A



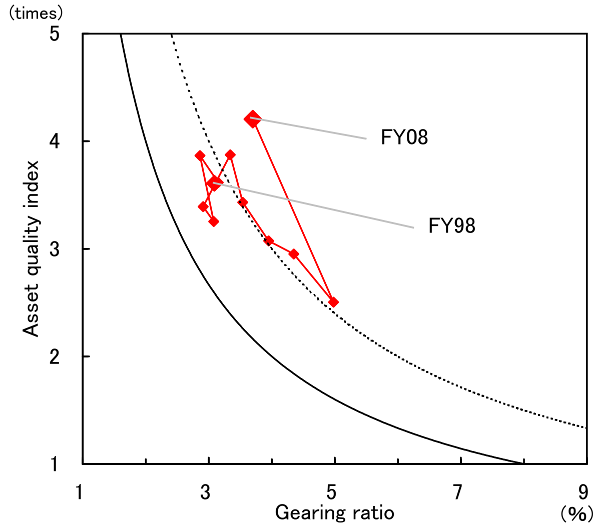
(2) Bank B



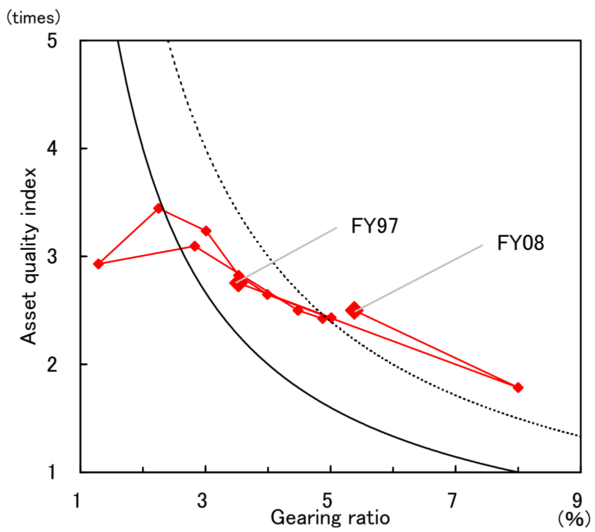
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

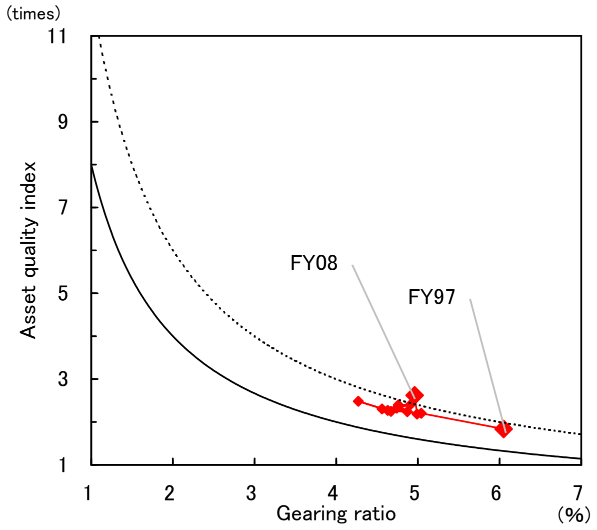
(Note) ——— : Target ratio of risk-based capital requirement = 8%

------ : Target ratio of risk-based capital requirement = 12%

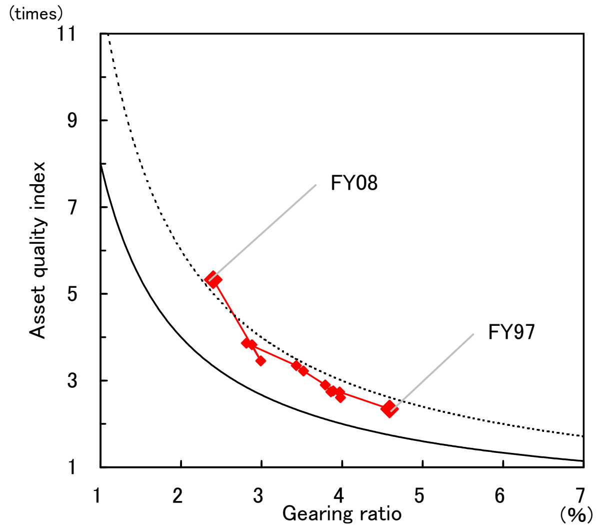
(Chart 13)

Gearing ratios and asset quality indices of Netherlandish commercial banks

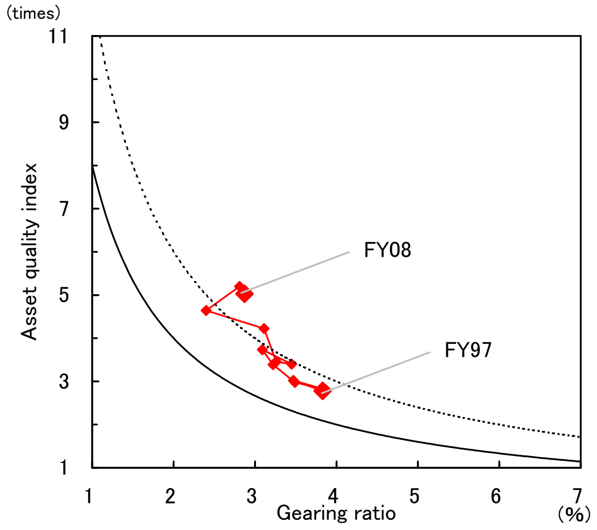
(1) Bank A



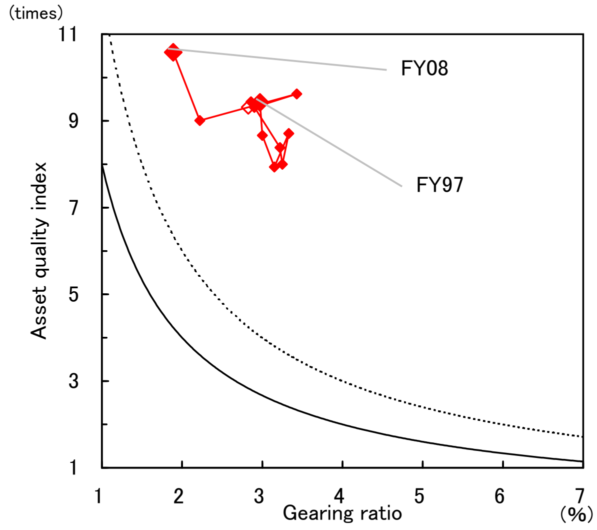
(2) Bank B



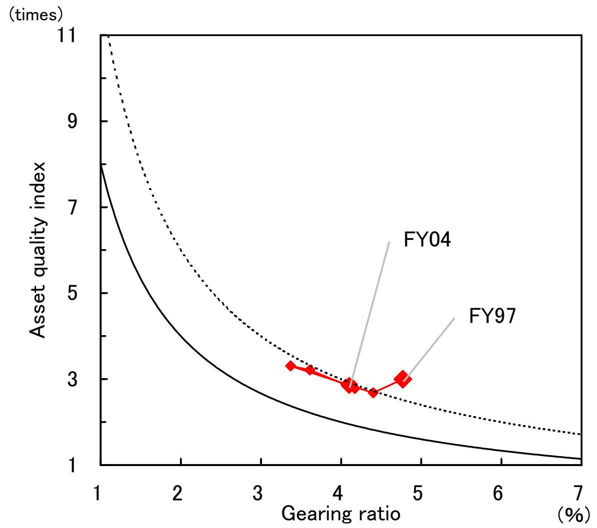
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

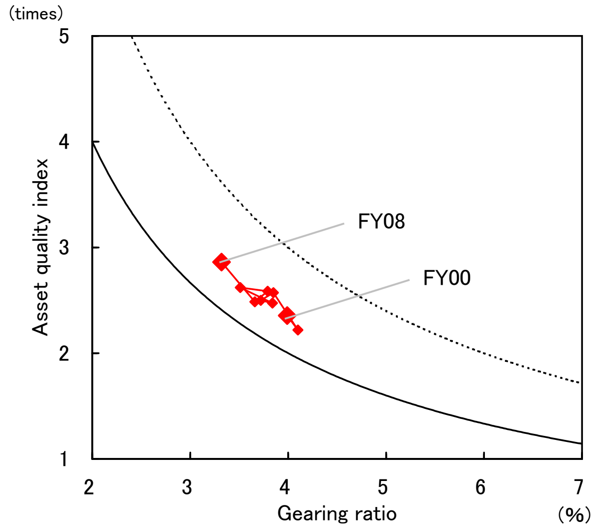
(Note1) ——— : Target ratio of risk-based capital requirement = 8%

- - - - - : Target ratio of risk-based capital requirement = 12%

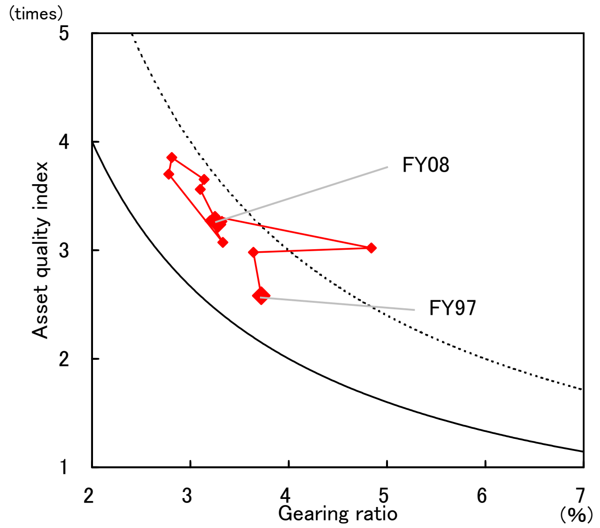
(Note2) The empty squares indicate data linearly interpolated.

Gearing ratios and asset quality indices of Swedish commercial banks

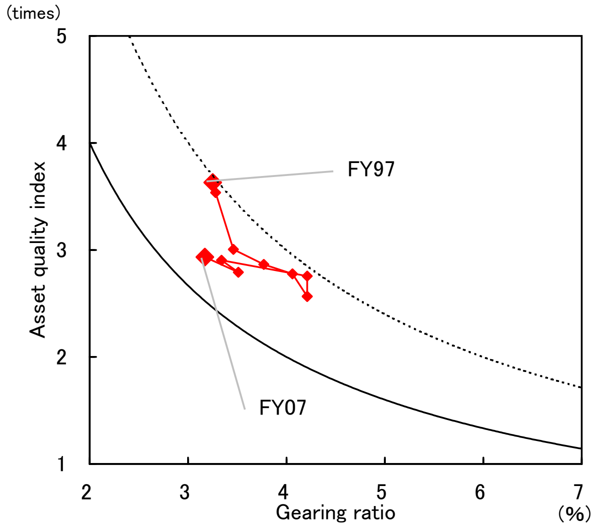
(1) Bank A



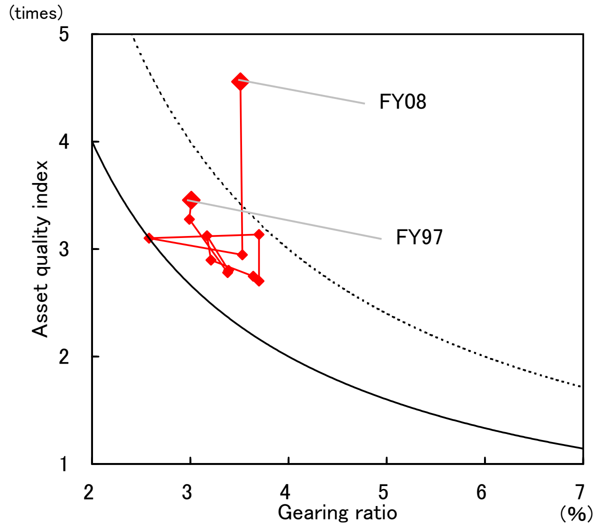
(2) Bank B



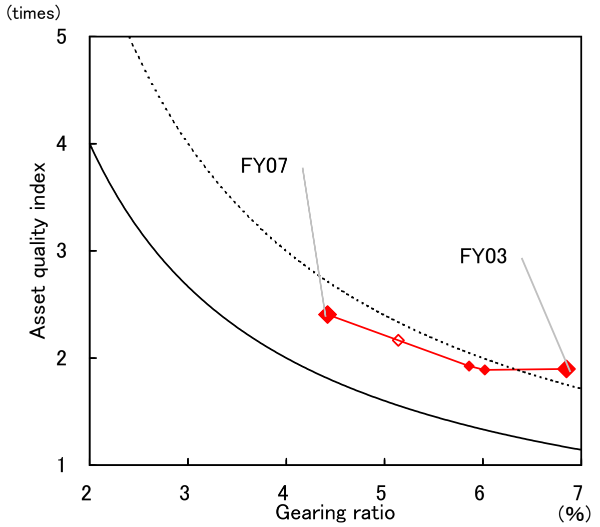
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

(Note1) ——— : Target ratio of risk-based capital requirement = 8%

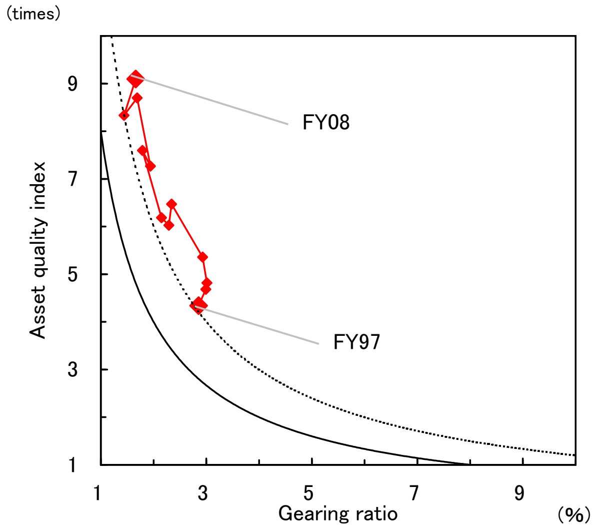
----- : Target ratio of risk-based capital requirement = 12%

(Note2) The empty squares indicate data linearly interpolated.

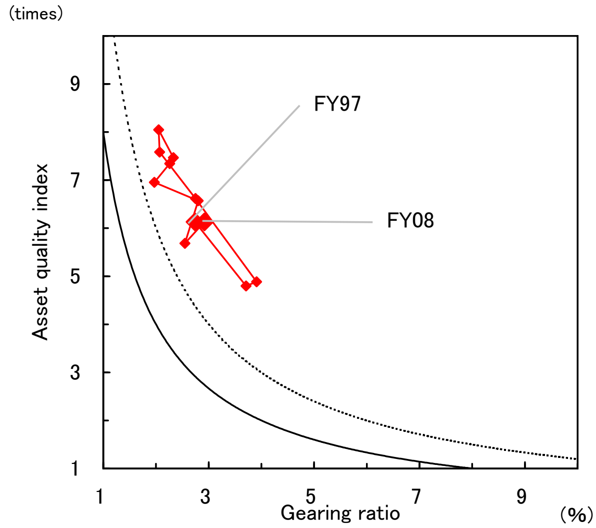
(Chart 15)

Gearing ratios and asset quality indices of Swiss commercial banks

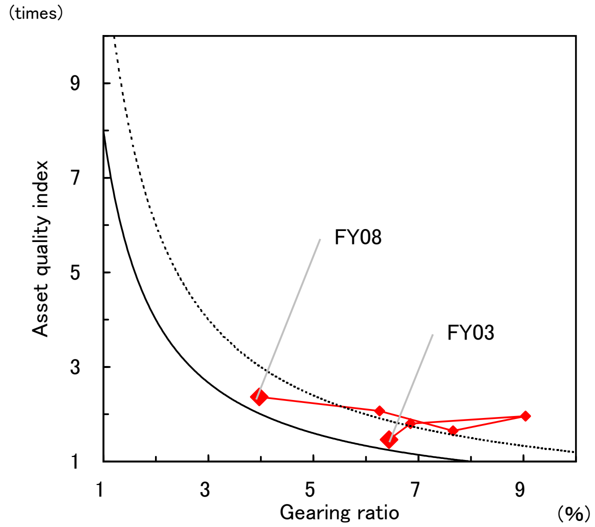
(1) Bank A



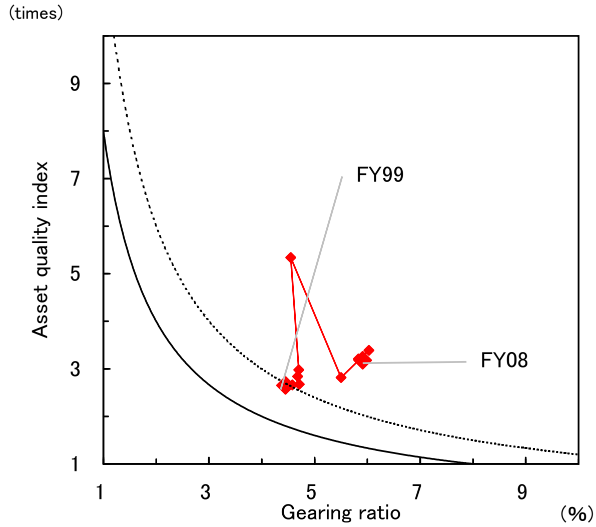
(2) Bank B



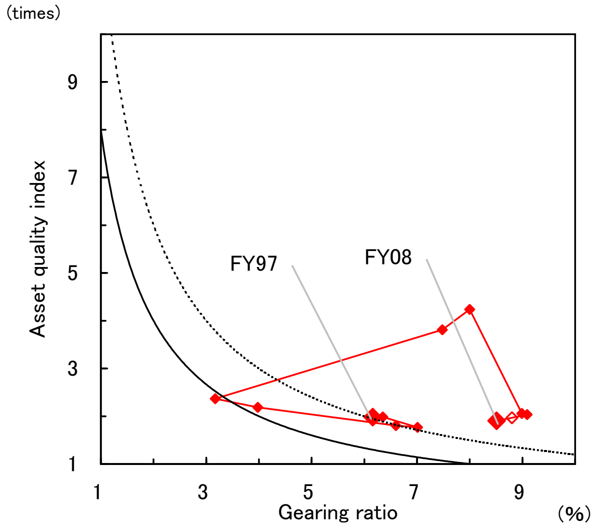
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

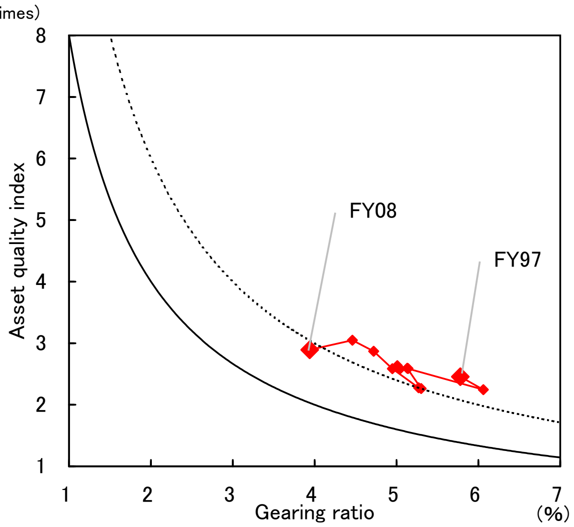
(Note1) ——— : Target ratio of risk-based capital requirement = 8%

----- : Target ratio of risk-based capital requirement = 12%

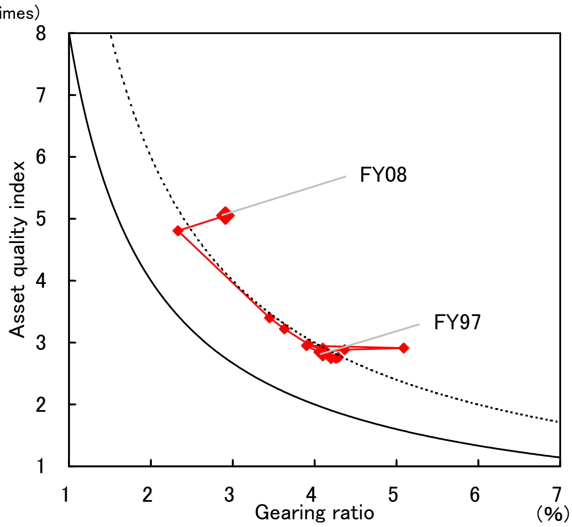
(Note2) The empty squares indicate data linearly interpolated.

Gearing ratios and asset quality indices of U.K. commercial banks

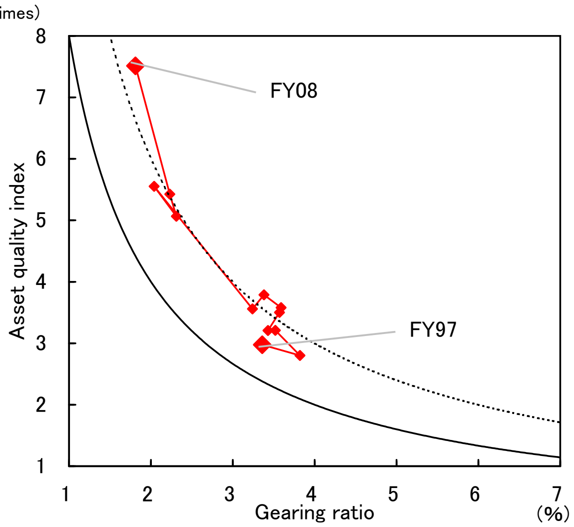
(1) Bank A



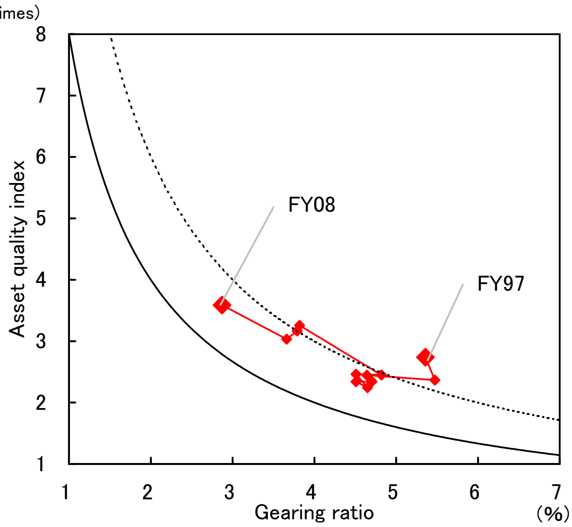
(2) Bank B



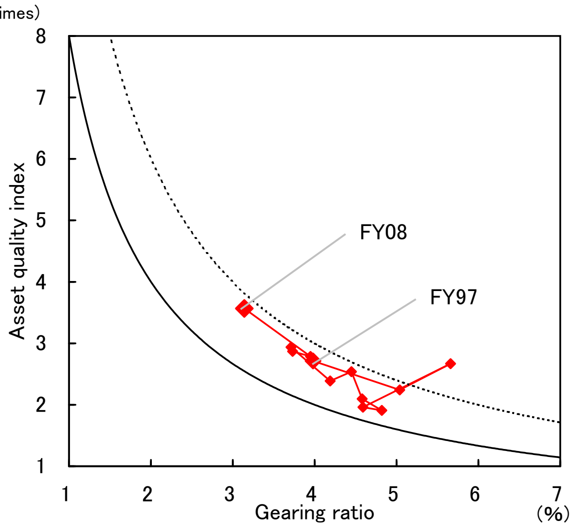
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

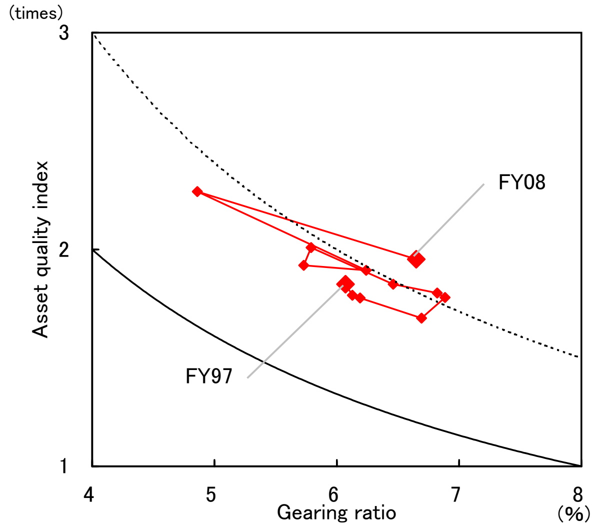
(Note) ——— : Target ratio of risk-based capital requirement = 8%

- - - - : Target ratio of risk-based capital requirement = 12%

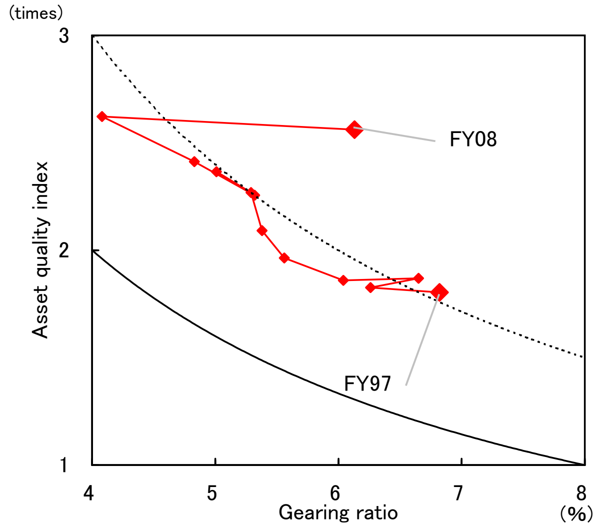
(Chart 17)

Gearing ratios and asset quality indices of U.S. commercial banks

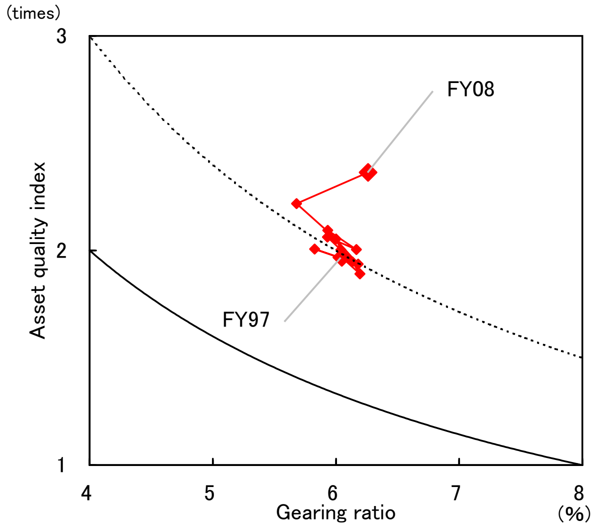
(1) Bank A



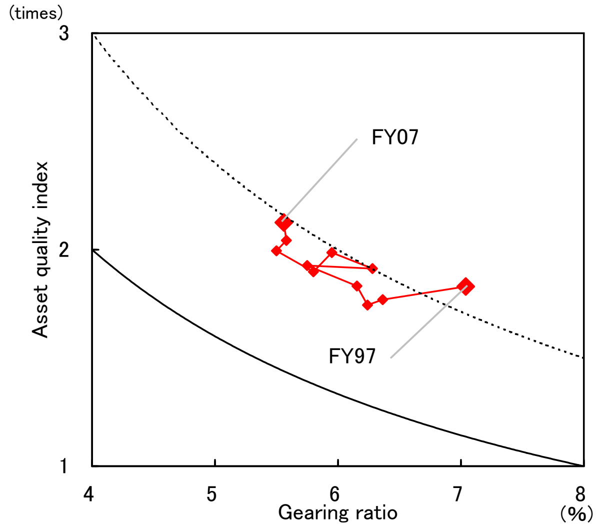
(2) Bank B



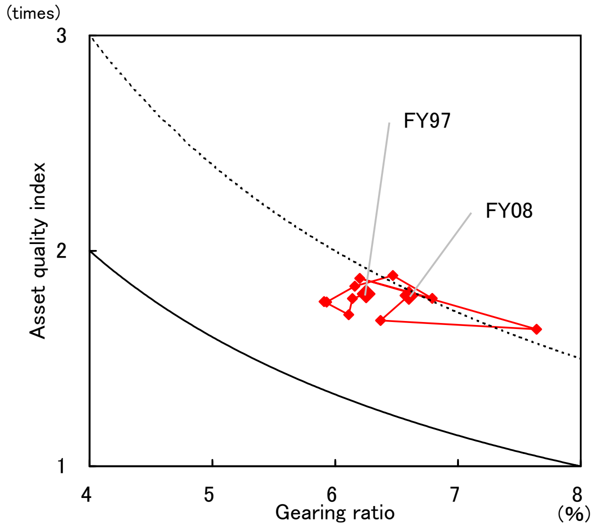
(3) Bank C



(4) Bank D



(5) Bank E



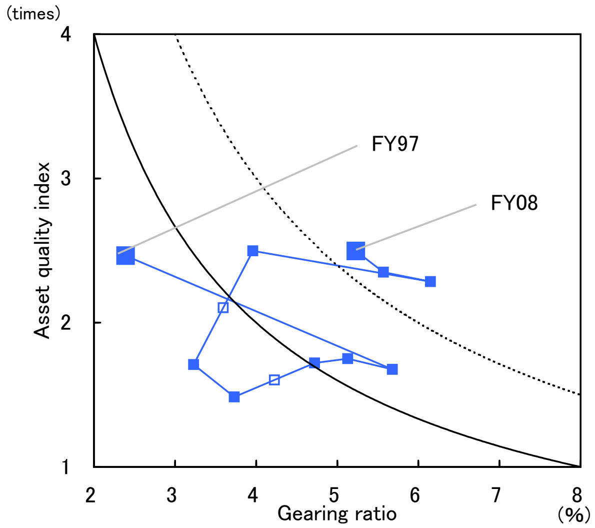
(Source) "The Banker" and the authors' calculation.

(Note) ——— : Target ratio of risk-based capital requirement = 8%

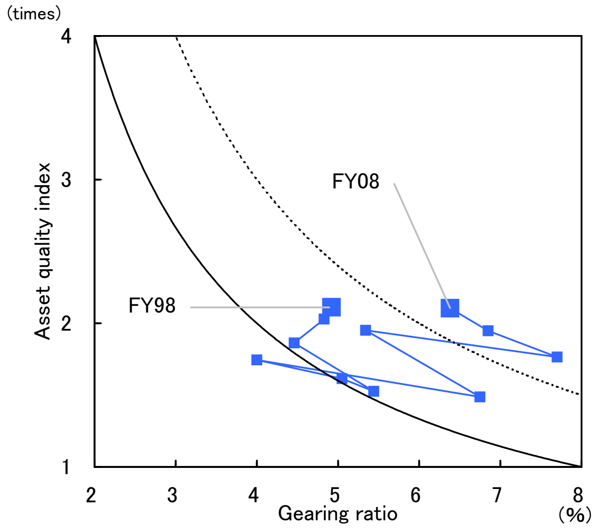
------ : Target ratio of risk-based capital requirement = 12%

Gearing ratios and asset quality indices of Chainese commercial banks

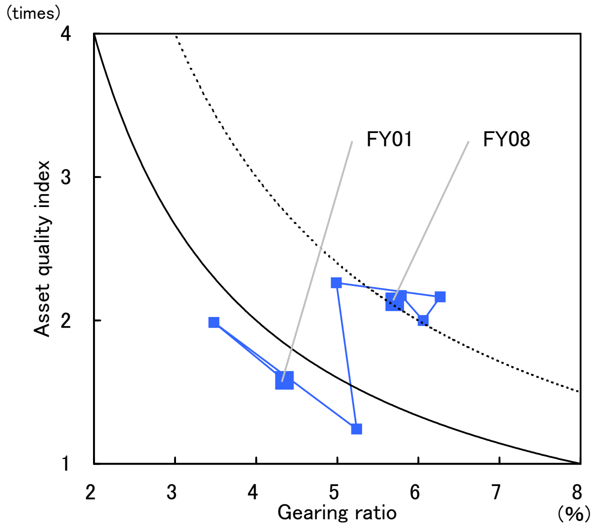
(1) Bank A



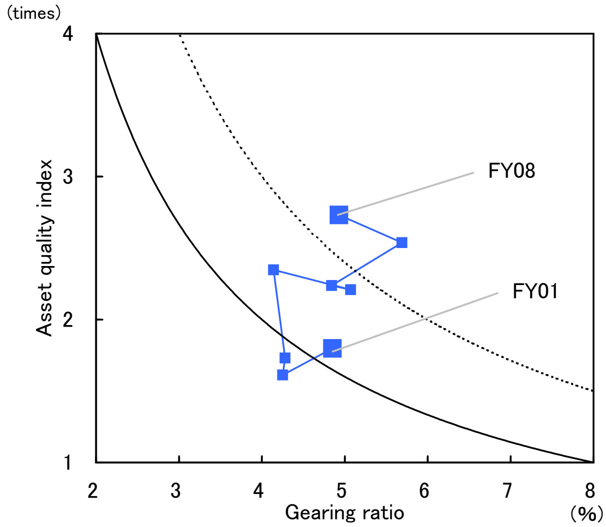
(2) Bank B



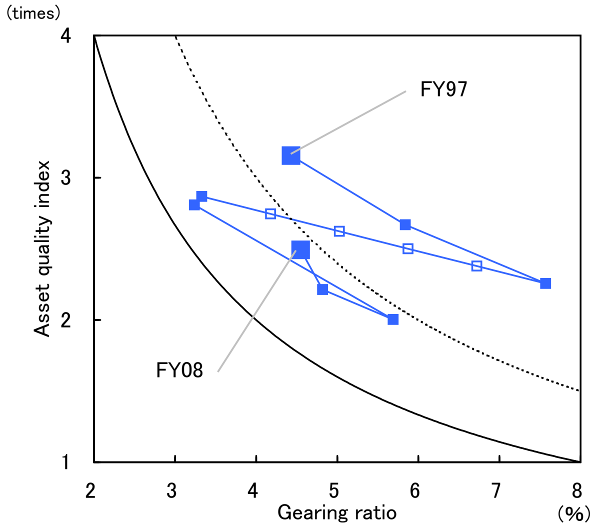
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

(Note1) ——— : Target ratio of risk-based capital requirement = 8%

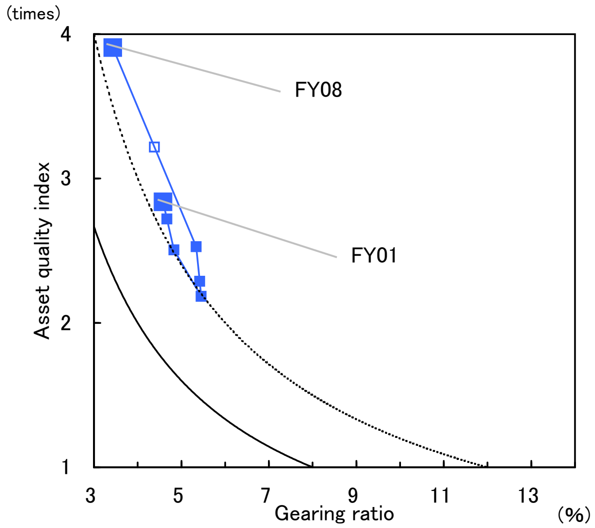
----- : Target ratio of risk-based capital requirement = 12%

(Note2) The empty squares indicate data linearly interpolated.

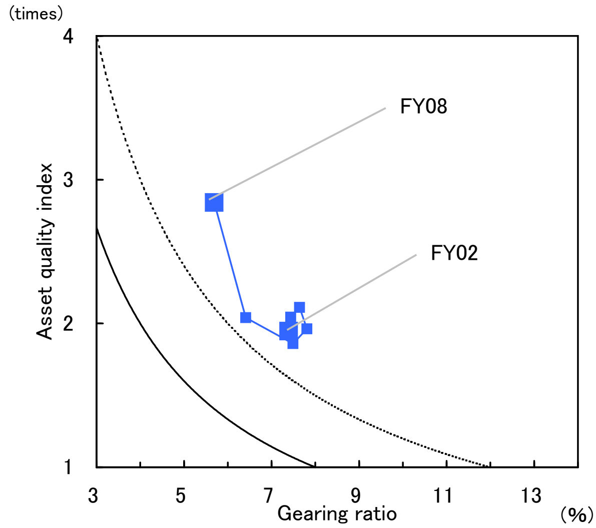
(Chart 19)

Gearing ratios and asset quality indices of Hong Kong commercial banks

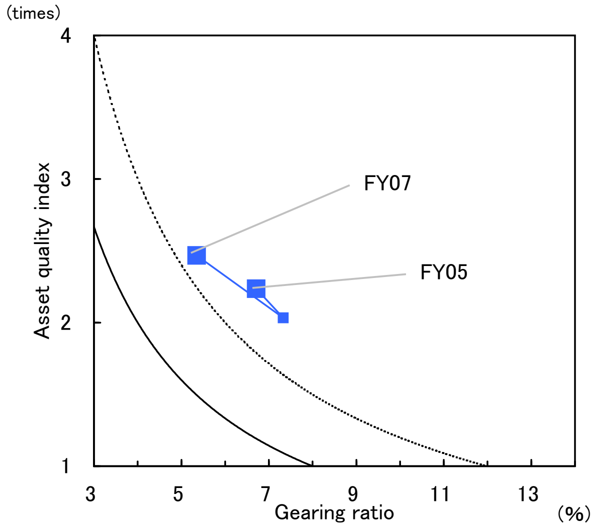
(1) Bank A



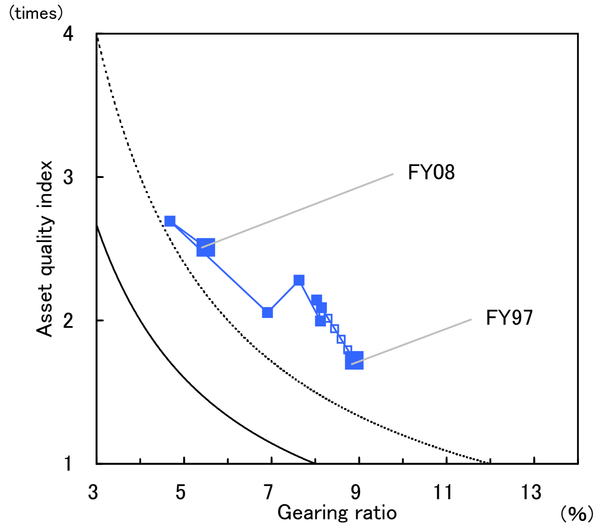
(2) Bank B



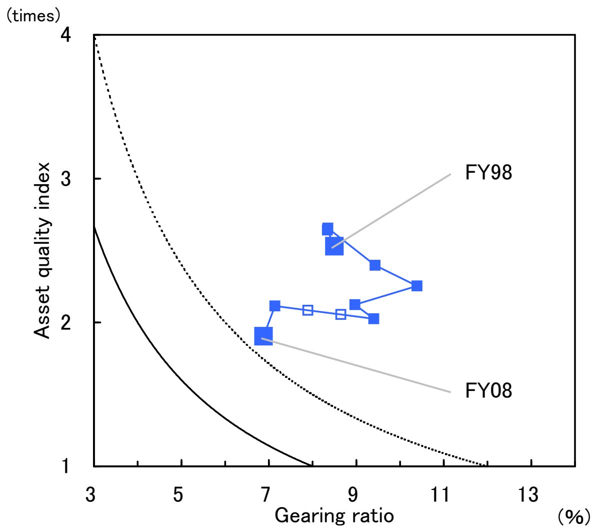
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

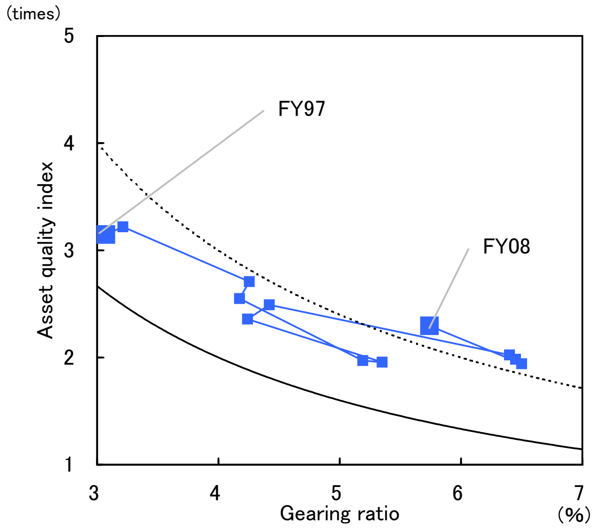
(Note1) ——— : Target ratio of risk-based capital requirement = 8%

----- : Target ratio of risk-based capital requirement = 12%

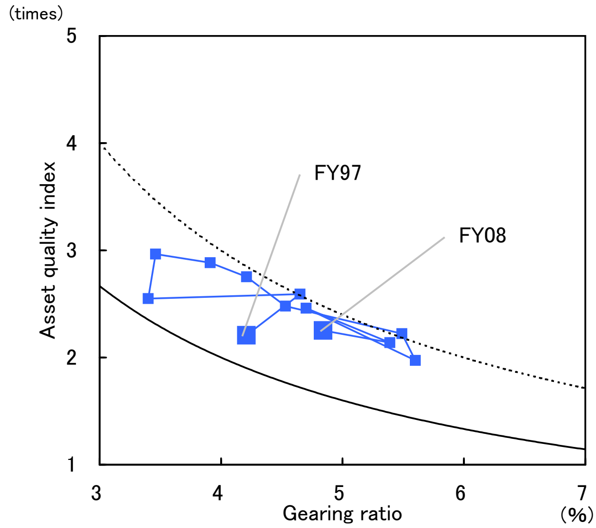
(Note2) The empty squares indicate data linearly interpolated.

Gearing ratios and asset quality indices of Korean commercial banks

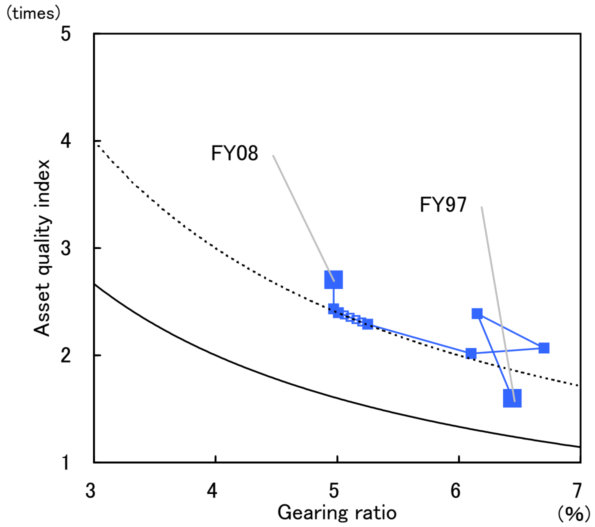
(1) Bank A



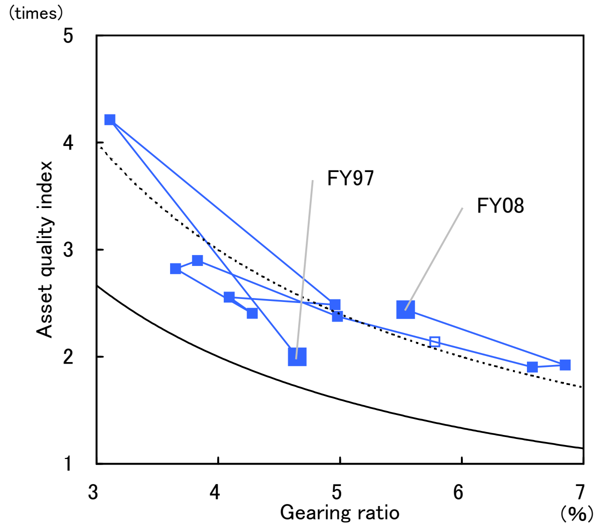
(2) Bank B



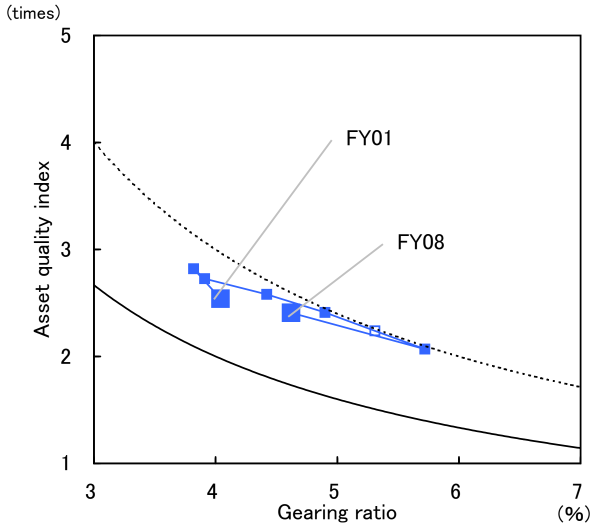
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

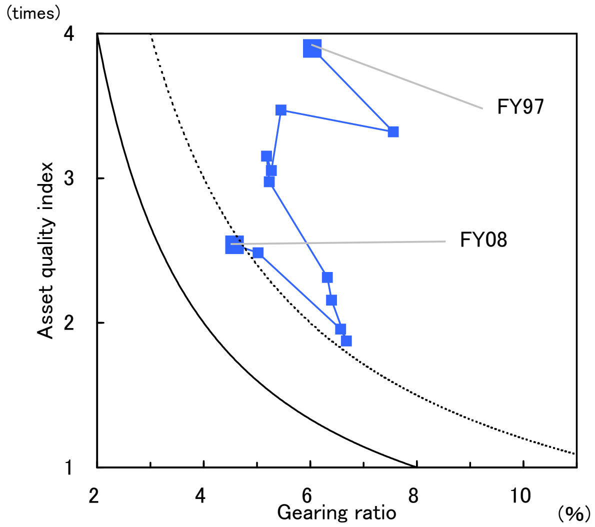
(Note1) ——— : Target ratio of risk-based capital requirement = 8%

----- : Target ratio of risk-based capital requirement = 12%

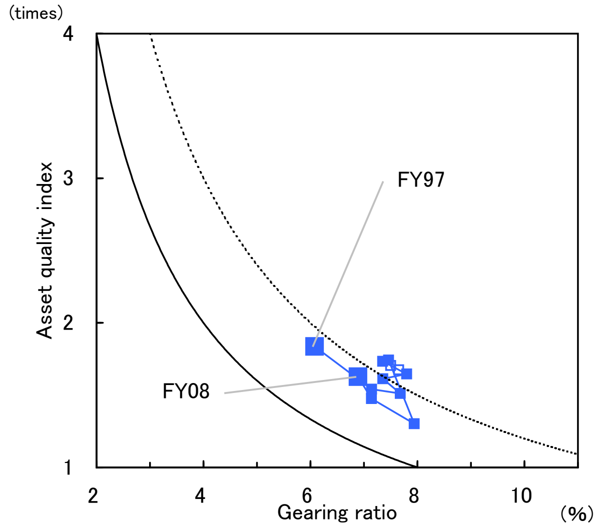
(Note2) The empty squares indicate data linearly interpolated.

Gearing ratios and asset quality indices of Taiwanese commercial banks

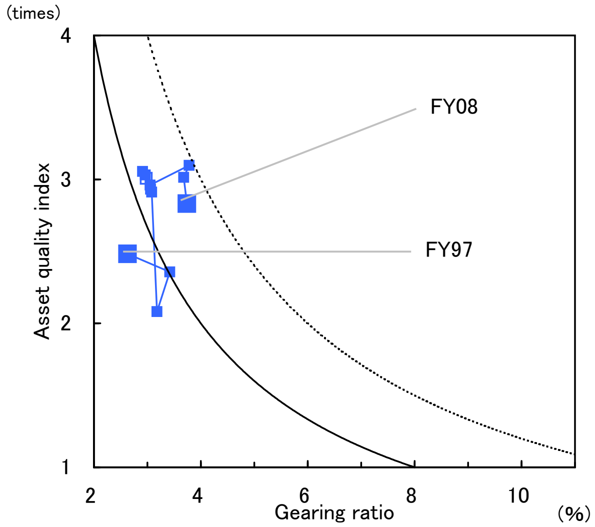
(1) Bank A



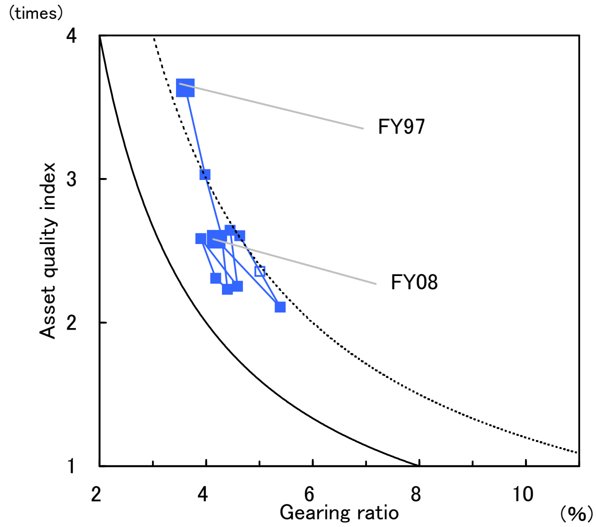
(2) Bank B



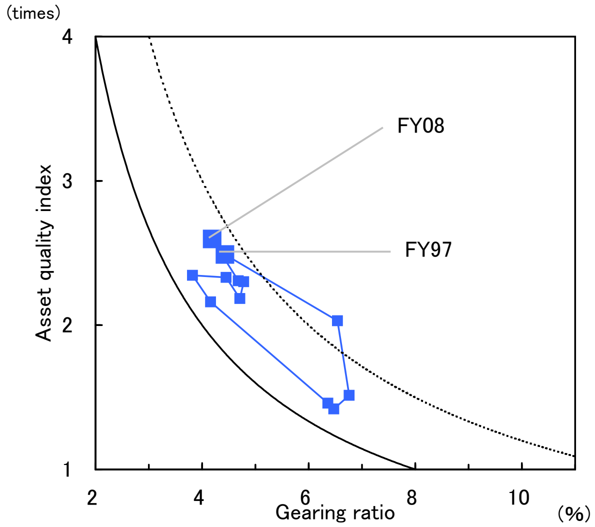
(3) Bank C



(4) Bank D



(5) Bank E



(Source) "The Banker" and the authors' calculation.

(Note1) ——— : Target ratio of risk-based capital requirement = 8%

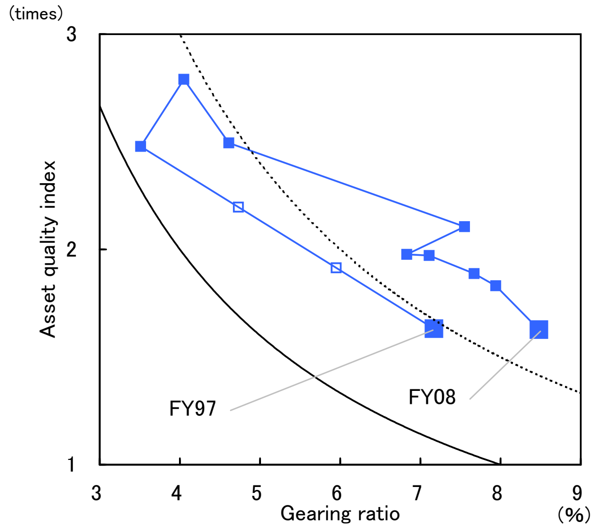
----- : Target ratio of risk-based capital requirement = 12%

(Note2) The empty squares indicate data linearly interpolated.

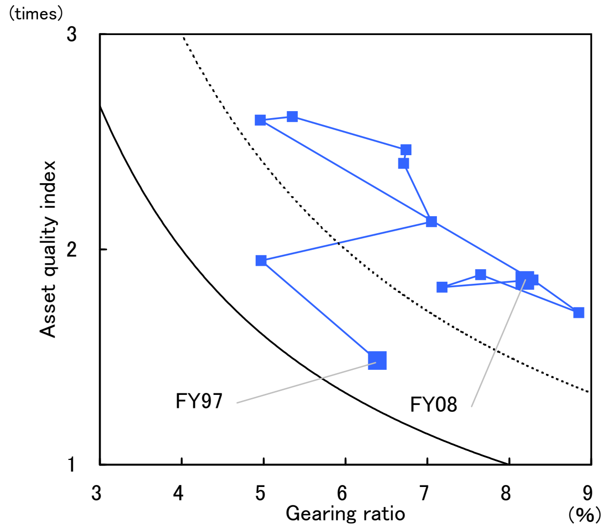
(Chart 22)

Gearing ratios and asset quality indices of Thai commercial banks

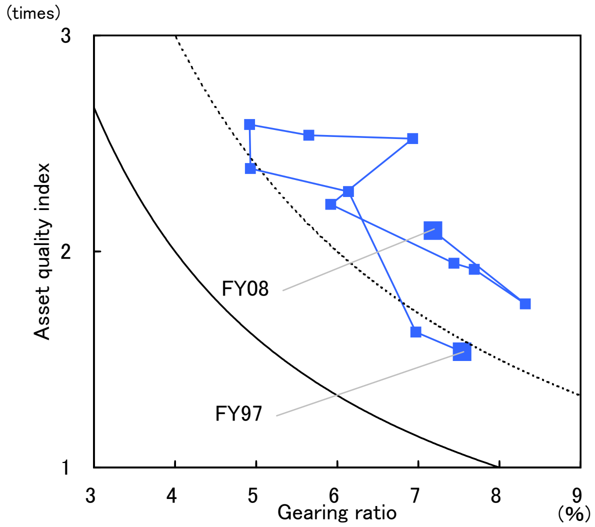
(1) Bank A



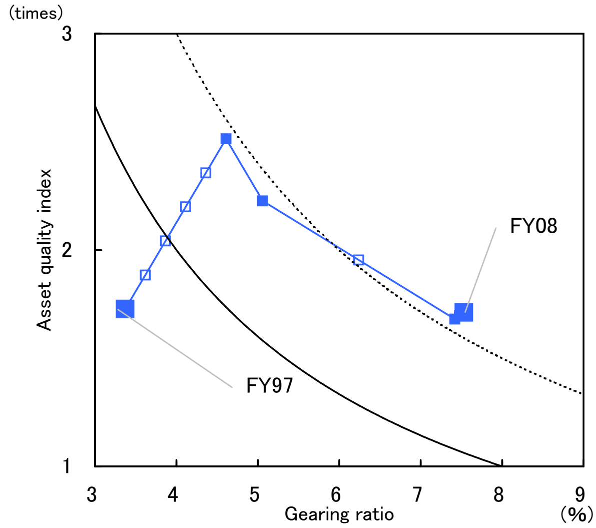
(2) Bank B



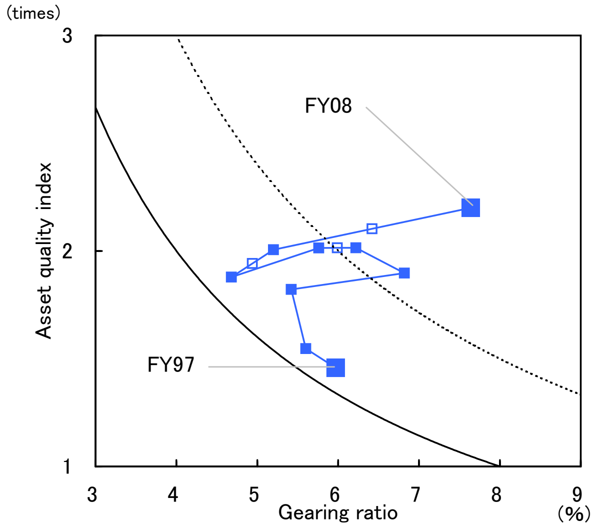
(3) Bank C



(4) Bank D



(5) Bank E



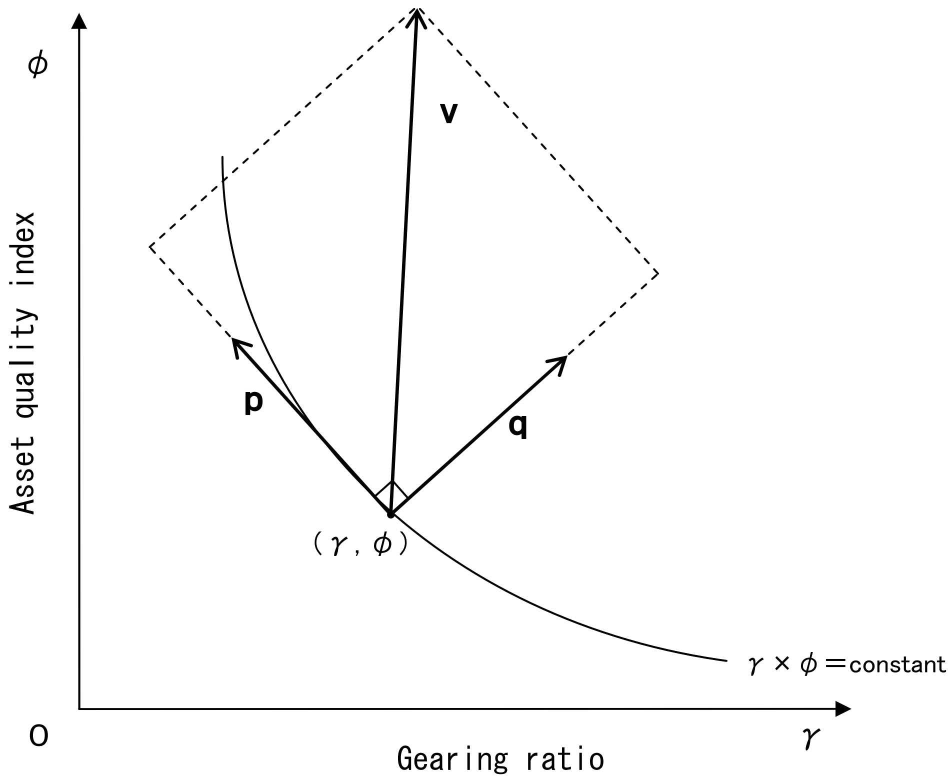
(Source) "The Banker" and the authors' calculation.

(Note1) ——— : Target ratio of risk-based capital requirement = 8%

------ : Target ratio of risk-based capital requirement = 12%

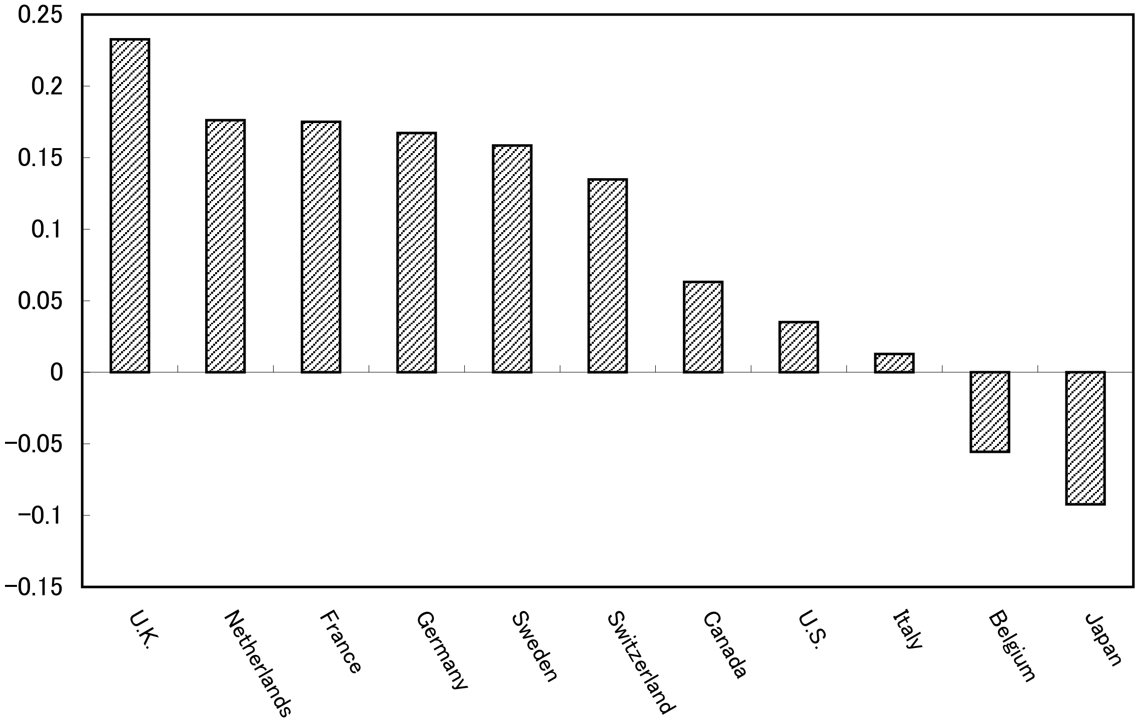
(Note2) The empty squares indicate data linearly interpolated.

Orthogonal decomposition of bank behavior

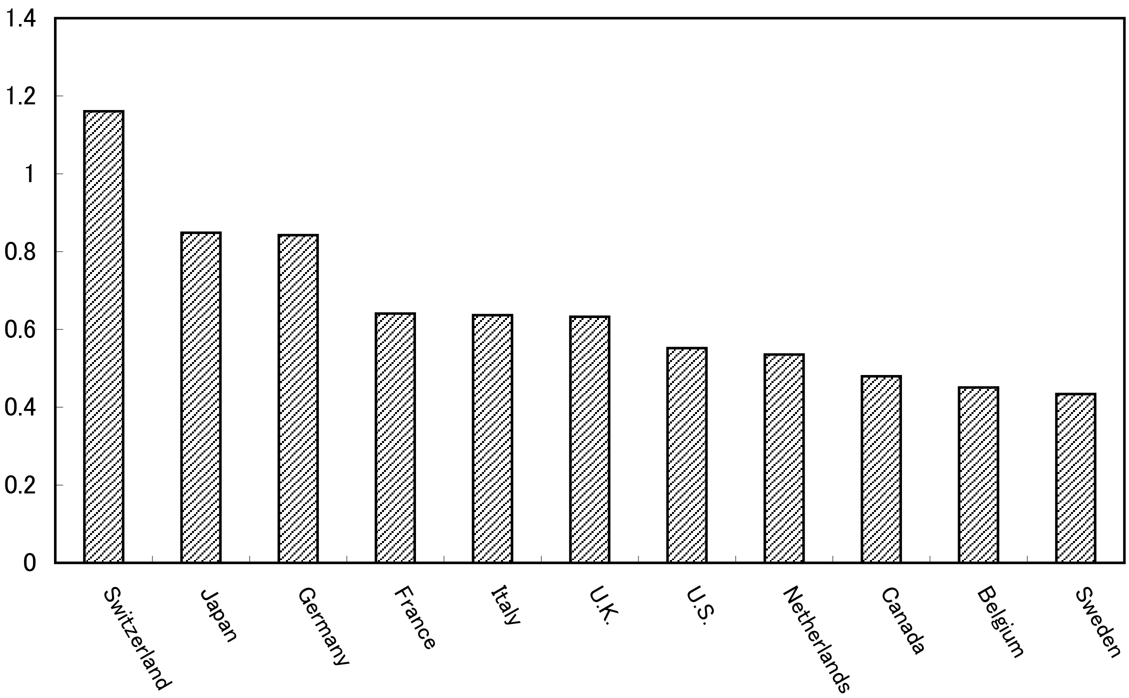


International comparison of bank behavior neutral to the risk-based capital ratio

(1) Trend components (the mean of a)

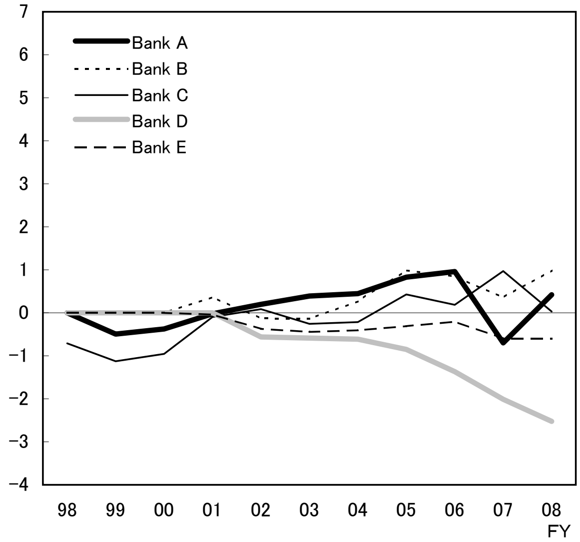


(2) Cyclical components (the standard deviation of a)

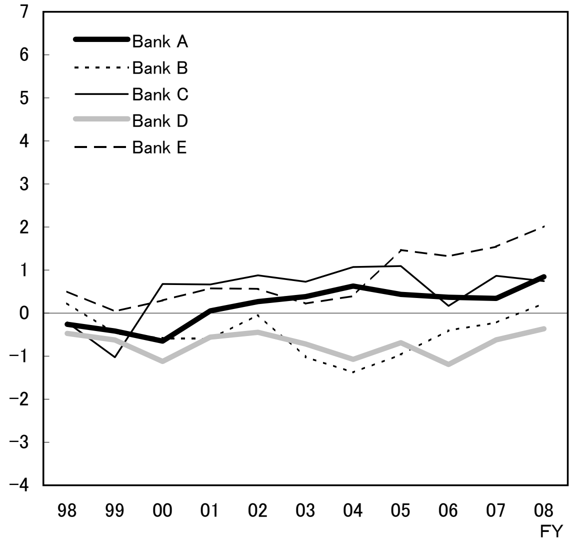


Behavior of G10 banks neutral to the risk-based capital ratio

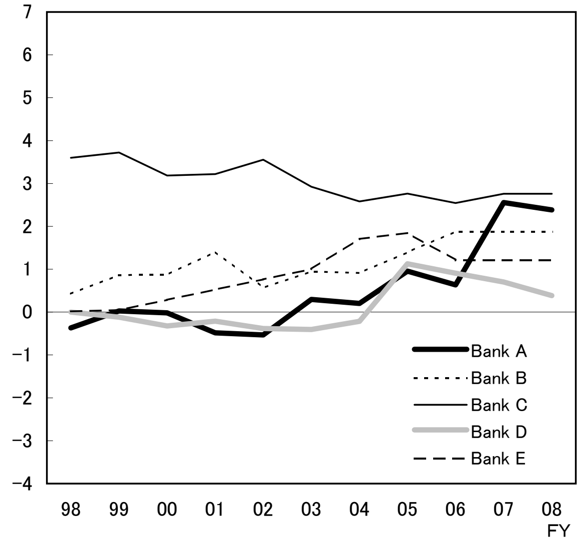
(1) Belgium



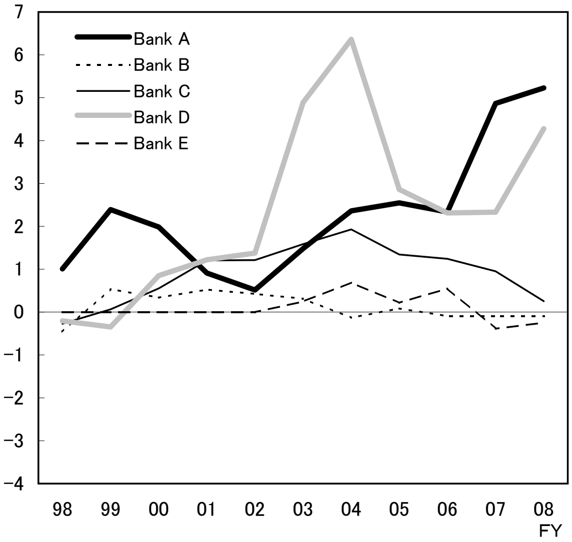
(2) Canada



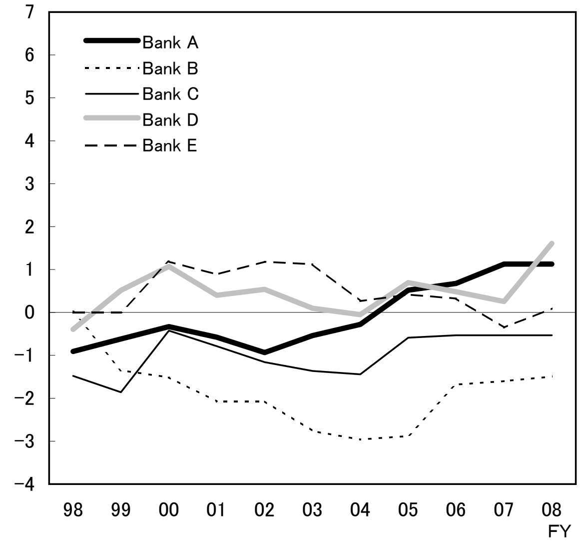
(3) France



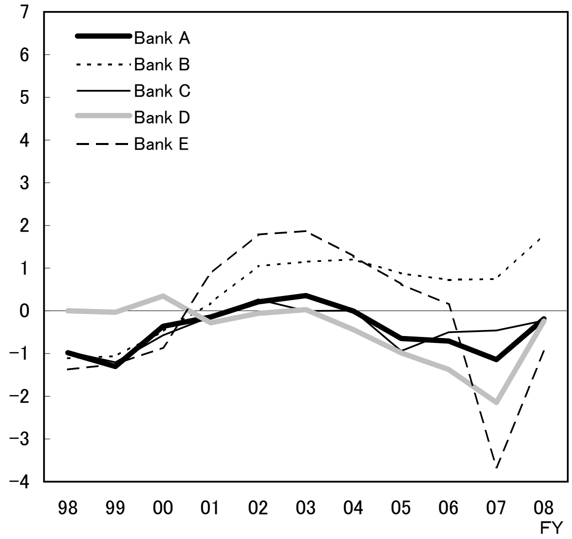
(4) Germany



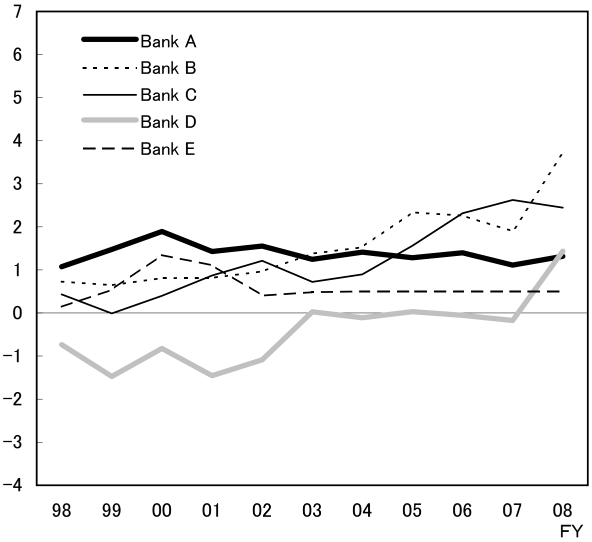
(5) Italy



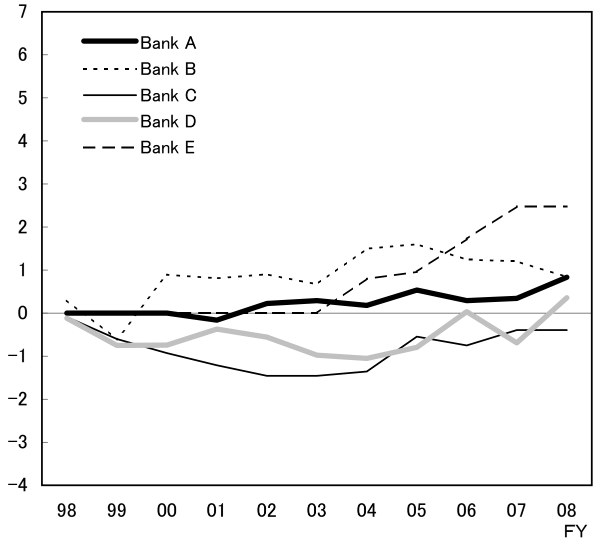
(6) Japan



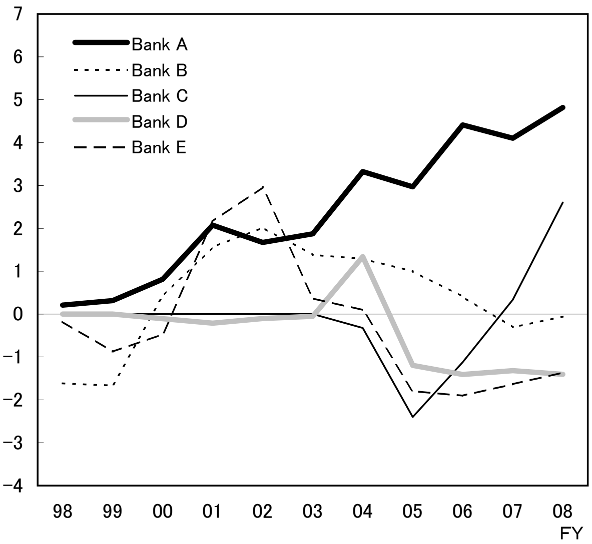
(7) Netherlands



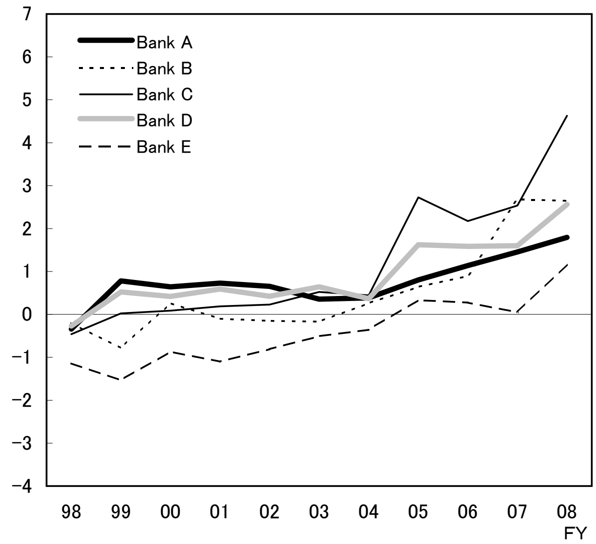
(8) Sweden



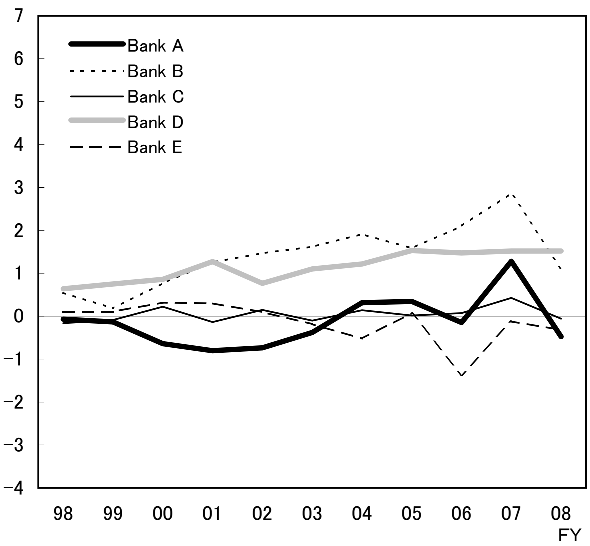
(9) Switzerland



(10) U.K.

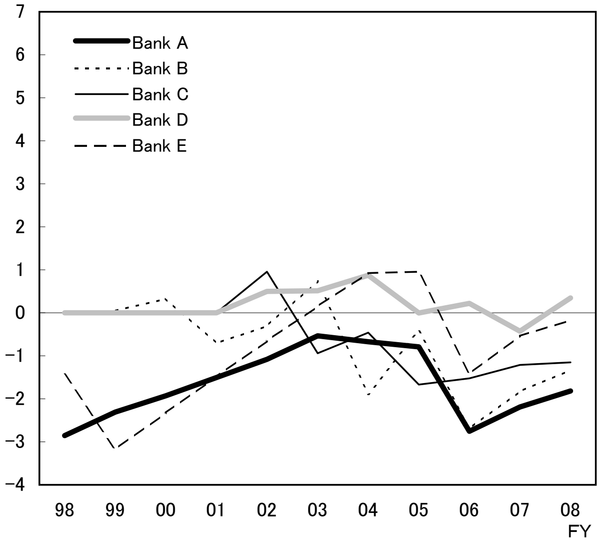


(11) U.S.

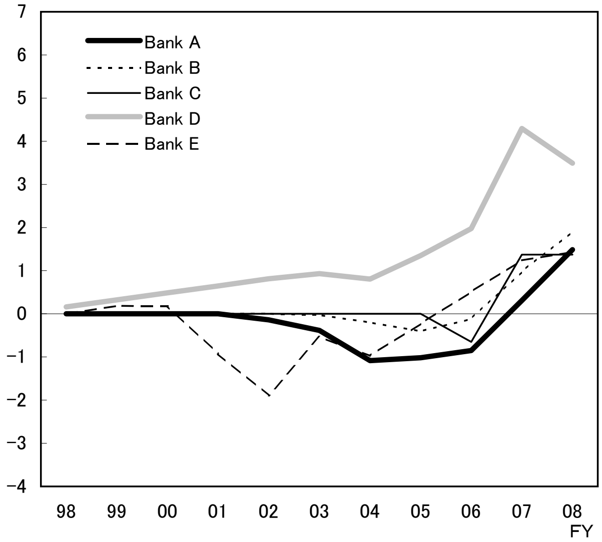


Behavior of Asian banks neutral to the risk-based capital ratio

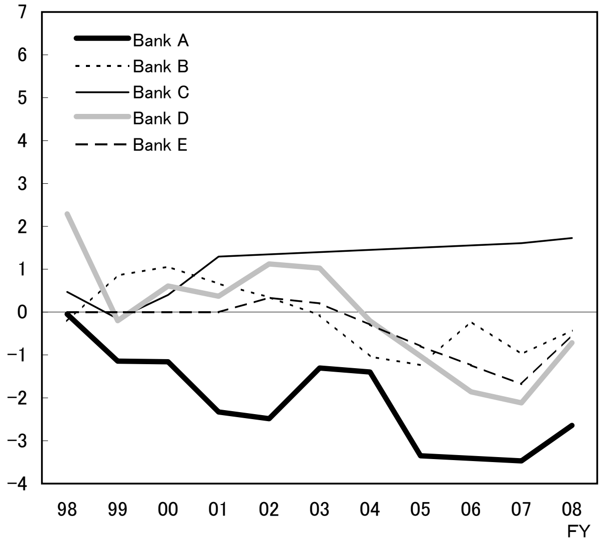
(1) China



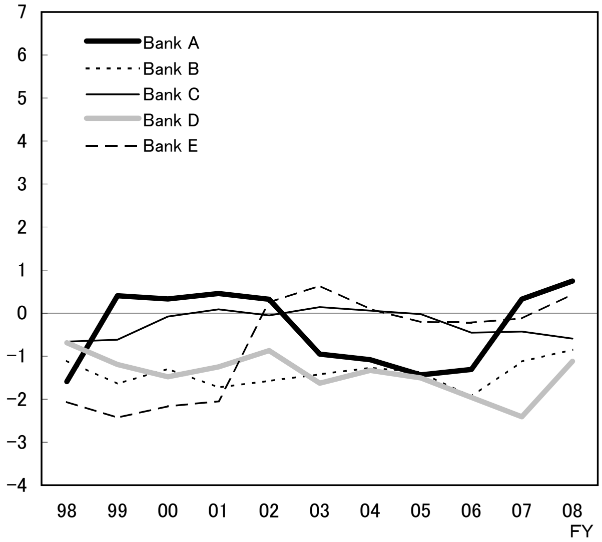
(2) Hong Kong



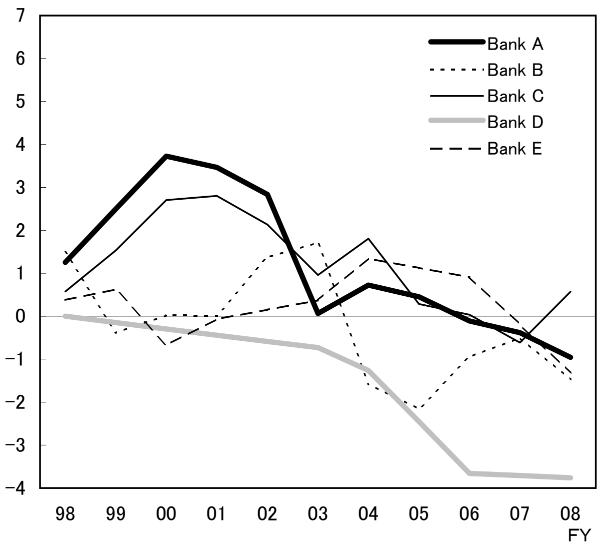
(3) Korea



(4) Taiwan



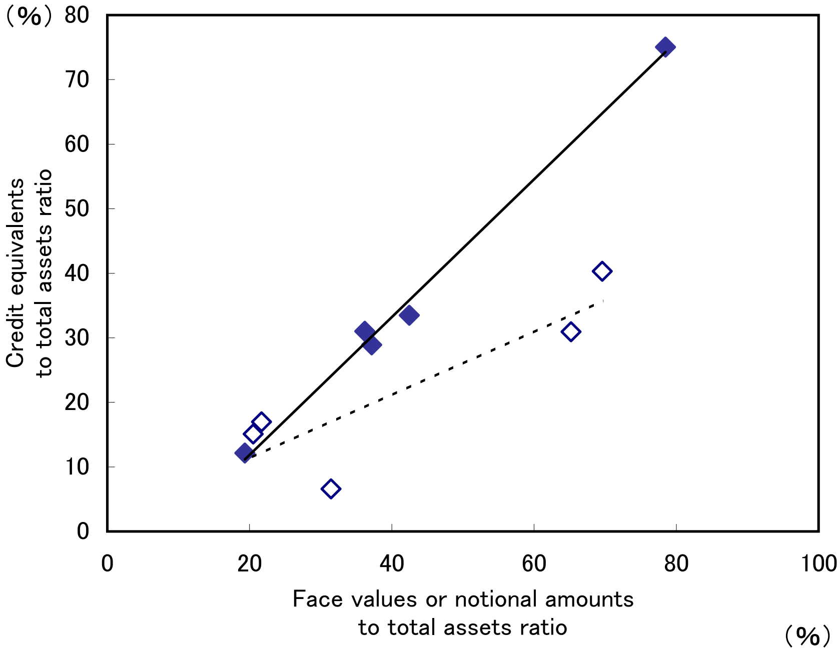
(5) Thailand



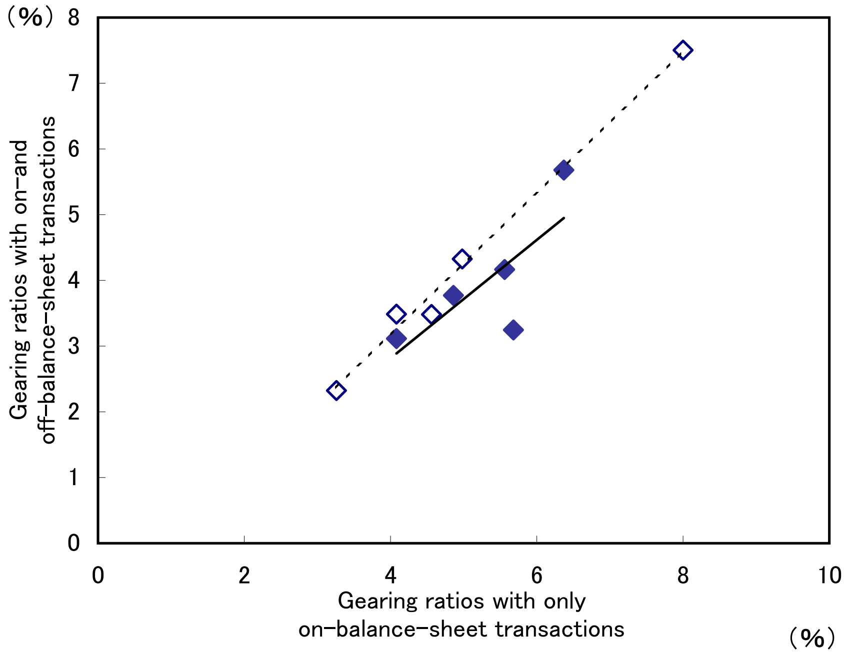
(Chart A1)

Gearing ratios with off-balance-sheet transactions

(1) Size of off-balance-sheet tansactions



(2) Gearing ratios with off-balance-sheet transactions

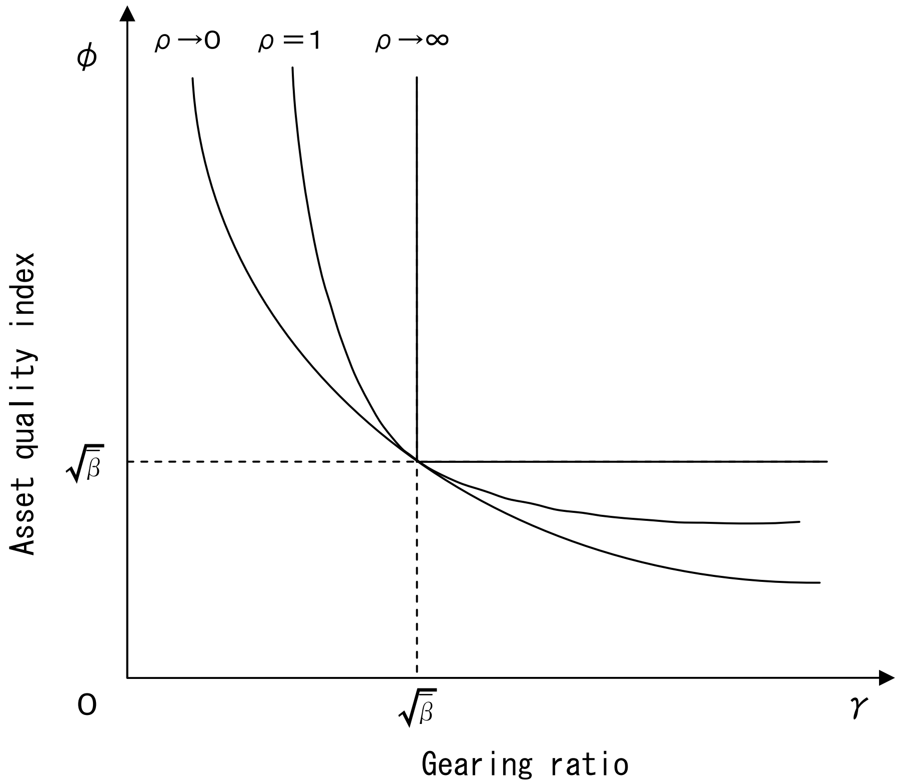


(Note1) As of the end of FY2007.

(Note2) ◆:U.S. commercial banks; ◇:Japanese commercial banks.

(Note3) ―:Regression line for U.S. commercial banks;
--:Regression line for Japanese commercial banks.

Regulations by the CES function



(Note) $\lambda_{\phi} = \lambda_{\gamma} = \sqrt{\beta}$

$\alpha = \frac{1}{2}$